Arnold Schwarzenegger
Governor

WHOLE HOUSE CONTRACTING PROTOCOLS PROJECT

VOLUME I

PIER FINAL PROJECT REPORT

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Energy Commission), conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

Whole House Contracting Protocols Project Volume I is the final report for the Whole House Contracting Protocols project (contract number 500-02-011) conducted by Bevilacqua-Knight, Inc. The information from this project contributes to PIER's Building End-Use Energy Efficiency Program.

For more information about the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/pier or contact the Energy Commission at 916-654-5164.

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Abstract

This report documents the Public Interest Energy Research Whole House Contracting Protocols Project, which focused on the retrofitting of existing homes in California to improve their energy efficiency. The project was built around identifying the successful practices of contractors currently engaged in whole house performance contracting in order to assemble their combined experience into a set of best practice protocols for whole house performance review and retrofitting. A complete set of the protocols developed during the project is contained in Volume II of this report.

In conjunction with the protocols, the project examined other aspects of whole house contracting such as contractor management and marketing practices, energy savings after whole house retrofits, and homeowner satisfaction.

The project conclusions outline measures that are needed to further accelerate the adoption of whole house retrofitting in California so that the state as a whole can realize the energy savings inherent in this approach.

Keywords: best practice protocols, whole house retrofit, whole house performance contracting, energy efficiency, comprehensive workscope

Executive Summary

Introduction

In California and the nation, the push is on to maximize energy efficiency, including taking measures to improve the energy efficiency in our homes. New homes are currently being built under initiatives such as the national Energy Star® Homes program and California's Title 24 energy code, which established energy efficiency standards for buildings to reduce California's energy consumption. However, these standards apply only to new construction. Existing homes, which represent the vast majority of California homes and are typically less energy efficient than new ones, provide a major unmet opportunity for energy savings through retrofitting.

Currently, energy efficiency programs for existing homes tend to address only individual measures of concern, such as ceiling insulation or window replacement. Although this conventional piecemeal approach does result in some energy savings, it fails to capture the greater energy savings and other valuable benefits of a comprehensive approach that looks at the whole house (WH) as an integrated system. That comprehensive whole house approach includes performance testing and reduction of the home's thermal load to ensure that the home's maximum potential energy and peak demand savings as well as safety, health, comfort and home value improvements are realized through thorough assessment, installation, and quality assurance.

Purpose

The Public Interest Energy Research (PIER) Whole House Contracting Protocols Project focused on analysis and retrofit methods for existing homes in California to improve their energy efficiency. The project's primary objective is to develop best practice protocols to be used by contractors and programs sponsoring home energy efficiency with particular relevance to the California housing stock, climate, and needs.

This report presents the final project summation, including the results of a national survey of home performance contractors designed to help identify the best practice protocols and a plan for accelerating the adoption of performance-based home retrofitting in California. Volume II provides trainers and practicing contractors with a reference manual that includes the complete text of the 45 protocols.

Project Objectives

The Whole House Contracting Protocols Project first sought to assess the current state of home performance contracting and its challenges by surveying contractors, including those active in the field nationally as well as California contractors unfamiliar with the concept. The study team merged this information with existing sources of standards for specific assessment and improvement activities, resulting in a thorough and consistent set of best practices that can meet the need for a practical guide to comprehensive home inspection, installation, and testing. These best-practice protocols are also intended to provide a basis for professional review, debate, and evolution to assure broad industry acceptance and ultimate ownership.

The project also sought to examine key business aspects of home performance retrofitting. These included management, marketing, and sales practices and problems, with resulting recommendations to better guide the adoption of appropriate business practices.

Yet another objective was to demonstrate and assess some specific home performance retrofits in the field, in order to gauge energy savings and homeowner satisfaction.

Technology transfer objectives focused on outlining a strategy for moving performance-based home retrofitting into widespread use throughout California. Also included were outreach efforts including publication of technical papers, conference presentations, regulatory testimony, and participation in related professional society and trade associations in support of home performance retrofit contracting.

Project Outcomes

The activities of this PIER project have given whole home energy-efficiency retrofitting more visibility in California and elsewhere, and have increased awareness and understanding of the issues involved in gaining further acceptance of this model by policymakers, contractors, and the public.

The project's best practice protocols provide a practical tool to be used by contractors and home performance training programs. Already they were successfully used in a California Public Utilities Commission implementation program and adopted as the basis for a project by the U.S. Department of Housing and Urban Development (HUD) to develop a system for improving energy-related practices of all contractors nationwide. When complete, the HUD project will provide online best-practices education to tens of thousands of remodeling and repair contractors nationwide.

Additionally, the protocols encourage an active and ongoing discussion within the energy efficiency community, as well as among heating, ventilation, and air conditioning (HVAC) and building-shell improvement contractors and their professional organizations, that will further the advancement of the whole house retrofit process and help it gain wider acceptance.

Conclusions

Technical and business barriers remain in the way of broad adoption of home performance contracting. Nonetheless, the best practice protocols provide a means of disseminating valuable new capabilities to contractors. Exposure to those new capabilities will encourage more contractors to consider whole house retrofitting as a model they can adopt for enhancement of their business.

The protocol set also complements emerging utility programs seeking to train and support contractors in a transition to improved energy-saving practices. Those publicly funded education and training opportunities, along with public education and contractor transition-support programs, play a vital role in preparing contractors for whole house retrofitting and gaining public understanding and support.

Recommendations

New research into homeowner motivations is needed to provide an adequate basis for state policy refinements to assess home performance retrofit programs more fairly. Current evidence is limited but suggests that non-energy benefits unique to comprehensive home performance retrofits may be the principal drivers of investment and success.

Integrating whole house retrofitting with *green remodeling and home solar programs*, along with partnering between public energy efficiency funding programs and the California Building Performance Contractors Association (CBPCA), can serve as a strong foundation for professional identity and statewide support.

Further *technical and business training plus ongoing support* are needed to prepare contractors for home performance retrofit work, and improved benefit/cost analysis policy and tools are needed to clearly demonstrate the cost-effectiveness of such support. This specifically focuses on the bias inherent in the current Total Resource Cost (TRC) test.

Publicly funded *implementation programs will be essential* for at least several years to build both an adequate tipping-point contractor base and sufficient consumer awareness to sustain those contractors in this new business.

Benefits to California

Effectively strengthening and gaining acceptance for the whole house energy performance model, along with its integration with the green building and solar energy movements, will require the emergence of a comprehensive energy-related home upgrading strategy. As this approach gains political and public support, the state will realize substantially increased residential energy savings. The reductions in home energy use and peak-period electricity demand across the state will mean greater energy security, reduced energy costs, avoidance of unnecessary investment in electricity system expansion, new skilled jobs in home improvement, and a host of environmental benefits.

Finally, homeowners and occupants will realize major non-energy benefits, such as increased comfort, safety, and indoor air quality (IAR) and resulting health improvements, as well as savings in home repairs—all of which will increase individual motivation to invest in these improvements and thereby to create a level of energy savings otherwise lost through conventional practices.

1.0 Introduction and Overview

1.1. Project Goals and Scope

This PIER project focuses on retrofitting of existing homes. The project seeks to contribute to the development of appropriate and consistent standards for comprehensive inspection, complete installation, and performance testing, including contractor management and marketing practices as well as technical competences. By extension, the project also seeks to translate such improvements into recommendations for programs to bring the whole house (WH) retrofit concept into routine use.

1.2. Home Performance Contracting

The basic principle of “home performance contracting” is the use of detailed home inspection, repair, and before/after performance testing to improve a home’s energy efficiency and related attributes, such as safety, health, and comfort. Performance contracting can be either comprehensive or focused on more limited system-specific scopes such as heating system upgrades and insulation. When performance contracting is done comprehensively across all aspects of a home’s construction and operation, it is referred to as “whole house” contracting. Both terms can be applied effectively to new as well as existing homes.

In California as well as across the nation, new homes are now being built under pathbreaking programs such as Energy Star® Homes and California’s Title 24 for raising construction standards. Even with these higher standards, the energy efficiency of those new homes could be much higher. But the potential for energy savings in the existing housing stock is much greater. Not only are existing homes typically much less energy efficient than new ones, but also existing homes far outnumber new homes. Even at the relatively high new construction rate in recent years (due largely to the historically low mortgage interest rates, which have now risen), we barely cover the needs of population growth rather than replacement. This means that most of today’s existing homes will be in use and *dominating the housing stock* for many more years. They thereby they represent by far the major opportunity for residential energy and peak demand savings.

Yet present energy efficiency programs for existing homes do not involve performance testing, and tend to address only individual measures, such as ceiling insulation, window replacement, air conditioner maintenance, inefficient appliance replacement, and increased use of fluorescent lighting. The home energy savings of such programs can be significant but tend to fall far short of the home’s potential savings due to their inherently limited scope. In addition, they fail to capture the added benefits of a more comprehensive approach. For example, complete weatherization and ventilation control of a home’s building envelope typically permits downsizing of the heating, ventilation, and air conditioning (HVAC) equipment if done at the same time, with reduced costs of equipment and operation as well as less noise, avoidance of drafts, and longer equipment life. Incorporating performance testing into such a comprehensive retrofit project assures that the expected benefits are actually achieved through installation quality assurance.

1.3. Project Tasks and Reporting

A variety of task and activity reports were delivered during this project, and this final report presents results of all original project tasks. The report is organized as follows with respect to those tasks:

- **Chapter 1—Introduction and Overview**: This brief chapter outlines the rationale for home performance retrofit contracting, summarizes the project tasks and report organization, and provides an overview of the principal conclusions and recommendations.
- **Chapter 2—Current Home Performance Contracting Practices:** This chapter reports on the procedures and results of a survey of practicing home performance contractors nationwide, with implications for improvements in future California programs and standards. (Primary research by Performance Systems Development, Inc.)
- **Chapter 3—California Contractor Attitudes toward Home Performance Contracting:** This chapter presents the results of the project's survey of California contractors recently introduced to retrofit home performance, to indicate characteristics that may contribute to success (Primary research by Lutzenhiser & Associates).
- **Chapter 4—Home Performance Protocols for California:** This chapter provides a summary view of the set of home performance diagnostic and business best practices developed in this project's research on current practices, existing references and standards, and recommendations of experts in this field. This chapter is supported by Appendix Volume B: Best Practice Manual, which provides the actual content of each best-practice protocol developed in this task (Primary research by Bevilacqua-Knight Inc. on business practices and by Performance Systems Development, Inc. on diagnostics).
- **Chapter 5—Contractor Training and Verification**: This chapter describes the use of the project's Best Practice Protocols in actual training and follow-up with contractors in an operating home performance program.
- **Chapter 6—Home Performance Retrofit Field Demonstration:** This chapter reports on the results of selected home performance retrofits, including homeowner experience and satisfaction as well as energy savings and other benefits.
- **Chapter 7—Moving Into the Mainstream in California**: This chapter describes the project's technology transfer activities, including a strategy for accelerating the adoption of retrofit home performance contracting throughout the State.
- **Chapter 8—Conclusions and Recommendations:** This chapter is a detailed discussion of the project's conclusions and recommendations for further research, regulatory interventions, and other activities to advance home performance contracting in California.
- **Appendix Volumes:** This final project report includes two volumes of Appendices. Volume I includes several appendices presenting survey forms and other procedural

details. Volume II is a reference manual including the full text of all the best practice protocols developed in this project.

1.4. Summary of Conclusions and Recommendations

Chapter 8 of this report provides a set of detailed project conclusions and recommendations for further action both in research and implementation support. Here we present a summary of those conclusions and recommendations.

- This PIER project has been influential in shaping the course of home performance contracting in California and beyond.
- The best practice protocols developed in this project have been used successfully in a California implementation program and have also been adopted in a U.S. Department of Housing and Urban Development (HUD) project to develop guidelines for contractors nationwide.
- The project's analysis shows that here are still major technical and business barriers to broad adoption of building science and home performance contracting by many contractors, with innovative business models likely to provide the most effective solutions.
- The current Total Resource Cost (TRC) test for program cost-effectiveness was demonstrated to be biased against home performance contracting, and must be refined to acknowledge the role of non-energy benefits in homeowner decisions to undertake such projects.
- A practical strategy for accelerating the adoption of existing-home performance diagnosis and retrofitting in California emphasizes integrating it with solar and green-remodeling brands for marketing and programs, and focusing on the California Building Performance Contractors Association (CBPCA) as the foundation for professional identity and support statewide.
- Extensive technical and business training as well as continuing support are needed to prepare contractors for home performance retrofit work, and innovative approaches are needed to make that support adequately cost-effective.
- Substantial new research into homeowner motivations is urgently needed to provide an adequate basis for State policy refinements to assess home performance retrofit programs more fairly so that the public can get the extensive benefits that those programs can offer.
- Publicly funded implementation programs will be essential for at least several years in order to build both a contractor base and adequate consumer education. The California Public Utility Commission's (CPUC's) 2007 Solar Roofs initiative, created by the Governor's approval of Senate Bill 1 (2006), includes key opportunities for expanding public awareness of energy efficiency improvements through alliances between solar and home performance contractors to provide optimal solutions to home energy use and peak load problems.

2.0 Current Home Performance Contracting Practices[1]

2.1. Introduction and Overview

This report provides the results of a national survey of home performance contractors designed to identify home retrofit best practices. The survey was completed in early 2004. It documents the business and technical practices of successful whole house and home performance contractors, thereby helping contractors attempting to adopt whole house and home performance business models become more successful. The survey results are applicable to both publicly funded programs (such as weatherization, energy efficiency) and private contractors. For public programs, success means promoting consumer investment in home retrofits and improving the resulting energy savings. For private contractors, success means obtaining a good profit in a business with high growth potential and delivering superior results.

2.1.1. Terminology

As used in this report, the terms “home performance” and “whole house” are closely related but have distinct differences in meaning intended to convey the benefits of moving beyond performance testing to offer comprehensive workscopes.

Home performance is the more inclusive term. It refers to contractors who use performance testing but without *necessarily* doing comprehensive workscopes that include both shell and HVAC improvements. Home performance contractors providing comprehensive workscopes include contractors who use subcontractors for some of the work as well as contractors who deliver both shell and HVAC improvements using their own crews.

Whole house is a more exclusive term. It refers specifically to contractors who focus on implementing comprehensive solutions for performance problems with a combination of HVAC and insulation work. The result of this distinction is that whole house contractors do home performance work, and are home performance contractors; in contrast, home performance contractors may not be doing whole house work.

2.2. Survey Methodology

The survey was conducted in two stages: a broad-based, online screening survey, followed by detailed phone interviews with selected contractors.

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[1] Except as otherwise noted, the principal author of this chapter was Greg Thomas of subcontractor Performance Systems Development, Inc.

2.2.1. Online Screening Survey

The screening survey was designed to identify contractors who had incorporated performance testing into a high percentage of their business and to provide a better understanding of the basic testing techniques they use. The screening survey also distinguished between not-for-profit providers of home performance services and for-profit private contractors. Detailed results from this survey and a sample of the instrument are available in Appendix B and C respectively.

The screening survey was promoted to approximately 2000 contractors whose e-mail addresses were obtained from (1) the lists of Affordable Comfort event attendees and (2) approximately 500 user registrations at the project's web page. The initial survey e-mail had a response rate of about 6% (over120 responses). After eliminating incomplete replies and the occasional curious energy efficiency program manager, 118 contractors remained. This is a geographically diverse group that includes representatives from 35 states, the District of Columbia, and Canada.

2.2.2. Phone Interviews

The screening survey was followed by detailed phone interviews and discussions[2] with the 16 contractors deemed most clearly successful and committed to building science-based methods. The contractors interviewed were also selected to provide representation across a range of company sizes, business models, and geographic locations. Two not-for-profits providing fee-for-service home performance services were also included. A copy of the survey instrument is provided in Appendix C.

This survey was a detailed inquiry into a small group of home performance contractors. These were systematically selected rather than a statistical sampling of all relevant contractors. Those interviewed were chosen from the screening survey respondents (and a few others known to the researchers) to represent relatively successful operations in a cross-section of the industry by location and business type. We interpret the findings to indicate only tendencies among such viable home performance contracting operations around the country, thus providing indications of best practices and avoiding the confusion that would result from a broader picture of this entire emerging and still ill-defined industry.

These interviews collected information on business, marketing, and technical practices; contractor perception of consumer concerns; and sources of training information. Each

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[2] Information on 1 of the 16 contractors was obtained from a workshop presentation on October 15, 2003, for new and potential Home Performance with Energy Star programs and resulting follow-up discussions. The business model for that successful contractor was deemed unique enough to merit addition to the study.

interview was, on average, more than one hour long. All contractors agreed to participate without subsidy. More information on these contractors appears in Chapter 3.

2.3. Contractor Characterization

Contractors to be interviewed in detail were chosen according to their success in creating a viable home performance business. The primary selection criterion was operating for at least two years as a home performance contractor with the majority of their income coming from performance tested work. The one exception was a large California based contractor actively working with the California Building Performance Contractors Association program and rapidly transitioning into a whole house home performance business.

Business characteristics of the organizations selected to participate in the detailed survey are shown in Appendix D. Key descriptors of the selected contractors are as follows:

2.3.1. Business Size

By usual standards, virtually all the respondents were small contractors. However, there was substantial variation among them, so we divided them into three size categories. Ten of the successful contractors chosen for the survey were considered "large" with estimated annual sales of approximately $500,000 and above. Two contractors were considered "medium" with annual sales between $100,000 and $500,000. Two contractors were considered "small," with sales of under $100,000. These smallest contractors provided little or no direct installation and primarily offered diagnostic and construction management services without becoming the general contractor.

2.3.2. Prior Business Status

Ten of the contractors were established in a conventional specialty. The remaining six were home performance startups. That is, they did not have an existing contracting business prior to adopting home performance testing as an integral part of contracting. Of those, two of the startups were now considered large and both had experienced rapid growth. Both combined a focus on HVAC installations with in-house shell work.

2.3.3. Organization Type and Location

Fourteen of the sixteen contractors were private sector companies. The remaining two were not-for-profits (NFPs) doing fee for service work. Eleven of the sixteen were from heating climates, such as New York, Wisconsin, and Vermont. (New York and Wisconsin have longstanding public sector support for home performance and, therefore, have more contractors who have gotten over some of the bumps in the road.) The remaining five contractors are from Texas, Arkansas, North Carolina, and California.

2.3.4. Business Specialties

Seven of the contractors selected are whole house or full service contractors, offering some combination of HVAC and shell work with their own employees. Four of the contractors are specialty shell contractors offering performance tested HVAC installation services using subcontractors. Five of the contractors do no direct installation work themselves, instead acting either as general contractors using subcontractors or as customer's representatives and supervisors, with the customers signing installation contracts with independent installation contractors.

2.3.5. Typical Home Performance Project Size

The average job size for the private contractors doing some significant part of the installation was $9333. In contrast, the not-for-profits averaged $4500; these tended to be low-income weatherization specialists. The remaining contractors, who act only as diagnosticians and coordinators of work by others, billed an average of $2250 since little if any actual installation work was included.

2.4. Origins of Home Performance Contractors

One of the most important lessons to be learned from successful home performance contractors is how different types of contractors can progress from the limited use of home performance testing to the establishment of a successful comprehensive home performance contracting business. Therefore, the phone interviews took a careful look at contractors' base of experience to determine (1) what starting points (or "origins") were most common amongst successful contractors and (2) which variations in origins lead to success with different types of business models.

2.4.1. Benefits of Previous Experience

Almost all the contractors interviewed had previous experience with some type of energy efficiency program. Many of the contractors were previously involved with utility energy programs or the Weatherization Assistance Program (WAP), and had acquired some level of testing skills in those programs but had not previously used the experience to move into offering home performance, whole house services, or diagnostics outside the scope of the existing programs.

Understanding and experiencing the usefulness of performance testing on a regular basis appears to have made it easier for contractors to consider adopting this new business practice based on testing. The contractors interviewed were able to take their experience in performance testing within the context of a funded energy program—for example, low-income weatherization—and transfer that into private market home performance.

Of course, the interest of these contractors may be due at least in part to program following. Contractors who are already comfortable working in energy efficiency programs, even if they involve no testing, may be more willing to access the support offered by the local home performance program. But even outside locales where formal home performance programs were being offered, most home performance contractors who responded to this survey had some prior testing experience.

2.4.2. Program Implications of Contractor Origin

Based on the results summarized above, programs seeking to advance retrofit home performance might do well to recruit from a pool of contractors who have participated in other energy efficiency programs. Moreover, in preparation for the introduction of a home performance contracting program, those existing energy efficiency programs could be modified to introduce key building science principles and skills. These transitional changes in existing programs might include additional performance testing, health, and safety testing, or the use of certification programs such as that of the Building Performance Institute (BPI), to help contractors develop key skills and understanding. These coordinated changes would help to develop a more sophisticated contractor base prior to explicit funding of a home performance program.

2.4.3. Contractor Implications

Contractors interested in moving toward whole house work should consider participating at some level in existing energy efficiency programs that offer performance testing and diagnostics training, even if the program is not whole house-based. They can use these programs to get their management and crew familiar with testing. The training offered may be as helpful as the work provided.

2.5. Effects of Contractor Specializations

The potential contractor audience for a home performance program is quite broad. The screening survey respondents included existing shell contractors (windows, insulation, weatherization), existing HVAC contractors, remodelers, and companies that had not previously done installations, such as home inspectors and startup contractors. It appears from both the screening survey and the phone survey that shell contractors and small general contractors are currently the prime source of contractors making the transition into home performance. Surprisingly, HVAC contractors, who typically have greater technical expertise and are the majority of those involved in home performance programs, appeared much less likely to embrace whole house approaches that integrate shell with HVAC disciplines.

2.5.1. Shell Contractors

Most of the contractors interviewed started as shell contractors. Regardless of the size of the company or their level of experience in home performance, there was a strong tendency for these contractors to subcontract some or all of the heating and air conditioning work that they generate as part of their whole house inspections. But not always: Two of the startup contractors with the highest growth rates brought the heating and air conditioning expertise and installations in-house with their own shell work. One of the larger shell contractors had merged with an HVAC company to offer whole house workscopes.

Why are shell contractors most likely to consider home performance work? The show of interest on the part of the shell contractors, both large and small, may be due to a desire to differentiate themselves in a market where quality and margins are constantly threatened by a low cost of entry. It is much easier to start a business as a window installer or insulation company than as an HVAC contractor. The lower cost of entry into shell work may work to create a situation that makes the home performance option attractive to quality oriented shell contractors, large or small, who want to grow or professionalize themselves by differentiating themselves from low overhead competition.

Shell specialists may also be more motivated by business uncertainties, since they are less likely to have the stability of continuing relationships with their clients than are HVAC contractors, whose business may stress periodic servicing and repair or annual service contracts.

2.5.2. HVAC Contractors and New Contractors

Although there is a significant financial opportunity for new contractors or existing HVAC contractors who adopt whole house approaches, it appears from the survey that they are not pursuing this opportunity fully.

In the interview group, there was only one HVAC contractor who had incorporated shell work into his business to support his "whole house" work. The focus of that business was performance warranties on new construction rather than whole house retrofitting. From the online screening survey, it also appeared that there were few HVAC contractors who were doing significant amounts of performance-tested work, and fewer still who had progressed to offering whole house solutions.

Perhaps the move of a few larger shell contractors into the HVAC business will stimulate some of the conventional HVAC contractors to expand their scope. Those HVAC contractors who are currently content to be subcontractors in home performance projects, with their work performance tested by the shell contractor, are likely to find it more profitable to move towards getting training, performing inspections, and installing performance tested HVAC and even shell improvements.

Another example of HVAC contractors moving towards whole house service delivery came from survey respondents in some regions who indicated that some HVAC specialists are starting to insulate attics as a part of treating the attic-based duct systems. Air sealing and insulating walls or using cellulose as part of strategic dense packing may not be far behind for these contractors.

2.5.3. Remodelers

Larger remodelers have a skill set that may make it easier for them to adopt and manage the complex, multi-trade business process of home performance contracting. One of the most successful contractors contacted was a remodeler who has rapidly adopted the multi-trade approach and developed a sophisticated marketing and sales approach. More information is needed on the potential success of remodelers in making this transition.

2.5.4. Program Implications of Contractor Specialization

Shell contractors may be early adopters of home performance techniques and may partner with HVAC contractors to offer comprehensive solutions. Early recruiting of HVAC contractors may be more difficult, despite their often greater technical skills. Avenues by which HVAC contractors may move towards home performance and whole house work include:

- The move of a few larger shell contractors into the HVAC business, however, may stimulate some of the conventional HVAC contractors to expand their scope.
- HVAC contractors who are currently content to be subcontractors (with their work performance tested by the shell contractor) are likely to find it more profitable to get

training, perform inspections, and install performance-tested HVAC, and perhaps even shell improvements.

- According to survey respondents in some regions, HVAC contractors are starting to insulate attics as a part of treating the attic-based duct systems. Air sealing and insulating walls or using cellulose as part of strategic dense packing may not be far behind for these contractors.

2.5.5. Contractor Implications

All types of contractors should think carefully about how they will incorporate the other necessary home performance trades into their work. They should consider including broader in-house capabilities as an alternative to subcontracting.

2.6. Transitions to Whole House Contracting

The survey provided a wealth of information on how contractors can maximize their chances of success and overcome common obstacles when building a business around home performance and whole house work.

2.6.1. Increasing Job Size by Taking on Broader Workscopes

All the largest contractors interviewed, with the exception of the two not-for-profits, tended to sell large jobs—$8000 or more, averaging over $9000. This appears to reflect their greater ability or willingness to incorporate a broader range of trades either in-house or via subcontracting. The smaller contractors had an average job size of $5000 or less, which may be due in part to the fact that the small contractors group included diagnostician/supervisors (who sell only their consulting services rather than actual materials, equipment, and remediation services) as well as shell installers**.**

All the contractors in the interview group use performance testing techniques as part of their business and technical process. But, as indicated by the average job size, the larger contractors are more successful at executing larger (that is, broader) customer workscopes. Larger/broader jobs also should mean that the contractors are having a greater impact on the performance of their customers' homes. As a result, the capability to do these larger jobs may help contractors create a stream of larger jobs as satisfied customers make referrals and help recruit customers who have an expectation of the project being more than just a furnace replacement or insulating an attic.

Taken together, the online survey and the phone interviews revealed three stages of contractor involvement with performance testing and building science:

- Performance testing with conventional limited workscopes (such as HVAC)
- Performance testing with broader workscopes and subcontracting of other trades
- An integrated whole house approach with all services offered in house

2.6.2. Program Implications of Transition Experience

Larger home performance jobs mean lots of consumer investment in efficiency. Helping contractors to do these more complete workscopes can result in a lower overall program cost per unit of energy savings because large jobs typically have greater positive impacts on customer energy efficiency than smaller jobs. Also, early evidence of such effects may be an effective way to get more contractors interested in participating in home performance programs. The added investment in contractor selection and training needed to encourage these higher impact jobs may pay off in more cost-effective programs.[3]

2.6.3. Contractor Implications

Bigger jobs with big impacts on houses provide a great way for contractors to prosper while delivering superior quality and value. Moreover, bigger jobs mean that fewer customers are needed to fuel firm growth, and customers who experience the big improvements in home performance from a whole house job can be excellent sources of referrals. But acquiring the ability to offer a broader workscope requires contractors to offer both HVAC and shell work, either by partnering with other trades or expanding their own in-house capabilities.

2.7. Opportunities for Startups vs. Existing Businesses

Only two of the interviewed contractors began as new home performance startups and grew enough to be considered larger contractors. Both are now full service whole house contractors that offer shell and HVAC work with their own staff. One of the startups transitioned very quickly from diagnostics only, to shell work, to doing HVAC work. When this firm began installing HVAC systems with in-house staff, their rate of growth increased significantly. The other company started as an HVAC contractor that also did shell work. Both now generate most of their income from the HVAC aspects of their work. These examples indicate that home performance startups can experience rapid growth and that benefits of adopting home performance are not limited to existing contractors.

The other startups focusing on shell work generally did not experience the growth of the startups focusing on HVAC.

Established contractors, however, may have to educate their existing current customer base on the added value of a performance-tested approach. One contractor effectively used a newsletter

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3 Home performance jobs involve a variety of measures that may not all be cost-effective based on energy savings alone, because those measures also contribute to non-energy benefits valued by homeowners such as home safety, equipment longevity, health, and comfort. Home performance programs face funding barriers due to agencies' cost-benefit justification requirements based on energy savings alone.

and form letter to educate his past customers on his new approach, attempting to stimulate new referrals from old customers that would better fit his new business model.

2.7.1. Program Implications of Startups versus Existing Contractors

Programs should distinguish between issues confronting startups and those challenging existing contractors. Programs can best support startups with home performance customer leads and business planning support to help them access capital. Similarly, programs can best help existing contractors by improving program-related lead generation and customer referrals.

2.7.2. Contractor Implications

Startups should consider qualifying themselves to do HVAC work in-house. Existing contractors should work to educate their current customer base on the advantages of performance tested comprehensive whole house work.

2.8. Using Inspection Fees to Screen for Serious Customers

The majority of contractors interviewed conduct detailed home performance testing as part of the inspection-estimate process. Most charge for this testing, typically to pre-qualify serious customers with specific problem-based motivations, such as health issues, high bills or uncomfortable rooms. The fees usually do not cover the actual cost of the inspection, and they are not considered a primary source of income, except for a couple of the smaller diagnostic-only contractors in areas without program subsidies. Some part—typically the larger part—of the actual inspection cost becomes part of the contractor's overhead, to be recouped in installation project prices. The typically high sales rates for home performance projects make this strategy possible and fair to all.

Survey results also showed that free inspections can still be effective in some situations. Several contractors operating in areas with home performance-related subsidies and/or whole house competitors offering free inspections provide free inspections, which are also linked to other extra efforts to screen or pre-qualify customers, such as prequalification for financing, and making certain that all decision makers would be at the home for the inspection.

Finally, a single contractor focused on new construction used neither the qualifying inspection fee nor the free inspection strategy but instead included the cost of testing in project bid pricing.

Overall, these results suggest that inspection fees are a critical part of the early home performance business model. The ability to get a high job-closing rate appears to be due at least in part to the customer screening that the inspection fee provides. The inspection fee screens for customers with enough interest, need, and ability to take action, who will pay the fee with the conviction that they will be able to make use of the information the testing will provide. The surveyed contractors charged from zero, as noted above, to $250 for their home inspections. Most contractors reported charging closer to $100, both inside and outside any local subsidy programs. Some of the contractors varied the fee based on demand. When jobs are booked at least ten weeks ahead (as an example), the fee is raised until the job backlog drops back below the threshold.

2.8.1. Optimizing Fees

Determining the optimal inspection fee is a considerable challenge for contractors. Too high an inspection fee may deter many good customers, reducing the contractor's access to income from those potential installations and possibly causing the contractor to become dependent on the income from the inspection fee itself. The surveyed contractors offering inspection-only services without installation or general contracting charge the full cost of their inspections—from $450 to $650—since they have no other source of income. This limits their markets. One inspection-only contractor includes post-installation inspection as part of the initial fee; others include supervision. Although these are excellent practices, they may force the inspector's price even higher. It is essential for contractors starting out in the home performance process to understand this relationship between inspection fee, number of customers and the closing rate on jobs so they can find the "sweet spot" at which their total income and profit (inspection income + installation income) are maximized.

One frequent complaint of the inspection/supervision approach is the amount of time required to educate or oversee the installation contractors on proper practices. A customer who insists on hiring an untrained contractor can significantly increase the cost of supervising the job. Directing the customer to educated installation contractors becomes an important part of the inspection process. This typically will lead the inspecting contractor into general contracting or even installation unless the inspecting contractor has other sources of income that are consulting-focused, such as teaching or building science forensics.

2.8.2. Program Implications of Inspection Fee Strategies

It is important to encourage contractors to underwrite part of the inspection cost. This will help drive contractors towards business models focused on generating income from the installations rather than the inspections. Treating part of the inspection's cost as an overhead item, coupled with adequate overhead cost recovery in pricing, results in the same total job price but a much more viable business.

2.8.3. Contractor Implications

Contractors should adjust the inspection fee to find the sweet spot where there are enough leads at a high enough closing rate that profits are optimized. The survey (as well as existing program experience) suggests that this level may be around $100 to $150. The contractor must also charge enough for the installations that that revenue more than covers the lost income from the "overhead" time spent inspecting and testing the building and supervising installations. If program subsidies are available for the inspections, strong efforts at customer prequalification before the inspection may replace using the inspection fee to pre-qualify potential customers.

2.9. Building Relationships During the Sales and Inspection Process

According to the contractors interviewed, customer relations and customer education are more important to the sales process than technical skills.

Techniques that rely on creating relationships and building trust, without the expense of performance testing or whole house inspections, have been taught in the heating and remodeling industries for some time. Those techniques can sometimes backfire due to the appearance of insincerity. However, the hands-on objectivity of the whole house testing process tends to support the development of trust as the customer can actually see the results of the testing. For example, the customer can be asked to accompany and help the inspector with small tasks, such as recording measurements or looking for air leaks during a blower door test. This not only demonstrates the inspector's competence and sincerity but also permits the customer to physically see and believe in the problems in the home, increasing their confidence in the process and the value of the proposed work. No direct sales effort is needed during the inspection process. The sales step is typically a separate later visit to provide results and cost estimates, although the customer is often already sold on the project because of the inspection experience.

Some contractors have adopted a one-stop closing process by verifying that all decision makers are at the inspection, sometimes by waiving the inspection fee. Other techniques include centralization of the sales presentation with an individual who travels between inspectors, visiting as many as six homes in a day. This sales system was supported by a serious and sustained marketing effort that also featured the availability of subsidized financing in its communications.

Of course, referrals from existing, satisfied customers help contractors establish a trust relationship with their new customers. In deed, the most successful contractors interviewed use this approach. Other reported valuable sources of referrals include well-informed friends, independent home inspectors, and program marketing by reputable allies such as a state agency or a utility.

Advertising in the Yellow Pages was not considered by the interviewed contractors to be an effective marketing tool. This is a direct corollary to the observations about the importance of customer referral and relationship building, since such advertising is essentially anonymous and impersonal.

2.9.1. Program Implications of Relationship Building Experience

Sales training that focuses on customer relationship building should be an important part of contractor training. The marketing training for contractors should focus on developing their ability to generate customers by a referral process. This may include educating third party professionals, such as home inspectors, code officials, and health departments. Related trades with frequent contact with prospective whole house customers, such as roofers or painters, can also become referral agents by being trained in the fundamentals of building science and the advantages of a performance tested whole house approach.

2.9.2. Contractor Implications

Contractors should seek out sales training that focuses on relationship building over the use of formula approaches to closing a sale. The process should be sure to include the customer in the testing. Contractors should develop their business process to maximize customer referrals and should develop relationships with key third parties by offering formal or informal building science education and possibly incentives.

2.10. Addressing the Price Objection With In-Home Financing

The primary customer resistance occurs when the expanded whole house proposal is being presented and the customer is faced with a price tag that is more than what s/he thought they would see or more than what s/he has readily on hand. Being able to offer financing right at the customer's kitchen table is a huge help to closing the sale, regardless of the interest rate of the financing. A number of the contractors in agency-subsidized programs pointed to their exclusive access to discounted or readily available financing as an important part of their ability to expand their business. Outside those subsidized programs, most of the interviewed contractors used HVAC manufacturer or supply house loan programs or accessed unsubsidized Fannie Mae loans through a local utility or other facilitator.

Answering the price objection with financing may not mean the customer actually uses the financing. It may simply address the customer's initial concern that they may not be able to afford the project. After customers have convinced themselves that they want the work done, they often find other sources of funds. The offered financing package may not often be used—but a low rate of use may not be a true indicator of its value as part of the presentation package.

The contractors interviewed consistently reported that the primary source of whole-house retrofit financing is contractor originated. This means that the contractor can provide the application and get rapid approval for the loan without losing sales momentum. In some areas contractors and local banks collaborate to allow contractors to originate loans, and the Fannie Mae process also works in this way. At least one successful contractor felt that the customer's ability to finance the project is so significant that he requires pre-qualification for financing prior to doing the home inspection.

2.10.1. Program Implications of Job Financing Options

Programs should facilitate easy access to financing. Due to the reported importance of financing, programs should consider even a mild subsidy on financing for participating contractors, if budget allows.

2.10.2. Contractor Implications

Contractors should seek out easy financing through suppliers and manufacturers, utility programs and local banks. Information on financing should be part of every whole-house sales presentation.

2.11. Managing Cash Flows with Commodity Bids

Seven of the contractors indicated that they still did some conventional jobs that were not up to home performance standards. In those conventional jobs they were generally still competing based largely on price. Three of these were large shell contractors who had been in business for some time. Another three were smaller newer contractors just entering the business. One was a remodeling contractor.

In these cases the HVAC and shell contractors are effectively still in transition. They may be small and without enough whole house customer leads to afford to say no to a customer who does not support the home performance business process, or they may be long term businesses with a large existing customer base such that they continue to get requests for price-based or limited workscope bids. The startups that experienced significant growth had no prior customer base but had enough financial strength and access to new customers to be able to focus more exclusively on home performance jobs.

Some of the trades contractors reported operating under a double standard, with one set of inspection and installation practices for customers within a funded program and another for customers for more conventional work outside the funded program, where the contractor feels more cost pressure. In these cases the installation workscope is also typically limited to a single improvement type such as windows, sidewall installation, or furnace installation. This may be unavoidable during the contractor’s transition to mostly home performance work.

Many of the contractors said that their transition to home performance was most hampered by the initial lack of demand for a higher quality product that was not cost competitive with other bidders. This refers mainly to the contractors’ initial transition to client referral-based marketing and to the inability of the contractors to differentiate their installation quality in their early days of adopting home performance practices. Customers may tend to rely on price when they don’t have information that they trust regarding other potential differentiating factors.

2.11.1. Program Implications of Mixed Business Models

Most contractors are unlikely to be able to move all of their work into the home performance model all at one time. In fact it may take some time for many contractors to transition entirely, if ever. A program requirement for all customers of the contractor to be given a home performance level of service may be unrealistic for both new and existing contractors to implement. During this transition period it becomes difficult to establish which customers should be subject to the program’s quality assurance standards. Tracking referrals from the program might be used to make sure that contractors are offering the level of service required for participation in the program to the customers provided to them by program marketing.

Contractors may also need support in developing a sales approach that helps them communicate the desirability and effectiveness of performance test-based comprehensive project scopes and their installations over conventional untested piecemeal installation practices. It would be useful for programs to develop information that shows the greater effectiveness achieved when installations are tested.

2.11.2. Contractor Implications

For maximum success, contractors should work toward a goal of generating enough referrals and other sources of home performance leads to allow them to refuse customers who do not want to pursue the home performance process. Doing home performance work and whole house jobs with significant impact on the customer’s living environment is the best way to get more customers who want the same benefits.

Contractors could look for documentation on how performance testing enhances the actual delivered performance of installations and use that information in their presentation process.

2.12. Getting the Most Out of Subcontracting

Nine of the sixteen contractors interviewed use subcontractors to install a significant portion of the improvements required. Subcontracting HVAC work was a significant strategy for most of the larger shell contractors. On the other hand, for HVAC specialists, subcontracting shell work was less common even though the shell work is typically the smaller part of a whole house workscope. One reason for this may be that shell subcontractors are often not certified or using performance testing techniques, which places an extra responsibility for performance testing on the prime contractor.

Since there appear to be benefits from offering all services in-house, it will be important to watch the development of these contractors over time, to see if there is a trend towards more work being done by the contractor's own crews. Since customer referral is a key factor in business success for home performance contractors, it could be important for job performance and referral that there are quality assurance and quality control processes in place for subcontracted work.

2.12.1. Program Implications of Subcontracting Experience

Programs should support contractors' efforts to subcontract work, but require that work to be performance tested.

2.12.2. Contractor Implications

Contractors can benefit by establishing relationships with quality subcontractors, either program participants or other reliable specialty contractors outside the program.

2.13. Pricing Strategies and Profitability

Higher closing rates have been promoted as a benefit of home performance, but the evidence from the interviews shows that contractors can succeed with a lower closing rate if they are careful to monitor their profit percentage on jobs. A majority of the contractors reported job-closing rates of over 50%—far better than in typical conventional jobs. However, some larger contractors are successful at generating enough work and profits with free inspections despite much lower closing rates. These contractors are apparently using higher gross profit margins to compensate for the overhead of doing more inspections that do not result in installations. This model appears to be less economically efficient than the higher-closing-rate model, resulting in the extra costs of many unproductive inspections needing to be borne by the other customers who do have the work done. Additional effort in customer prequalification also appears to be successful in addressing this issue and increasing the closing rates.

2.13.1. Program Implications of Job Pricing Options

Contractors need to be informed that the increased cost of sales, due to the contractor subsidizing the cost of inspections, can be returned from increased profits from installations. However, they should also understand the economic limitations of the low-price model.

2.13.2. Contractor Implications

Lower inspection prices may yield more inspections but not enough additional sales to offset the overall increase in the cost of sales. This will require a higher pricing structure to be adopted for installations. This makes the contractor vulnerable to competition from others with more optimal inspection pricing.

2.14. Promoting Services versus Product

The majority of the contractors interviewed did not specifically promote Energy Star branded products. This is likely because the home performance sales process is service focused, not product focused. The contractors go into buildings with the goal of determining the customers' most pressing needs. They therefore tend not to rely on selling specific brands or promoting product attributes unless those products contribute to the best solution for the key problems in a building. The contractors who successfully establish a trust relationship with their customers may not need the additional selling power of Energy Star products to help them sell jobs—and often the most important home improvements do not involve Energy Star products, in any case. As indicated elsewhere, the contractors were doing very little appliance-related work, so the Energy Star labeling was potentially useful mostly in the area of building products and equipment.

This finding applied both inside geographic territories with broad local Energy Star product promotions and in areas without any local Energy Star promotion. The emerging "Home Performance with Energy Star" programs, in contrast, seek to add the Energy Star branding's credibility to performance-based whole house approaches rather than to specific products. This implies that the Home Performance with Energy Star branding of the service may be an important way to link Energy Star to the home performance contractors' service-based sales approach.

2.14.1. Program Implications of Promotion Options

The Home Performance with Energy Star program should be used to increase consumer confidence. In addition, Energy Star *product* sales training should be adapted for use in the home performance sales process in order to increase the adoption of Energy Star equipment, materials, and appliances. This also suggests that home performance programs could be expanded to include assessment and encouragement of appliance upgrades not directly connected with HVAC or shell problems, such as refrigerators and laundry equipment.

2.14.2. Contractor Implications

Energy Star represents a supplemental way to demonstrate to the customer that the contractor is offering quality, if this approach can be coordinated with the overall home performance approach. Energy Star may also provide opportunities to further broaden the contractor's scope and value to the homeowner.

2.15. Home Performance Practices in Successful Use

The survey provided information on the technical practices most commonly used by successful home performance contractors.

2.15.1. Home Inspection Staffing and Closing

Contractors doing inspections reported that they typically spent three to four hours doing the inspection. Including travel plus analysis of the inspection data, pricing, and proposal development, contractors typically reported spending a full eight hours on the inspection and developing the proposal for a customer.

With the process taking this long, it is uncommon to find a one-stop close in this business outside of heavily funded programs with fairly fixed workscopes. In a one-stop close the contractor develops the workscope and prepares the estimate while on the job site. After three to four hours of going through a house, everyone needs a break. The contractor is unlikely to sit down and develop a proposal in front of the customer, although one very successful contractor does this using a two-person inspection and sales team. New contractors are more likely to have to take the work home and then make a separate visit to close the job.

In the case of the contractor using a one-stop close with a two-person team, the testing was separated from the sales and estimation process. This reduces the time required for the inspection and allows the most effective salesperson to do sell more jobs, without the burden of doing all the testing themselves. The salesperson was able to meet with the decision makers and often come to agreement on a contract after the inspection had commenced and initial findings were available for an estimate.

Some of the contractors interviewed incorporate the pre-retrofit diagnostics into the installation, rather than performing the inspection up front before developing their proposal. This can limit the amount of information a contractor is working with and can lead to unpleasant surprises for both contractor and customer during the job. However, it does make sense to limit testing of systems that are known to need a high level of work, such as poorly designed distribution systems that cannot perform even minimally enough for the testing methods to be useful. A good change order process is probably important for contractors attempting this approach.

Listening to the customer and addressing all their performance related needs may take more time but is reported to also lead to larger job sizes.

The average time taken by the interviewed contractors to get back the customer with a proposal is about five to seven working days, although this varied widely in the sample. No contractors reported this interval to be a problem in the sales process. The contractors going beyond this time period indicated that they were not happy with their own performance. Two contractors provided reports the same day. Neither provided customized reports; the response to the customer was described as more of an estimate, with information development such as building energy modeling occurring after the sale. One larger whole house contractor provided a customized report with modeling in two days.

2.15.2. Program Implications of Job Closing Alternatives

The one-stop close is enticing due to its potentially lower cost of sales. However, unless the improvements subsidized by the program are fairly tightly defined, resulting in consistent workscopes, it may be best to avoid promoting a one-stop closing process. Contractors may evolve to a one-stop close, but this model seems difficult for newly trained entrants.

2.15.3. Contractor Implications

After the home inspection and analysis, expect to make a second visit to the customer to close the job, at least while learning the home performance business.

2.16. Conducting a Wide Range of Diagnostic Tests

The use of blower doors, duct testing of some type, and combustion safety testing were the most common test procedures. Actual measurements of coil airflow were not common. Duct testing practices were regional due to variations in duct location relative to the outside. Carbon monoxide (CO) safety testing is a strong part of contractors' testing protocols. Ventless combustion appliances are considered dangerous, and most contractors interviewed are insuring that ranges and ovens have at least an operable exhaust vent in the area. The one contractor who works on new construction rarely tests for carbon monoxide. All other contractors routinely perform comprehensive CO testing. Combustion equipment is seldom tested for efficiency. Equipment replacement recommendations tend to be made based on equipment age and condition rather than tested efficiency.

There was a general trend among the contractors to avoid doing detailed testing-in (during a pre-retrofit inspection before the job is sold) that could instead be done during the installation process. A good example of this is duct testing. Testing-in with ducts was less common than testing out, apparently because of the common (and usually correct) assumption that most ducts are inadequately sealed or designed.

Responses indicated a typical level of diagnostic testing centered on combustion safety, including the following:

- Carbon monoxide in ambient indoor air
- Combustion appliance zone (CAZ) pressure testing
- Combustion appliance vent pressure testing

The contractors interviewed generally agree that these are the key areas in which they must be sure that problems do not exist before starting work. This concern is due to a combination of program requirements, concern for liability, and peace of mind. Some contractors also worked in housing where the CAZ was not directly associated with the living area. One contractor stated that the CO and vent pressure tests were not routine because potential problems in the CAZ did not translate to problems in the home. The contractors seemed more likely to reduce up front duct testing than to reduce upfront health and safety testing.

In a similar example, thermostats were more often recommended for replacement with electronic devices without checking the anticipators for proper setting.

2.16.1. Indoor Air Quality (IAQ) and Health & Safety

Aside from the CO and pressure issues mentioned above, IAQ diagnostics are usually limited to a moisture inspection, without analytical investigation. Molds are not identified, since most contractors agreed that any mold in the building needs to be addressed whether or not it is inherently a health risk. In this view, whether rightly or wrongly, naming the mold species only adds an additional and unnecessary cost. Most of the contractors stated that they corrected moisture problems, not mold problems, and that they did not specifically contract to mitigate/clean existing mold from buildings.

There were only a couple of contractors who have performed any radon testing and they did so only if the customer initiated the request. No contractor was testing for volatile organic compounds (VOCs). Additionally, only contractors working on low income Title X housing are providing lead-safe work practices and lead testing is not performed by any contractor interviewed.

Installation of carbon monoxide detectors did not seem to be a standard operating procedure. Very few contractors interviewed reported installing CO detectors and no one indicated that fire egress was evaluated or discussed with customers.

2.16.2. Building Shell

Only two contactor performed infrared (IR) imagery, and both used it only on a limited basis. The equipment costs constrains some contractors, but it seemed that the contractors are not aware of how valuable a tool for shell analysis IR imagery can be, or have not considered the added value of thermal imagery in a customer report or analysis when subcontractors are being directed in insulation and air sealing. Programs should seek ways to encourage IR as a sales tool as well as an important diagnostic technique. This could include purchase subsidies or tool sharing arrangements. IR is also an inspection procedure that is commonly recognized and asked for by customers.

2.16.3. Air Distribution

Duct leakage was usually measured when ducts were placed outside the "pressure boundary" of the building. Contractors considered the leakage inconsequential when ducts were located inside the pressure boundary, that is, a basement or second-floor joist system. Only two contractors responded that they always do duct testing; most of them said they "usually" do duct testing, typically at the end of the installation, when the installers are still there to remedy defects.

2.16.4. Pressure Balancing

During the phone interviews, contractors were asked about the frequency with which they perform pressure-balancing tests of the conditioned zones of the building. Three contactors responded that they do not provide balance tests as part of the Home Performance inspection, while eight contractors routinely provide such testing. In addition, four contractors interviewed occasionally provide such testing, but mostly in cases involving specific complaints or distribution system modifications.

Of those contractors who routinely provide pressure-balancing testing, the larger HVAC companies stated that they did not provide the testing at the time of the general building inspection and diagnostics, but did provide the testing at the completion of all installation work. They stated that pressure-balancing problems usually exist in buildings, and that to test "up front" is an unproductive exercise because the work that is proposed on areas of distribution repair, shell modifications, ventilation, etc., will change the building dynamics and not necessarily for the benefit of balanced pressures. However, at the completion of all scheduled work, a technician can accurately evaluate and correct the levels of imbalance that exist. Their conclusion was that no matter what the findings of the initial building inspection, pressure balancing would ultimately need to be performed before the job was complete.

2.16.5. Program Implications of Diagnostic Scope Options

Careful attention should be given to specifying minimum standard home inspection scope and protocols, in order to assure consistent program quality and customer satisfaction. Scope and procedures may differ among home performance programs, based on program goals, but the standards should be intentional rather than accidental and variations among contractors within a program should be closely monitored to assure that the program is achieving its intended effects.

2.16.6. Contractor Implications

Home performance contractors must be prepared to meet program standards. Occupant safety is a crucial aspect of any home performance work and must be done properly. Inspection standards should be consistent for every house, and contractors should expect to continue expanding their skills and services with experience in order to provide true whole house retrofits.

2.17. Developing Building Performance Models

All the contractors interviewed develop some sort of building model for a variety of purposes, such as heating and cooling plant sizing, distribution system sizing, estimating savings, providing investment and payback information to customers, etc.

A number of the contractors expressed concerns about the accuracy of models but at the same time very few of the contractors were validating models against fuel bills or collecting post-retrofit billing data for analysis. The difficulty of accessing actual fuel bills and taking into account customer behavior were cited as reasons for not tracking post retrofit performance. Contractors did trust the software to help customers make investment decisions and to compare the relative savings potential of various improvements.

Air Conditioning Contractors of America (ACCA) Manual J-type sizing procedures for HVAC installations were used by contractors not relying on Manual J for modeling, but only when equipment replacement was required. Manual D was used only infrequently for distribution sizing.

There was a stated tendency for some contractors to delay the development of energy performance modeling and sizing of equipment and distribution until after the job is sold. This tendency might be correlated to the closing rates in the businesses, with lower closing rates creating an increased tendency to delay investment in the development of the job until after the sale.

2.17.1. Program Implications

Programs funded as part of energy efficiency initiatives may have an interest in focusing contractor and customer attention on cost effective energy efficiency improvements and may see building modeling as a way to provide accurate information to both the contractor and the customer on where to make investments. Developing a building model is a major time commitment for the contractor but seems to be considered core part of home performance and whole house contracting, even by private contractors outside of programs. Improving contractors' access to pre and post retrofit fuel usage data may assist the contractors in developing more accurate building models and improve both the desire and the accuracy of projecting savings. Providing feedback to contractors on their estimated energy savings may also act as an incentive to model.

The time required to develop a model and project savings for an individual building clearly interferes with the implementation of a one-stop close. One of the contractors doing a one-stop close continued forward with modeling and savings projection after the sale. Information on the evaluated success in meeting projected savings in other similar houses was provided at the time of sale to help build credibility for savings claims in the absence of the results of modeling.

2.17.2. Contractor Implications

Contractors should consider using information from the modeling process to assist in sales and to help increase credibility with the customer. Validating the model against actual energy bills may be necessary to maintain customers' belief in the savings projections.

2.18. Activities Falling Outside the Scope of Home Performance

The survey revealed that environmental hazard mitigation and electric baseload[4] reduction typically did not fall within home performance and whole house contractors' typical workscopes.

2.18.1. Environmental Hazard Mitigation

Only one of the contractors promoted IAQ mitigation specialty services, in this case radon, even though health was listed as a major concern of their customers. One reason for this might be the mitigation industry's separation of testing from mitigation. Testing specialists in this area typically do not have the specialized building science knowledge of the home performance contractors, resulting in workscopes that contractors may not be comfortable with. Another reason could be the high cost of liability insurance for contractors specially trained in IAQ

[4] Baseload here refers to home energy uses that are relatively constant year-round rather than seasonal. Baseload uses exclude space heating and cooling but include water heating, appliances, lighting, miscellaneous small appliances and other plug loads, and specialty items such as pool pumps.

hazard assessment and mitigation. The additional overhead cost of that insurance can easily impair the home performance contractor's ability to compete against other contractors for non-mitigation jobs.

Home performance work may be done that reduces the growth of mold and minor mold growths may be cleaned up, but none of the contractors reported willingness to do mold mitigation under the supervision of testing specialists.

Similarly, few of the contractors had a specific program in place for addressing lead contamination.

2.18.2. Program Implications

Programs should consider whether the boundaries of their program should include emerging health and safety practices that may not yet be commonly used by residential contractors. Whether or not such practices are to be included in a program's definition of home performance contracting, the full range of health and safety concerns likely to be encountered must be clearly and consistently treated in training, marketing, and quality control in order to provide boundaries for both contractors and clients.

2.18.3. Contractor Implications

A business focus on health and safety, as well as energy efficiency, should include developing a clear understanding of how construction may affect the occupants of the buildings. Contractors should also consider expanding their range of expertise to include health and safety topics even if beyond the scope of the local home performance program.

2.19. Electric Baseload Reduction

Unfortunately, high electricity baseload use is not believed to be of customer concern by most of the contractors interviewed. Little home testing is done beyond that required by utility or weatherization programs. Contractors did not seem to be concerned or interested in saving baseload dollars, even though electricity costs are generally higher and paybacks quicker. This may be due in part to lack of easy access to utility bills and the resulting low use of billing analysis as part of the diagnostic process. Increased post-retrofit access to utility bills may also increase contractor and customer interest in reliable sources of savings such as baseload measures.

Only one contractor routinely separated out baseload as part of the diagnostic process. The new construction contractor approves all types and placements of recessed lighting fixtures, but this may be primarily driven by concerns for air conditioning load and envelope leakage instead of baseload energy use.

2.19.1. Program Implications

Contractor education and involvement of the contractor in post retrofit energy use scorekeeping are two program design options that may help focus contractors' attention on baseload. This is an area that needs additional study.

2.19.2. Contractor Implications

If a contractor's business model is going to include saving energy, baseload savings seem an easy way to get fairly secure savings at a low cost.

2.20. Training and Education

The survey findings included information on how contractors find home performance information for themselves and for their employees as well as how they educate their customers.

2.20.1. Improving Public Education

Publicly funded customer education efforts in various regions of the country generally did not receive high marks for effectiveness. Energy efficiency educational efforts were referred to by some contractors as "trite," and as "repeating inaccurate information." The comments came from a mix of contractors, some in areas with home performance programs and some in areas without specific home performance programs. Some of the contractors felt that marketing experts for home performance programs might want to consult some of the participating contractors and gain a better understanding of the home performance process before launching or re-launching their ad campaigns.

Contractors are in close contact with the customer and must develop a trust relationship with the customer in order to make a sale and therefore actually save energy by installing improvements. The concern voiced by the contractors may come in part from encountering consumer focused educational efforts that interfere with the contractors attempts to differentiate themselves from other contractors that do not performance test their work or offer comprehensive workscopes.

As indicated elsewhere above, customer education was considered a key part of the sales process. The reliance on the referral process for customers seems to indicate that the contractors' customers are more readily educated by their peers.

2.20.2. Program Implications

This is clearly an area needing further study. There may be information available to home performance programs that will indicate the effectiveness of their advertising. Other programs may benefit from contractor feedback. The responses from areas without home performance programs may indicate frustration with conventional consumer education that does not promote home performance.

2.20.3. Contractor Implications

Contractors should consider providing more formal feedback to local or regional marketing efforts, so that the marketing efforts have information on the impact of their education on the contractors attempt to sell performance tested work and comprehensive workscopes.

2.21. Enhancing On-the-Job Training

Training is considered an important investment of time and money. The larger contractors interviewed all had some type of formal on-the-job training system for employees. Most of the contractors were seeking additional training for their staff. The contractors have trouble finding qualified staff. Formal and informal apprenticeship programs, connecting more experienced staff with newcomers, are frequently used to encourage technical staff to learn more and earn more.

Some of the contractors using certification programs had integrated the certifications into their pay scales, providing explicit career direction to their employees and financial incentives for professional development.

Conferences and periodicals were listed by a number of contractors but were considered as sources of basic information and not regarded as sources of the detailed or hands-on information needed to implement new business and technical practices. These sources of information instead served as maps of the home performance territory. Contractors also accessed supplier and manufacturer trainings as a primary source of technical information.

2.21.1. Program Implications

Enhancing on-the-job training capabilities of smaller contractors and providing additional on-the-job training resources to larger contractors may be a way to engage the contractors in additional cost effective training.

2.21.2. Contractor Implications

Contractors could consider investing in outside training for certain core staff and using those staff to support the training activities of other staff.

3.0 California Contractor Attitudes Toward Home Performance Contracting[5]

3.1. Overview

This chapter presents the results of our analysis of practical limitations, barriers, or impediments to adoption of building performance (BP)/whole house retrofit business models by California contractors. The data were obtained from interviews with contractors in the San Jose and Fresno metropolitan areas who have been involved with the California Building Performance Contractors' Association's programs. These programs are designed to train and support a new generation of residential contractors in order to gain energy efficiency and non-energy benefits (such as comfort, safety, health) for California's homeowners through the contractors' provision of state-of-the art testing and building science-based retrofit services.

In this chapter we first present the CBPCA program goals and define some key elements of the CBPCA approach. We then describe our sampling, data collection and analytic methodologies. We report our findings, organized in terms of three important clusters of factors that influence the innovation process: (1) contractor attitudes and values ("interests" or "concerns"), (2) organizational and technical attributes of contractor firms ("capacities"), and (3) forces in the market environment ("conditions"). We conclude by considering some of the ways that these three sets of factors work together to both facilitate and impede organizational innovation.

3.2. Project Director Perspective

This survey was undertaken by subcontractor Lutzenhiser & Associates based on their work in independent evaluation of the California Home Performance Program pilot implementation. That program, under the direction of the California Building Performance Contractors Association with funding from California ratepayers under the auspices of the California Public Utilities Commission, took place during the fall of 2002 through March of 2004. It sought to attract, train, and monitor contractors in the Fresno (Central Valley) and San Jose (South San Francisco Bay) metro areas to do whole-house diagnostics and complete remediation of deficiencies in energy efficiency, combustion safety, moisture control, air quality and related health and comfort issues. This CPUC program has been re-funded for 2004–2005. This report is based on the subcontractor's survey of a sample of the contractors solicited for that program.

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5 Except as otherwise noted, this chapter was researched and written by subcontractor Lutzanhiser & Associates, who were also the formal independent evaluators of the CBPCA home performance contractor training program for PG&E and CPUC in 2002-05.

In order to understand what exactly it is that contractors are hoped to do, it is important to provide some background information about CBPCA program goals and to define some key terms used in this report.

3.3. CBPCA Program Goals

The goal of the California Builders Performance Contractors' Association is to develop and support "Building Performance Contracting" through the training of HVAC, insulation, weatherization, and general remodeling contractors. Contractors interested in conducting whole-house diagnoses are provided seven days of classroom and field training that cover the following elements:

- Building performance contracting business and marketing practices
- In-depth technical training in building science, testing, diagnoses, and retrofit selection
- Assistance in purchasing diagnostic tools
- In-field mentoring
- Higher-level technical training, if needed

The building performance diagnosis services provided by trained contractors to homeowners include both home performance testing and remediation. In this process, the building performance contractor first identifies, through sophisticated testing procedures, what the home needs for better energy efficiency, economy, air quality, structural soundness, long-term value, and the health, safety, and comfort of its occupants. Then the contractor presents a package of remediation services—building science-based retrofits and remodeling work—based on the diagnosis. In this way, the needs of the whole house can be addressed in a single transaction.

3.4. Definitions

Building performance contractors are contractors using performance testing as part of their business, but not necessarily doing comprehensive work scopes that include both shell and HVAC improvements.

Whole house contracting refers specifically to a focus on realizing comprehensive solutions for performance problems with a combination of HVAC and shell (such as insulation) work. "Whole house contractors do home performance work, but home performance contractors may not be doing whole house work" (Bevilacqua-Knight (a), p. 4).

Contractors interested in home performance testing may become "a Home/Building Performance contractor" by incorporating testing procedures into their current business model. A single-focus business (such as shell, insulation, or HVAC) that includes home performance testing may transition to Whole House contracting by offering a comprehensive range of work, either using its own employees or through the use of subcontractors. And a full service contractor (such as, one that currently does both HVAC and shell work) would be considered a Whole House contractor if they incorporated performance testing into their current business practice.

Barriers, limitations, and *impediments* are used interchangeably in this project to denote factors in the normal everyday business worlds of contractors that may prevent them from considering building performance in their work, that may keep them from participating in CBPCA program training, and/or that may inhibit their adoption of whole house contracting in their businesses. As noted in the introduction, these factors may reside in the attitudes, values and perceptions of the contractors themselves, in the organizational realities of their businesses, and/or in the economic, regulatory and market environments within which they do business.

3.5. Contractor Survey Methodology

3.5.1. Interviewee Selection

The CBPCA supplied Lutzenhiser Associates with a sample of 29 contractors that were appropriate to interview either because of 1) their non-participation in training and/or orientation/marketing sessions, or 2) because they did not actively pursue building performance testing after having been trained. All of the cases in the sample were called several times, and a total of 18 (62%) were contacted and interviewed.

For the purpose of this analysis, those contractors who were solicited by CBPCA but did not attend training, orientation or marketing sessions will be referred to as *non-participants (NP).* Those who attended a session but are not actively pursuing building performance testing (using the CBPCA model) will be referred to as *partial participants (PP)*. Where non-participants and partial participants are considered together, they will be referred to as *non-active*. Interviews from full-participants were also drawn upon in the analysis and listings of barriers presented below. The *absence* in non-active cases of certain characteristics found among successful adopters are also used, then, to identify barriers or limitations to both participating and the subsequent development of successful BP and WH businesses.

The twenty nine-contractor NP/PP sample included thirteen HVAC contractors (nine interviewed: two interested NPs, six PPs and one uninterested NP), four construction companies (one NP contacted who was still deciding about future participation), three remodelers (all interviewed: one NP, two PPs), two window/door contractors (one NP interview), three raters/analysts (one NP, two PPs), one consultant (an NP interview), and three others who attended orientation sessions, but with whom we were unable to make contact.

The NP/PP sample was divided into five groups based on CBPCA solicitation efforts, level of contact, and participation in orientation, training, and/or marketing sessions. These included:

- Five contractors that were solicited by phone or mail who did not respond/reply.
- Of these, none were interviewed, though call attempts were made to all five.
- Eight contractors that were contacted several times by the CBPCA for the October or January 2004 training, but did not attend. Seven were interviewed.
- Eight contractors that attended a marketing orientation session but did not continue by taking the 6-day training. Five were interviewed.
- Five contractors that attended a 6-day training session, but did not develop a BP business model. Three were interviewed.

- Three contractors that attended a 6-day training session, started to develop a BP business model, but didn't follow through. All three were interviewed.

3.5.2. Interview Questions

About half of the interviews with non-active contractors took place in the fall of 2003. At that time, a lengthy interview was administered regarding various aspects of the CBPCA program. Information specific to participation barriers were extracted from those interviews for this report. The other half of the non-active sample was interviewed in January 2004. These cases were administered a smaller set of eight questions, which were designed to collect information regarding reasons for non-participation specifically for this analysis. In addition, questions related to business characteristics were answered by those interviewed at both time periods.

3.5.3. Data Collection

Interview guides were developed in consultation with CBPCA program staff and were used to conduct telephone interviews with members of the contractor sample. Where it was agreeable to the interviewees, tape recordings of the interviews were made to capture their answers in their own words. If taping was not agreed to, the interviewer took detailed notes. All verbatim interviews and notes were transcribed and coded. In the subsequent analysis, significant themes were identified, barriers noted, firm characteristics recorded, and similarities and differences across all dimensions examined. Different levels of participation were compared, and contractors' experiences and explanations were analyzed for underlying patterns and structure.

3.5.4. Analytic Model

The results were organized in an analytic model that has proven useful in other contexts to help understand differences among firms in the adoption of energy efficiency innovations (such as Janda et al. 2002). The model focuses on three sets of interrelated factors—specifically, the "concerns," "capacities" and "conditions" of focal actors and firms. All three sets of factors, singly and in combination, exert strong influences on the ability of firms to innovate in areas related to energy efficiency and conservation.

"Concerns" or in this case types of "interest" in the program, point to the reasons why persons (such as contractors) get involved and are able to persist in their efforts to pursue building performance/whole house contracting (BP/WH) business models. The issues at this level are related to motivation and commitment, and they are rooted in individuals' attitudes, values and beliefs. In the case of CBPCA's BP/WH innovations, concerns are important in determining both initial interest and follow-through with the program. They are factors most closely related to *key personnel* in the businesses involved.

"Capacities" are factors *located within groups*—in this case, the businesses or firms, rather than individuals. In this category, we find influences and variables related to firm organization, competencies, assets, dependencies, and so on.

"Conditions" are factors that reside largely *outside of the organization*, in the environment within which the business has to operate. These are forces that are also largely outside of the firm's control, but that set limits, present opportunities, and offer threats to the health and success of the organization.

3.6. Principal Findings of the Survey

What exactly are the "innovations" desired by the CBPCA that are the focus of this analysis? The CBPCA is offering training in basically two innovative business models: performance testing, and performance testing coupled with whole house contracting. Both are a significant departure from "business as usual" in the contracting areas that the CBPCA is recruiting from. For example, both require contractors to adopt a building science-based perspective. Testing and reporting are at the core of both models. Testing involves the purchase and use of technically sophisticated devices (such as duct blasters, blower doors, and, if possible, infrared cameras). Careful reporting (to the customer and to CBPCA) is required and that, in turn, requires hardware, software, and computer competencies, since test results must be input and uploaded. Reports to customers must include detailed estimates of projected energy savings and retrofit costs. Recommended retrofits must be packaged to offer the customer options that meet multiple goals, including a healthier home, saving energy, reducing costs, increasing the home's value, contributing to a cleaner environment and improving over-all livability.

Our findings indicate that a combination of factors, including types of concern, organizational capacities, and market conditions influence 1) contractors' willingness to pursue these models, as well as, 2) their abilities to persist, once the models have been adopted.

3.7. Concern/Interest

As noted, the Concern dimension involves the motivations, attitudes and values of key personnel in the business. These are not simply matters of personal preference or personality. They also seem to be influenced by contractor backgrounds and experience—such as experience with energy, efficiency, programs, testing equipment, building science approaches, and related matters. On the basis of our interviews, we have identified five interest orientations related to the adoption of BP/WH contracting business models. These include the: Disinterested, Passive Interest, Shot-in-the-arm Interest, Cutting-Edge Interest, and Experienced Energy/Performance Interest. Of these, only the latter two are likely to lead to a sustained pursuit of BP/WH contracting. This is an important finding, because the maintenance of interest or concern is necessary in overcoming both limited capacities and adverse conditions (although a favorable combination of these sets of factors also seems to be important in BP/WH model adoption).

3.7.1. The Disinterested

This is a logical type that seems to be quite large, based upon the CBPCA's aggressive efforts to solicit participation in BP/WH training from various contractor lists, with limited response. We attempted to contact contractors in this category (that is, were recruited by CBPCA, but expressed no interest in return). None of them were willing to talk to us.

3.7.2. Passive Interest

Two non-participants and one partial-participant that attended an orientation session (but not the training) were categorized as passively interested in the BP business. These market actors attended training sessions primarily to stay informed of current developments in the industry. Their specific reasons included: "environmental scanning" to see what was on the horizon, checking out potential new competition, or to gain information that they could use for their own purposes. Two excerpts help to describe this category:

> *"I attended the orientation because I was interested in learning about it, um, in the interest of my clients [contractors], so that I could tell them about it. Because … it's hard to get working contractors to go to a seminar during the day during the week." (Consultant)*

> *"I'm interested in knowing what you guys [CBPCA] are up to. … You know, someone sent us something … we were like 'Okay, what's this about?'" (Title 24 specialist)*

3.7.3. The Business "Shot in the Arm" Interest

A number of market actors may attend training in an attempt to improve the success of their business. Among those interviewed, four reported this sort of interest in the CBPCA program (one currently with non-participant status and three partial-participants that attended Orientation sessions in spring 2003). This type of interest is not limited to owners of businesses that are struggling, but include owner/managers that are looking for a more successful/profitable model. This type of interest tends to be accompanied by a focus on finding a business model that can guarantee rather immediate success (profit/return on investment). These businesses may also tend to have one or more capacity barriers (see below) that limit participation.

> *"… [I'd like to] know how the contractors do. If there starts to be some activity and it looks like it's going to move, then I may reconsider training some people and what have you." (Mechanical/General Contractor)*

> *The reason I was interested in it (CBPCA BP/WH training) was that it goes right along with my business." (Window/Door Contractor)*

> *"…I was doing a lot of work with the Housing Authority ... and I thought this might be the next step in it and seeing if we couldn't build our business around that aspect of construction, rather than getting into the building and remodeling itself." (General Contractor)*

3.7.4. Cutting-Edge Interest

Market actors that have a cutting-edge interest consider themselves to be leaders in the industry. These businesses have key personnel that are 1) interested in the future, 2) are able to anticipate changes (technological, economic, industry trends) that may contribute to (or threaten) their long range success, and 3) are willing to invest time and money in professional development and staff training to incorporate these "new, best-business" practices before competitors.

Four contractors (one non-participant and three partial-participants) reported this sort of interest. It was serious enough to motivate all three of the partial-participants to attend both an orientation and a 6-day training session. These actors seem to have the potential to be early adopters of new technologies—and this was the case among those interviewed. One HVAC contractor has incorporated duct testing (before and after each job) into his business model, one is using training information to improve his own business practices, and one uses the whole house perspective as a sales tool (and informs his clients of the service offered by CBPCA-trained HVAC contractors). Yet none of these three contractors went beyond partial adaptation of the BP/WH business model.

Reasons given varied from: 1) having no interest in changing a business model now focused on new construction, to 2) a remodeling contractor that embraces the WH concept but is satisfied to rely on CBPCA-trained HVAC contractors to test and fix any problems, to 3) an HVAC contractor (happy with training) who was unwilling to purchase the testing equipment and software prior to doing field testing.

Rationales for participating in CBPCA training that were given by contractors with cutting-edge interests in BP/WH included:

> *"Because I believe in cutting technologies and new product lines. I like to stay ahead of old stuff." (HVAC contractor)*
>
> *"…knowledge and keep abreast of what's going on." "[for him, the training was] …more of perfecting what I already knew and put it to practical use." (Duct Tester/Rater)*
>
> *"I'm … interested in newer building techniques and processes and ways to make the industry more efficient and more professional. … I'm not applying a lot of what I've learned. …I now have a different perspective on how to look at system and how to talk to my clients about getting an evaluation of a system if they want to do a whole house remodel, for example. Evaluating a whole house is now a much more critical sales tool for me." (Remodeler)*

3.7.5. Experienced Energy/Performance Interest

All of the currently active contractors who are successfully implementing the BP/WH business model, fall into either this category or the previous one. These are contractors with energy efficiency industry experience, previous training, a current business that has at least a partial energy efficiency (such as weatherization) focus, a belief in the importance of diagnostics, and/or a conviction that a whole house retrofit approach is the right thing to do in serving customers. Some of these characteristics and attitudes were also present in non-active participants.

For example, not every contractor with experience in the energy-related industry (such as former CHEERS raters, HVAC contractors with Pacific Gas and Electric Company [PG&E] training) expressed a primary interest in leaning more about diagnostics. However, for four HVAC contractors this was their primary interest. Two non-participant firms (that CBPCA will continue to solicit for training) reported either looking into fully incorporating a "more workable" [modified] BP model into their current business, or, believing that the WH approach is "the right thing to do," said that "the sooner we get more contractors trained the better off we're going to be." (HVAC contractor)

The two partial-participants in this category both attended training (one also attended an orientation session), and both were committed to adopting a BP model after training in the spring of 2003.

> *"We've been doing this sort of stuff already. … And this just basically closed the loop for us as far as looking at the whole house."*

However, neither business has been able to fully follow-through on their plans to date. In the case of one company, a lack of time to commit to something "totally new" was a barrier. They also needed to buy one additional piece of equipment, and their key staff member in the area (currently responsible for estimating and designing, testing and customer relations) expressed a need for further software (TREAT) training.

> *"Some of it was way over my head some of it I understood." … "it's a lot of information to be able to take and assimilate into a sales presentation or diagnostic type approach".*

From a still interested but NP HVAC contractor that didn't have time to attend:

> *"Well I think it's the right thing to do. I think it's important that we install the equipment the way it's designed to get the most efficiency out of it."*

From a still interested but NP Residential Remodeler who hasn't had time yet to attend training:

> *"I'm interested in green building and a component of that is indoor air quality. So the diagnostic program is something that I'm interested in."*

An HVAC contractor in this category had attended training in order to:

> *"… give our customers additional avenues for energy efficiency. We've been promoting energy efficiency for many years and this is something else to be able to say something that's different. … any time you can get yourself exposed to something new that not only are you bettering yourself, but you're also able to solve customer's concerns and problems and better understand the scope of the work that you're doing. And be able to do a better job."*

Again, the contractors in the final two concern/interest categories bring with them a desire for new knowledge and a commitment to improved practice. These interests may not be enough to move them fully into the BP/WH business. However, interests of this type and intensity may be necessary ingredients.

3.8. Contractor Capacities

"Capacities" are organizational attributes of the business that support or limit innovation. On one hand, capacities play an important role in determining the ability and willingness of key personnel to adopt new business practices. However, limitations in organizational capacities significantly inhibit innovation. Some of these limitations are obvious to market actors and were readily reported to us. Others are less obvious, although they can be inferred from the examples that market actors give.

A variety of capacity issues and limitations are identified in the discussion that follows, including limitations imposed by firm type and size, degree of specialization, culture, technology, marketing, and management capacities. While the list is not exhaustive, it does reflect a surprisingly wide range of capacity issues experienced by the contractors interviewed. We also note that, while a detailed analysis of capacity *patterns* was not conducted, factors such as limits in skill sets, management assets, and so forth also often seem to be go together in practice.

3.8.1. Business Type

There is a wide range of business types in the residential construction industry, including: general contractors, remodelers, HVAC, consultants, and specialty contractors (windows/doors, roofing, siding, insulation, plumbing, electrical), as well as companies that offer combinations of these services. It may be the case that some of these types are more likely to adapt to changes in the industry by adopting new business practices, new technologies, new product lines, and/or new ideas. However, there is too little direct evidence from active participant interviews to suggest, at this point in the program, that knowledge of business type allows an accurate prediction of which companies will be willing to adopt a BP/WH model.

For the current analysis, we made a business type comparison of three subgroups:

1) businesses that did not participate in training sessions (after attending orientation)

2) businesses that attended training

3) the currently actively participating companies.

That comparison suggests no discernable difference by business type, per se, across categories of participation—with raters, HVAC contractors, and remodelers found in each group.

Its is clear from the entire sample of non-active and active companies that those who are either currently offering HVAC services, or those with some background with mechanical systems and energy programs, are most attracted by the CBPCA training. This finding agrees with the CBPCA (cited above) national survey of successful BP/WH contractors that found that "…there is certain degree of self-selection occurring in this process." However, early adopters of the BP/WH concept in California also seem to differ from those identified in the CBPCA national study, which reported that successful early adopters often, "… started as shell contractors." In California, HVAC, multi-service, and remodeling contractors have been the first to make the transition to BP/WH contracting.

3.8.2. Size of the Firm

The size of the contractor's organization—particularly small size—can offer significant barriers to CBPCA training participation, and to BP/WH model adoption among those who have been trained. Small size translates into limits on manpower available to allocate to BP/WH services vs. other tasks. Size is also certainly related to issues of workflow and capitalization (discussed below), although it is probably not perfectly correlated with those factors.

The contractors (non-participants, partial-participants and active BP contractor) range in size from the single-owner/operator up to a company with 55 employees. Size does seem to be strongly related to *level of participation*—with single owner/operator businesses the least likely to attend a training session. Companies that attended a training class but were subsequently non-adopters (with the exception of one rater) had a significant staff base—ranging from 4 to 28 employees. Companies ultimately adopting a BP/WH model, with the exception of one small general contractor/remodeler, are businesses ranging in size from 8 to 55. If this tendency holds true with contractors taking the latest series of training classes, firm size may become a viable screening tool for the CBPCA.

One small contractor captured the size issue nicely when he said:

> *"I'd have to hire more employees to give me more time. It just comes with growth [hiring] and I'm not going through that right now." (HVAC contractor)*

3.8.3. Degree of Specialization

Related to business type and size is the degree of specialization of both the services offered in the market place, as well as in the differentiation of roles within the organization. Both types of specialization can influence acceptance and adoption of BP and WH contracting.

As noted, BP/WH requires the use of specialized equipment. But this may also be novel equipment for that firm (or, at least, for some of the employees in the firm), depending on its specializations. BP/WH also requires attention to details that have long been claimed by other specialties (particularly HVAC) the building trades. So, both particular specialization (such as in windows, roofing, kitchen/bath remodeling) and lack of a specialization (such as insulation, HVAC) can limit the ability of the contractor to seriously consider BP/WH as a business model.

BP/WH contracting also requires that owner of the firm and his/her employees think of the house as an integrated whole. Therefore, *which persons in the firm* are selected to attend training may be critical to determining whether the firm chooses to adopt BP or WH practices or not. If that person is too much of a specialist, the big picture issues may elude him/her.

The ability of market actors to successfully manage (or think about managing) a larger business, or a more diverse business, has some connection to the variety of skill-sets the owner and the employees possess. The currently active CBPCA BP/WH firms have the combinations of specialized skills necessary to conduct diagnostic testing, operate computer modeling software, schedule jobs of greater complexity, market novel services, provide customer education, and meet reporting requirements (items discussed in more detail below).

Lack of experience and related training is also an aspect of specialization. In some cases, this means limited technical savvy (limited skill-sets)—especially skills related to HVAC in firms specializing in non-HVAC trade areas. Specialization also may bring with it difficulties in learning the fairly wide range of the necessary techniques involved in home performance assessment and retrofitting. However, long-standing technical capacity, and even HVAC specialization, do not guarantee either the ability to grasp the importance of (let alone the nuances of) BP practices, or the willingness to incorporate these practices in the business.

For example, when asked whether the training made him comfortable with the operation of BP diagnostic software, one contractor said:

> *"No. You know, we were just getting revved up for our preventative maintenance and I went through that kind of quickly. Some of that was way over my head, some of it I understood. But I guess it's just something that the more you use it the more you understood how it works, you would be more and more familiar with it and be able to implement it in a program. It's a lot of information to be able to take and assimilate into a sales presentation or diagnostic type approach. So that's kind of where we were at, it's a lot to take in at one short period of time, so we just kind of "Let's get through the summer so we can really have some time to be able to dedicate the time to do this." (HVAC contractor)*

On the level of *specialization of the firm itself,* we also find that moving completely into whole house contracting and pushing beyond the conventional boundaries of specializations may run afoul of consumer expectations.

> *"I would love to be able to implement that (performance testing) on every call. Obviously some calls you're not going to be able to take that approach. You know, you get rental properties; they don't care. A person moving out of a house will say "Hey I just need a unit" I mean, so you got to kind of tailor it to the needs of your customers. It's something that I like to talk about and let them know that there is a different way and say "Hey we can do it many different ways, what would you like us to do?" (HVAC contractor)*

Also, businesses that seem to have a limited ability or inclination to broaden their scope into the other specialties needed, may simply be small (but viable) market actors that service a customer base with limited capital. CBPCA training may be useful to inform and potentially improve their business practice, but won't move them into new business specialties.

> ***"***
We're basically a residential retrofit company. We do furnace change-outs and add on air conditioning. … Well, (the training) originally sounded interesting until I got in there and found out … they were talking about $30-40,000 jobs which is not what we do. … the market that we handle, they're not going to put out that kind of money to do those types of measures that were being talked about." (HVAC contractor)

3.8.4. Culture or Nature of Current Practice

An area that is closely related to specialization has to do with the ways in which the trades have negotiated their division of labor across the construction industry. When we talk about "culture" and "current practice," we're speaking of the taken-for-granted ways of doing the work in the trades that include: the sequential ordering of tasks, the separation of "technical" and "manual" work (and workers), the importance of plans, codes, and the routinization of conventional practices, and (perhaps ironically) limited acquaintance with (and patience for) paperwork, reporting requirements, etc.

Traditionally, houses are built and inspected in stages that result in specialty contractors (framing, roofing, wiring, insulation, HVAC, plumbing, appliances, plumbing, lighting, siding, raters, etc) being physically separated by schedule and/or by area under construction. The work is divided, the time is divided, the responsibilities are divided—being brought together by a construction supervisor, foreman or job boss (who is responsible for implementing plans and work flow schedules), and sometimes by an architect, master builder, or hands-on general contractor. In large firms and big jobs, the division of labor can be complex. In small firms and jobs, sometimes 1-2 people juggle all or most of the work (often under significant time and budget constraints). In either case, unless the integration of tasks and building elements is carefully planned at the outset and monitored throughout the job, issues related to building system interactions and quality of execution can (and do) "fall through the cracks" between the trades.

BP/WH is concerned precisely with these things that fall through the cracks in current practice. It is a *new* approach that requires new ways of thinking that run counter to conventional wisdom and divisions of labor.

> *"The rest are real reluctant. I mean it's like…their attitude…seems to be that 'you can't tell (me)', 'I've been doing this for thirty years.' You know? I've even had a couple that I had to quit testing for the builder because the installer just would not comply. He would not get away from the duct tape, he didn't use mastic with it, he just would not comply. … Those are the types of things that I run across in new construction." (Tester/Rater)*
>
> *The BP/WH integration approach also runs counter to the conventional installation business model, particularly in the HVAC industry.*
>
> *"… this [BP/WH] isn't just your regular 'Well let's throw a box on the roof' type installation." (HVAC contractor)*
>
> *"… they [homeowners] are being bombarded by the typical contractor who comes out and wants to replace the unit, you know, contractors like us that come through and we start talking something different all of the sudden they're like "Well why are you the only one talking about it." And all the sudden you're talking about indoor air quality, you're talking about duct testing and house pressurization, and they're saying like 'Whoa, wait a second, this is the first time we've heard anybody talk about this and we've talked to four different contractors.'" (HVAC contractor)*

3.8.5. Contractors' Network Development

A related problem, when attempting to adopt a new whole house retrofit approach that requires the combined work of technical and installation people in the areas of HVAC, windows, insulation, and so on, lies in the lack of *network connections* among the trades. General contractors tend to know and work with multiple subcontractors. Subs may encounter one another on the job (although efforts are made to keep them apart). Remodelers often have to master multiple trades, although they also have to work with a variety of specialists (such as HVAC contractors, interior designers, plasterers, painters, etc.) in doing their work. Overall, however, the industry is not tightly networked along the supply chain. Because an *integration* and *combination* of improvements are required by the BP/WH approach, it is necessary that successful contractors either perform all of the required work in-house (using their own crews), or carefully coordinate the work of various subcontractors, as indicated by each job.

Even when the specialist roles of subs are coordinated by a general contractor, the lack of overlap in their areas of expertise continues to pose threats that the work (and adaptations on-the-fly) of one can negatively impact the improvements made by others. Semi-stable networks of subs that have experience working together on WH projects can alleviate some of this. However, current poor network development reinforces narrow perspectives on the work that hinders current specialists in developing a sustaining interest in the WH concept.

As we have seen, many of the contractors interviewed were too small and/or specialized to do the work hiring only their own employees. Most of these because of factors already discussed (firm type, size, specialization, experience, skill-sets, etc.), we would believe, lack experience and comfort in hiring and depending upon specialty subcontractors.

> *"Even, I mean, I have an extensive knowledge and an engineering degree and I could sell most of it. But I can't put most of it in. I don't want to deal with roofing and insulation and glass and all that. I could contract it out. But there you have to develop a network. If you want that kind of system to happen, I think a network has to develop; of aligning trades that are energy, you know, energy-related trades, that are not competing necessarily [emphasis added]." (Mechanical/General Contractor)*

3.8.6. Ongoing Work Flow, Prior Commitments, Scheduling Problems

Under the best of circumstances, the matching of the flow of jobs with the assignment of workers leads to tight schedules and efficient use of human resources and equipment. This means that, except in large firms, time is limited for owner and/or technician BP/WH training. In most cases, however, contractors seem to face backlogs of work and shortages of labor that make participation in training even more difficult.

The non-participants and partial participants interviewed, almost to a person, reported that "lack of time" for training is a common barrier. In particular, for many the problem is having a block of several days in a row—making this barrier almost insurmountable, in their view.

> *"The classes were during the week, during working hours, and it just didn't fit into my schedule. Something always came up. I think if they had the program at night or on weekends I think they'd get a lot more participants. But because it's during the week, during working hours, it's a pretty big commitment. I think it was a three or four-day commitment, you know, all in a row. If it was one day a week or something like that I know it would work better for me." (large HVAC Contractor)*

"I'm still interested in it, it's just that taking six days off from work at the time that the class was offered just wasn't feasible." (Remodeler)

"…too busy. I've turned down a few because I'm too busy right now." (HVAC Contractor)

"…have it one day a week, or one day every other week, until you get the course finished. I don't have a problem with the length of the course, but I have a problem with you expecting contractors to be away from their business for six days in a row. It's not going to happen." (Consultant)

"Lack of time" did not prevent a number of contractors from actually taking the entire course, however. So while workflow and time constraints are certainly factors that may warrant some innovation in the delivery of training for some contractor types, other issues also lie behind the simple "lack of time" explanation. The size of firms is part of the story—most contractors who reported that they didn't "have enough time" also had very small operations (although a few larger contractors offered the same response). There are also unpredictable fluctuations in consumer the demand for work, and seasonal factors are certainly at play—meaning that during some periods there isn't time for training, while at others there is. [These sorts of external pressures are discussed further under "conditions," below.]

3.8.7. Price/Commodity-Driven Estimating and Bidding Practices

Work flow and time constraints can also be traced, at least in part to commodity pricing. An illustration is the change-out HVAC equipment—drop in a new box, same size, same British thermal units (Btus), lowest price, shortest installation time, highest profit. Not only have contractors come to adopt this approach, but they expect that consumers now expect it as well, demanding the lowest possible bids for commodity equipment and services. To offer a non-commodity package is seen to risk customer "sticker shock," that pushes them toward more conventional competitors. To take a concrete example, an HVAC contractor faced with balancing the problems of cost, size, and air flow might recommend an oversized unit to a customer, rather than risking losing the job by suggesting a more appropriate plan that includes two smaller units that will cost somewhat more, but in the long run be much more energy efficient.

Moving away from a commodity (high-volume, predictable-margin) pricing model is not just perceived by contractors to be *somewhat* risky. The very existence of the firm may be perceived to be at stake, such as if the contractor fails to secure a steady stream of even low-margin jobs. Threats to cash flows, in turn, threaten payrolls, lines of credit, tax payments, etc.

So these contractors have developed a model that "works" for them (at least it's part of what keeps them in business). It also provides a template or "mind-set" through which the BP/WH alternative is judged (BP/WH proponents and successful BP/WH contractors would say unfairly judged). Doing diagnostic work and providing reports to homeowners, without a guarantee of a job in return, can be seen to encourage bid shopping by consumers. This can be seen as particularly risky if the BP diagnostic work has been performed at a price below cost (see further discussion of this point below). Lack of familiarity with the cost estimation in areas outside of comfortable specialties, and having to solicit coordinated bids from subcontractors—when seen through the commodity model lens—raises concerns about possible low profit margins on subcontracted portions of the work. And, through this lens, the potential for large amounts of technician time required for diagnosis and estimation/reporting can be feared to result in unacceptably high overhead costs that are not now part of the business.

3.8.8. Low Capitalization and Significant Cash Flow Issues

In part, because they are trapped in a commodity model, at least many small firms lack the capitalization and the cash flow needed to cover the required investment in new BP testing equipment. These firms are also not able to routinely fund professional development and/or employee training, to cover the costs of lost business during training time, or to front the resources that may be needed to support new marketing costs.

> *"I had some of the tools … so I was very interested in diagnostics tools as a whole and whether they could be used effectively, cost effectively, in the marketplace, to the point where a contractor could make some decent money with it. … To actually get a mechanic trained in it was going to cost me close to five thousand bucks, and …the tools—another six thousand. To be able to go out on a [new venture with] what appeared to be a, very, very limited market. … we were talking about doing a joint venture in this area as a separate entity. And it just didn't pan out. It just didn't make sense. Not enough for me to invest four days of mine or my mechanic's time and to buy thousands of dollars of tools." (Mechanical/General Contractor)*

> *"But at this point I could not see it as a cost effective move. Basically an investment now might give me a return three years from now. I mean to sell $100,000 in sales is a lot of sales. You know, on a start up activity. And you've got to, by the time you put marketing pieces together and all the sales related stuff—because people do not understand energy, they really don't. Whether it be a facilities manager or a homeowner, they really do not understand how to save energy. Turn off the light switch, yeah. Mess with the air conditioning, no. They really don't understand it." (General Contractor)*

> *"Getting the tools [diagnostic equipment] is not that difficult. Staying up to speed with it and getting your technicians properly orientated is difficult." (Mechanical Engineer)*

3.8.9. Human Capital, Organizational Skills, Management and Planning

Reports from both small and larger contractors underscore the importance of employee professional development. As the construction industry has become more complex (in terms of technology, regulations, etc.) it has become increasingly difficult for contractors to manage all aspects of the business equally well. The number of training sessions offered by manufacturers, trade associations, private consultants, and utility companies attest to the need to constantly update skills.

> *"Getting the tools [diagnostic equipment] is not that difficult. Staying up to speed with it and getting your technicians properly orientated is difficult." (Mechanical Engineer)*

Among those interviewed, we found that companies with at least several employees (including technical and office support staff) were more likely to attend training, and were more likely to begin to transition toward a BP/WH business model. While adding home performance testing to the business may not require additional personnel, the transition to whole house contracting does require a somewhat higher degree of management, organization and planning skills than are available in many very small companies.

Some of our interviews also led us to believe that BP/WH businesses require that owners have a sense of purpose or a vision for the future of the company. Therefore, having a plan and a sense of direction that allows for innovation may be key difference between businesses that innovate and those that barely keep up with daily business.

> *"I've been in about every trade out there, but the past two and a half years I've been trying to focus on the energy area (heating, insulation, air sealing, high efficiency, and water heating). I've been doing a lot of training … so that's the direction I'm in. I'm in transition … whole house diagnostics and contracting … it's right up my alley." (General Contractor)*

However, simply being on the lookout for opportunities to innovate does not seem to be sufficient. In our typology of concerns or interests, those with the "shot-in-the-arm interest" are looking for business innovations, but they generally lack the capacity to adopt them. Successful or transitioning contractors, on the other hand, have a business model and a plan for the future that *whole house contracting fits into*. This is illustrated by a contractor who said:

> *"I've been in basic home performance for 7 or 8 years. And the training that I have gotten was sporadic … but when they (CBPCA) told me what they were going to do, really it just…put it all into one basket." (HVAC Contractor)*

They also have the authority to change the future direction of the company, as demonstrated by this owner who reported:

> *"We're thinking about expanding our general contracting into the new home market where we'll build new homes using high performance standards. [The company] is doing its own marketing and is having some success with door-to-door canvassing, test-marketing for 'building performance,' and plans to change our Yellow Page ads to language about "indoor air quality and healthy home." (General/HVAC Contractor)*

The successful owners are also willing to invest resources and time to implement their plans. This means that they sometimes must make significant resource commitments to get though the development stages that involve purchasing equipment and training staff not only in new ways of acting, but also in new ways of *thinking*.

> *"I would probably say (I've invested) $30,000 to $35,000. That's the equipment, the training (of self and employees), and the time away from work, all of it." (General/HVAC Contractor)*

Successful whole-house contracting requires management of disparate groups of employees and/or subcontractors. To ensure that complex work scopes are done well, within budget and on time, management, organization and planning are required. A combination of these skills is rare to find in one person, and even in larger firms. The problem is stated poignantly by one small contractor:

> *"It doesn't seem like I can keep track of it all and get things within budget. So I'm going to where I'm just hiring people out (rather than managing about ten employees) and using them as sub-contractors to lock them in on pricing and just try to do it overall as a general." (HVAC Contractor)*

3.8.10. Marketing and Sales Experience

As one contractor put it, "The bottom line for a contractor is sales and profit. It's the only reason that they should get into this business." Many contractors we interviewed claimed considerable *sales* expertise. However, BP/WH contracting seems to require more in the way of *marketing* than *selling*—and sales and marketing are distinctly different undertakings.

A dictionary definition terms a "sale" an exchange of goods or services for an agreed upon sum of money. In the HVAC business, for example, the "sale" in this sense happens when a furnace breaks down in the winter or an AC unit goes out in August. For many in the repair or retrofit business, the task is to "sell" a particular item to customers who are both at a disadvantage (in terms of information and available options) and wary. In the commodity model, the lowest price is often stressed in the "sales pitch."

Marketing, on the other hand, involves "… the process of planning and executing the conception, pricing, promotion, and distribution of ideas, goods, and services to create exchanges that satisfy individual and organizational objectives."[6] This is more than a complicated way of talking about "selling." It points to a more complex undertaking that is ordinarily not required of the construction trades.

For example, in most conventional HVAC, remodeling, repair businesses, "leads" and "jobs" are generated by past dealings, a good reputation, referrals, and an advertisement in the Yellow Pages. However, marketing new products and services requires more, including public and customer education. When this happens now in the industry (such as when a new furnace technology or window system enters the market), the marketing responsibilities are largely borne by product manufacturers and their wholesale distributors.

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[6] American Marketing Association. www.marketingpower.com/live/content4620.php

The CBPCA spends considerable effort to incorporate a market strategy into its training. But some contractors still have a difficult time seeing its value. One sales-oriented contractor put it this way:

> *"… property owners, and landlords, that type of people. Energy is only a small part of what they care about. And when you talk about energy conservation with them it's not important. … So if you have a proposal for higher-efficiency equipment for the most part they will not consider it because it blows their budget." (HVAC Contractor)*

On the other hand, one active whole house contractor clearly understands the value of educating his customers and finds that his marketing efforts have been returned with new referrals.

> *"… I'd say probably since February when we went through the classes with CBPCA we've been a little better organized in doing a whole house type thing. And we're getting referrals from people that, when we go out to talk to somebody who has been referred to us, they're almost sold before we get out there. And it's just a matter of kind of taking them through a few steps to let them know what we find about their particular house and what issues need to be resolved and what it's going to cost. … and they were just absolutely astounded at what it was going to cost to do the repairs. … However, I was able to show them, and give them some referrals, and even though what we actually did for them eventually cost about double what they were planning on spending, they did it, and they're extremely happy. (General/HVAC Contractor)*

3.8.11. Degree of Integration of Computers and Information Systems in the Business

A final potential problem area for contractors interested in the BP/WH approach involves the use of computers and information systems. In our interviews, we did not ask about the degree to which computers were routinely used in each of the businesses. We assume that even the smallest business uses computers for at least accounting and billing, and that many use them for inventory databases, internet searching, and other common business functions. However, we need to know more about the levels and types of computer use in different types of businesses.

During our interviews, office support was rarely mentioned. However, we strongly suspect that this is their *primary* use of computers. The fact that businesses own and use computers for office support does not mean that they possess either the hardware, software, or technical skill-sets necessary to do computer-based whole house modeling, system simulation and sizing, complex estimating, financial planning, job/bid coordination and tracking, or web-based reporting. Possession of at least some of these capacities is a definite advantage in adopting BP/WH approaches, and their absence is a definite handicap.

When we inquired in our interviews about the TREAT software (used for BP modeling)—particularly whether it was purchased and if diagnostic reports are being given to customers—we learned from many of the contractors who participated in training that learning the TREAT software was a significant challenge. In fact, in the case of one of the most successful whole house contractors, the owner of this firm described the process he had to go through to overcome this potential barrier:

> *"Most of the guys [his employees], 5 or 6 who went to the training, flopped with TREAT software. I finally learned TREAT and OTTER [and], found one guy [in my employ] with the 'temperament, gifting and patience' needed to run the software." (General Contractor)*

Ultimately, in this firm, the responsibility for testing, data input, report production, and review of the report with the customer (sales/marketing opportunity) is carried by one person.

Another contractor that intends to get into whole house testing and retrofitting, reported that the requirement to use TREAT for reporting to customers and account to the CBPCA, was one of the main reasons for his firm's lack of continued participation. He saw TREAT as "old fashioned by California standards" and that:

> *"…the amount of time it was taking … to input all of this information was actually more than or as much as we were actually doing the work. We didn't feel a benefit coming out of that, although it does have some interesting benefits, but we're looking at some other options to take care of that same situation…There is another company that is doing pretty much the same thing. … We'll be going to a class that they're putting on and looking at that." (HVAC/Plumbing/Shell Contractor)*

3.8.12. External Conditions

The term "conditions" points to a variety of factors that reside *outside of the business*—in the environment within which the business has to operate. Conditions are largely outside the control of contractors, but they influence what contractors do (and when and how they do it). An important fact about barriers or impediments in the organizational environment (or *market context*) is that they are *not uniform or static in their influence*. They are variable across markets, perhaps affecting small contractors and large contractors differently, and they may have different effects in different locales. They also fluctuate across time—whether this might involve seasonal cycles or business cycles. And they *evolve* or *trend* through time, as macro-economic and technological changes interact to produce new products and new markets.

A few of these conditions were mentioned in contractor interviews (such as escalating workers' compensation rates). However, most were not offered as explanations by contractors, who are largely concerned with day-to-day business and short-term prospects, not sweeping changes or economic cycles. Nonetheless—on the basis of theory and the observation of sources of change in many other markets—we believe that the "conditions" element of the "concern, capacities and conditions" model are important to consider in the residential retrofit industry case as well.

Because these sorts of influences and impediments to BP/WH cannot be adequately studied using small samples, self-reporting methods, and short time scales, we have not examined them in any detail. So in the balance of this section of the report, they are simply identified.

From an policy point of view, all of these areas warrant serious research attention in order to identify appropriate public sector roles and policy instruments that might be developed to both strengthen private sector concerns/interests and capacities to confront these conditions, as well as to work to moderate their effects upon the entire industry (and encourage its evolution toward BP/WH approaches).

These factors include:

- *Lack of and/or unpredictable sources and volumes of customers ("leads")*
  These result from changes in consumer interest (and consumer's own concerns, capacities and conditions), as well as lack of industry and/or government efforts to educate consumers and encourage BP/WH activity.
- *Competing demands on business capacities*
  This involves escalating government reporting requirements, changes in the regulatory environment, changing technical requirements from product manufacturers, and related factors.
- *Insurance and benefit rates*
  For example, worker's compensation, and related employee expenses.
- *Seasonal factors*
  These include shifts in demand for different types of work and changing rates of demand across the year (such as, summer is a busy time for HVAC installers).
- *Ebbs and flows of economic conditions*
  Changing levels and nature of consumer demand (such as following the "bubble burst" and the "stock options collapse"), changes in labor markets, increases in cost of money/financing, etc.
- *Operating in markets with disproportionate number of lower income households*
  This limits the size of jobs and the ability of customers to pay, may be accompanied by collections problems, demands for pro bono work, etc.
- *Competition*
  The presence of competitors and new competitive pressures in core business (HVAC, general contracting, windows, etc.), also possible growth of competition in the BP/WH niche.
- *Network dynamics*
  Market actors and interest groups (such as trade associations) continually reinforcing traditional division among trades (discussed above), but also reinforced through certification, licensing, regulation, codes, inspection, etc.
- *Utility role*
  For example, utility support or absence of support for energy efficiency in general and BP/WH approaches in particular; history of ebb and flow of utility interest and program levels in the past have made some contractors wary.
- *Government role*
  Visible support (and lack of support) for residential retrofit for energy system and

environmental public purposes; presence, absence and amount of available rebates and incentives for BP/WH work.

3.8.13. Interaction of Concern, Capacities, and Conditions

The three sets of factors interact with one another. For example, with a strong basis in concern or interest, many (but not all) capacity issues can be addressed—and even many adverse conditions may be overcome. In the opposite case, lack of serious interest may prevent the most capable and best-situated businesses from successful adoption of the BP and/or WH contracting model(s).

Also, combinations of supportive concerns and capacities often go together. For example, serious interest + size is likely to accompany an effective delivery system (either in-house or subcontracted), as well as management capability and technical competencies. In the opposite case, we can see how hard it might be to sustain interest when capabilities are low (such as staffing, expertise, cash flow) and conditions are not conducive (or will not be perceived to be conducive).

4.0 Home Performance Protocols for California

4.1. Introduction

This chapter presents a typology of home performance "best practice" topics to be used in this project as the scope of a Best Practices Guidebook. It provides outlines of specific topics for which "best practices" are needed to guide contractors working in the field of home performance diagnostics and retrofitting. Each line of the following tables represents a topic for which recommended best practices have been identified and indexed to reference sources, where available.

This project's primary goal is to develop this Best Practices Guide as a reference for contractors and sponsoring programs in California and elsewhere. It represents a key step in standardizing the home performance contracting process and provides a foundation for subsequent refinements and corrections by the industry. The following tables are organized into these categories.

4.2. Overview of the Protocol Set

Inspection and Diagnosis Practices

- General Practices
- Customer Concerns
- Site Inspection
- Health, Durability, IAQ, and Safety
- Moisture Inspection
- Mechanical Ventilation
- Carbon Monoxide
- Combustion Appliance Zones
- Heat Exchangers
- Combustion Efficiency, Flue Inspection, HVAC & Domestic Hot Water (DHW)
- Appliance Venting and Vent Pressure
- Building Envelope
- Thermal Boundary
- Blower Door Test
- Transition Zones
- Duct leakage
- Cooling System
- Heating and Cooling Ductwork, System Air Flow Testing
- Conditioned Zones
- Baseload Appliances and Lighting

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Analysis and Presentation Practices

- Prepare For Calculations
- Conduct Billing Analysis
- Conduct Base Building Calculations
- Evaluate Ventilation Requirements
- Evaluate Improvements for Inclusion in Packages Based on Both Energy and Non-Energy Impacts
- Create a Customer Report
- Estimate the Cost and Proposed Price For Recommended Improvements
- Create a Customer Proposal and a Workscope
-

Installation Practices

- General
- Windows
- Moisture Control and IAQ
- Combustion HVAC/WH/Appliances
- Lighting and Appliances
- Insulation
- Air Distribution Systems
- Cooling Systems
- Test-Out and Documentation
-

Business Practices

- Assuring Quality
- Marketing Home Performance Retrofits
- From Leads to Home Inspections
- The Diagnosis and Sale
- Field Activities Infrastructure
- Onsite Job Management Activities
- Job Follow-up Activities
- Administrative Business Practices

A Note on Contractor Discriminants

One of the outcomes of the project's national home performance contractor survey was an increased understanding of how various factors affect the selection of best practices. Most work on recommended best practices to date has focused on the impact of Climate and more recently on Trade. In this project three new contractor variations are added: Origin, Contracting Type, and Size. Best practices recommended to contractors will need to be adjusted based on these primary discriminants.

Table 4.1. Primary discriminants

Climate	Trade	Origin	Contracting Type	Business Size
Heating	HVAC	New	Whole house	Small
Mixed/Cooling	Shell (or parts)	Existing	Subcontractor	Medium
	General Contr.	NFP	General Contr.	Large
	Whole House		Inspection only	

In addition, contractors enter the home performance business with varying levels of knowledge, and for at least some, the acquisition of adequate expertise may require several stages of training. *Beginning, intermediate, and advanced* levels may be used as options to allow for the evolution of contractors over time. Best practices will need to be defined with reference to these stages to provide contractors and programs further guidance on how to progress contractors to advanced levels of competency.

4.2.1. Best Practice Protocols and Learning Objectives

The project's Best Practice Protocols were based on a set of over 450 more specific "learning objectives." These were developed over the past several years of the research team's experience in home performance training and implementation and augmented during the project through outreach to professionals nationwide. The full set of learning objectives could be divided many different ways to define protocols. In this project we focused on creating topical groupings that in our view would be readily understandable and convenient for contractors. The final protocols are in a slightly different arrangement but the content is the same.

Because the complete text of the full set of Best Practice Protocols would be unduly long for inclusion in this volume, the Protocols are instead presented in full in the Best Practices Guide that accompanies this Final Report.

4.3. Learning Objectives by Protocol

4.3.1. Inspection and Diagnosis Practices

Table 4.2. Inspection and diagnosis practices—general practices

Maintain and utilize diagnostic equipment in accordance with manufacturer specifications.
Perform a "Whole House" investigation.
Maintain a logical sequence to the order of systems testing.
Determine probable causes and resolutions for issues and problems.
Record results and written recommendations.

Table 4.3. Inspection and diagnosis practices—customer concerns

Involve the occupant at the beginning of the investigation.
Identify the number of occupants and appliance utilization habits for ventilation.
Ask about the structural integrity of the building.
Ask about historical or seasonal moisture issues.
Ask about systems performance.
Ask about health concerns or complaints.
Ask about occupant influence on distribution systems.
Ask about building configurations, auxiliary fuels and thermostat settings.
Collect energy use information from fuel vendors, or fuel-use records.

Table 4.4. Inspection and diagnosis practices—site inspection

Evaluate site drainage opportunities for ground water, surface water and roof runoff.
Determine air quality issues that may result from building's location.
Evaluate solar impact on southern exposures.
Evaluate heating degree days (HDD) and cooling degree days (CDD).
Evaluate wind effect and any potential impact.
Identify the foundation systems present and moisture's impact on them.
Inspect building foundation for the effects of site design issues.
Inspect building frame for moisture and associated degradation.

Table 4.5. Inspection and diagnosis practices—health, durability, IAQ, and safety

Inspect crawl space for existing or potential pollutant sources.
Provide a short term radon test.
Identify other home conditions contributing to poor air quality.
Compare home pollutant levels with acceptable and unsafe levels.
Evaluate the need for additional or seasonal fresh air supply.
Identify improper storage of volatile organic compounds and household chemicals.
Determine response options to any identified fuel leaks.
Evaluate any lead associated with building materials that may require handling in the course of any proposed work.
Inspect building for material storage that poses potential fire hazard.
Conduct egress evaluation and provide recommendations to customer.

Table 4.6. Inspection and diagnosis practices—moisture inspection

Conduct a visual inspection of the building for indications of excess moisture.
Conduct a relative humidity test.
Utilize a psychometric chart to interpret potential for moisture problems.
Evaluate the causes of any mold and mildew growth in closets, corners and remote areas of the living area.
Evaluate the impact of humidifiers and dehumidifiers upon the indoor air quality and upon the integrity of heating/cooling appliances.
Evaluate and control moisture sources that produce condensation on interior building surfaces.

Table 4.7. Inspection and diagnosis practices—mechanical ventilation

Identify any pollutant sources requiring ventilation as a control method.
Measure capacity of mechanical ventilation systems.
Determine ventilation requirements based on building use, size, and occupants.
Determine type of ventilation system that is most appropriate.
Determine controller best suited for mechanical ventilation.
Determine proper placement of the air supply and air exhaust components of a ventilation system.

Table 4.8. Inspection and diagnosis practices—carbon monoxide

Establish that the house is safe.
Determine the operational range for each draft in each vented combustion appliance.
Configure the combustion appliance zone into "worst case."
Determine if there are any safety issues with the combustion appliance zone.
Identify any issues that might require immediate attention.
Identify the proper location to conduct a meaningful carbon monoxide test.
Follow mechanical operation of combustion appliances in the proper sequence.
Test drafts with the use of differential manometer.
Respond to action levels for carbon monoxide in the home environment.
Inspect ovens and ranges for CO-efficient operation.
Evaluate the positions, performance features, and operating ranges of existing carbon monoxide detectors.
Evaluate any potential for occupant exposure to carbon monoxide.
Conduct a carbon monoxide test of gas ovens and range tops.
Conduct another ambient environment carbon monoxide test.
Share results with the building's occupants.

Table 4.9. Inspection and diagnosis practices—combustion appliance zones

Take control of all mechanical and combustion equipment.
Configure the building and each combustion appliance zone for greatest potential for negative pressure within that zone.
Perform appliance operations testing.
Measure the extent of negative pressure created within the zone, under worst-case scenario.
Identify the dynamics that influence the combustion appliance zone.

Table 4.10. Inspection and diagnosis practices—heat exchangers

Identify design specifications for a variety of heat exchangers.
Inspect for indications of heat exchanger deterioration.
Perform appropriate tests according to the type of heat exchanger.

Table 4.11. Inspection and diagnosis practices—combustion efficiency, flue inspection, HVAC, & DHW

Identify design and performance specifications for combustion appliances.
Configure the building for combustion appliance testing.
Determine the appropriate location to collect combustion gas samples.
Determine when “steady state” has been attained by temperature readings.
Measure samples of combustion products and combustion gas characteristics.
Maintain and properly utilize combustion efficiency test equipment.
Perform a combustion efficiency test and compare results to manufacturer’s specifications.
Measure the temperature rise across the heat exchanger.
Identify techniques for inspecting combustion chambers for a variety of appliances.
Evaluate thermostat performance.
Evaluate thermostat location with relationship to occupant comfort.
Evaluate the benefit of installing a setback thermostat.
Identify fuels and distribution systems used within a building.
Maintain and utilize diagnostic equipment in investigation of fuel leaks.
Conduct a water heating appliance evaluation.
Identify the type and components of cooling systems.
Provide a maintenance inspection of the cooling system.
Identify the tools and products used and perform a cleaning of cooling systems.
Record results of cooling system inspection.

Table 4.12. Inspection and diagnosis practices—appliance venting and vent pressure

Identify all ventilating appliances to be tested.
Inspect venting system for design, maintenance and safety.
Identify all un-vented and under-vented combustion appliances.
Inspect appliance vent for obstructions and design.
Inspect combustion appliance vent systems for required clearance to combustible materials.
Provide a vent pressure test.
Conduct vent spillage tests.

Table 4.13. Inspection and diagnosis practices—building envelope

Identify the framing style used in construction.
Determine framing techniques and characteristics incorporated into a structure.
Inspect the building envelope for continuity.
Identify the building materials utilized in establishing the building envelope, and any degradation.
Evaluate ventilation systems that penetrate the building envelope.
Determine if attic ventilation has any impact on the conditioned areas of the building.

Table 4.14. Inspection and diagnosis practices—thermal boundary

Define and document all existing thermal boundary components.
Collect relevant building dimensions.
Perform a visual inspection on each thermal boundary component.
Conduct an infrared inspection of the entire thermal boundary.
Record results and recommendations on the attached sheets.

Table 4.15. Inspection and diagnosis practices—blower door test

Configure the building envelope for pressure testing.
Configure the internal building configuration for pressure testing.
Identify and correct building conditions that may be problematic during pressure testing.
Select an appropriate location and install a blower door.
Conduct and interpret a blower door test.
Determine the type of test (pressurization or depressurization) best suited for the building.
Utilize a blower door in the evaluation of air sealing needs and the effectiveness of installations.
Ensure the building and systems are operational, at the completion of blower door work.

Table 4.16. Inspection and diagnosis practices—transition zones

Identify all transition zones associated with the conditioned area.
Inspect key junctures of the building frame for air leakage or signs of long term air leakage.
Utilize the blower door in the evaluation of the building frame for air leakage paths.
Quantify leakage between conditioned areas and attached zones.
Establish a selected pressure difference across the air/thermal boundary.

Table 4.17. Inspection and diagnosis practices—duct leakage

Inspect ducts and associated areas.
Establish ducts and zones in a testing mode.
Configure the building and install diagnostic equipment for duct leakage testing.
Perform and interpret a cumulative leakage test.
Perform and interpret duct leakage to the outdoors test.
Perform and interpret individual duct leakage tests.
Identify air leakage sites in a forced air system.

Table 4.18. Inspection and diagnosis practices—cooling system

Balance zonal pressures that exceed action levels.
Ascertain duct leakage.
Consider duct conduction.
Consider room-to-room air flows.
Consider air flow through the evaporator.
Consider refrigerant charge.
Consider condensing unit sizing

Table 4.19. Inspection and diagnosis practices—heating and cooling ductwork, system air flow testing

Identify the components of the distribution system and provide a visual inspection.
Evaluate the heat transfer characteristics of the heating/cooling distribution, with relationship to occupant comfort.
Identify the basic principles of proper duct design.
Measure airflow across the cooling coil.
Evaluate air flow volumes with relation to recommendations.
Identify factors affecting airflow requirements.
Evaluate cooling load reduction options.
Identify distribution components requiring insulation.

Table 4.20. Inspection and diagnosis practices—conditioned zones

Identify and configure each potential zone of the living space.
Test the levels at which positive and negative pressures occur within zones of the building.
Develop a pressure balancing strategy.
Assess and address energy, health, and safety implications created by zonal pressures.

Table 4.21. Inspection and diagnosis practices—baseload appliances and lighting

Seek information from occupants related to baseload appliance usage and performance.
Conduct a lighting survey for efficiency considerations.
Identify and repair/replace recessed lighting fixtures that contribute to building air leakage and compromise thermal boundaries.
Conduct a refrigeration appliance evaluation.
Evaluate the use of flow restrictors and low flow showerheads.
Maintain and utilize diagnostic equipment in the evaluation of baseload systems.

4.3.2. Analysis and Presentation Practices

Table 4.22. Analysis and presentation practices—prepare for calculations

Collect energy cost data.
Collect HDD and CDD information for the related service territory.
Select a modeling tool for energy calculations.
Select a tool for energy bill analysis.
Prepare to maintain records for all testing, proposed workscope, and support documents.

Table 4.23. Analysis and presentation practices—conduct billing analysis

Collect utility bill data.
Determine the baseload energy use and the temperature-dependent energy use.
Calculate heating and cooling energy use for the building, normalized for the heated or cooled area.
Compare weather normalized energy use to the weather normalized energy use of similar buildings.

Table 4.24. Analysis and presentation practices—conduct base building calculations

Calculate the volume and surface areas of the building relevant to test.
Build a software-based building model of the home.
True-up the building model.
Calculate the correct size for the cooling/heating equipment.
Evaluate the performance of the distribution system.

Table 4.25. Analysis and presentation practices—evaluate ventilation requirements

Determine the current and proposed pressure boundaries for connected building zones.
Translate artificially created airflow rates into natural airflow rates.
Determine the amount of cumulative ventilation required for site-specific situations.

Table 4.26. Analysis and presentation practices—evaluate improvements for inclusion in packages based on both energy and non-energy impacts

Evaluate health and safety improvements.
Evaluate improvements based on comfort.
Evaluate building durability improvements.
Evaluate resource efficiency improvements.
Calculate savings for a range of improvements including energy efficiency.
Calculate the simple payback for recommended improvements.
Calculate life cycle benefit/cost relationships for recommended improvements.

Table 4.27. Analysis and presentation practices—create a customer report

Provide a description of the building's current condition.
Identify health and safety issues.
Show where energy is currently being used in the building.
Identify any incentives available.
Provide a list of improvements with a description of each.
Recommend packages of improvements based on various levels of investment.

Table 4.28. Analysis and presentation practices—estimate the cost and proposed price for recommended Improvements

Select methods in accordance with building codes and industry standards.
Define the installation standards and specifications for proposed measures.
Identify the materials and equipment specifications for each measure.
Calculate the materials and labor costs associated with proposed measures.
Incorporate the cost of overhead into the estimation process.
Routinely compare actual profits to estimated profits.

Table 4.29. Analysis and presentation practices—create a customer proposal and a workscope

Develop a customer pricing proposal.
Present the pricing proposal to the customer.
Develop a crew workscope.
Retain information so that it can be retrieved if the customer delays implementation.

4.3.3. Installation Practices

Table 4.30. Installation practices—general

Maintain safety and cleanliness in the work area.
Provide installation instructions and standards for each measure.
Provide materials application in accordance with industry standards and building codes.
Balance zonal pressures that exceed action levels.

Table 4.31. Installation practices—windows

Select replacement windows.
Install replacement windows.
Air-seal existing windows.

Table 4.32. Installation practices—moisture control and IAQ

Identify area where molds and other biological growths appear.
Correct moisture problems in wet crawl spaces.
Set or adopt standards for practices and limits on mold-related correction work.
Monitor radon levels within a building.
Provide wet cleaning of lead contaminated surfaces.
Isolate or remove sources of pollutants (VOCs, etc.) that may be affecting the living areas of the building.
Install kitchen exhaust fan to remove pollutants associated with the operation of kitchen appliances.

Table 4.33. Installation practices—combustion HVAC/WH/appliances

Clean burner assemblies and perform adjustments.
Clean or replace furnace air filters.
Clean and lubricate distribution fan motor, fan vanes, inspect/replace fan belt.
Clean and tune gas oven/range top burners, to reduce carbon monoxide outputs.

Table 4.34. Installation practices—lighting and appliances

Install energy efficient lighting based on performance characteristics.
Recommend energy efficient appliances.

Table 4.35. Installation practices—insulation

Insulate sidewalls with high-density cellulose.
Insulate attics and roof systems.
Insulate floor and foundation areas.
Determine the requirements and location for vapor barrier placement, with installed insulation.

Table 4.36. Installation practices—air distribution systems

Distribution system repair- redesign criteria.
Identify and correct duct leakage and conditioned air leakage into unheated crawl spaces and attic areas.
Identify and install various duct and pipe insulations.
Cooling distribution system design considerations including convective loop impacts.
Maintaining humidifiers and condensate pans in central conditioning appliances.

Table 4.37. Installation practices—cooling systems

Conduct instrument attachment and house configuration: evaluate superheat and subcooling.
Collect data for air conditioning systems.
Perform superheat charging calculations: non-TXV cooling systems.
Perform subcooling charging calculations: TXV cooling systems.
Perform airflow calculations: evaporator temperature difference method.
Compute actual system output.
Assess evaporative cooling viability and options.

Table 4.38. Installation practices—test-out and documentation

Measure the effectiveness of air sealing.
Provide performance testing for all installed measures.
Provide testing of all systems that maintain interaction with installed measures.
Document all systems testing and maintain test results.

4.3.4. Business Practices

Table 4.39. Business practices—assuring quality

Create and use a standard job quality assurance process routinely.
Review all test-out data and repair as needed to assure adequacy and accuracy.
Review all job notes and comments for indications of any problems.
Define and use a formal Dispute Resolution process.
Instill the importance of quality assurance in all staff and subcontractors.

Table 4.40. Business practices—marketing home performance retrofits

Develop and use a consistent and effective marketing message.
Develop marketing materials for public distribution and presentation.
Use existing mass media channels where cost-effective.
Create your own marketing initiatives beyond mass media.
Make use of existing customer base for repeat business and referrals.
Make use of existing organizations and groups as allies and branding sources.

Table 4.41. Business practices—from leads to home inspections

Respond effectively to leads.
Make clear arrangements for the diagnostic visit.
Establish a pricing strategy for the home diagnosis and evaluation.

Table 4.42. Business practices—the diagnosis and sale

Perform the home inspection and develop a proposal.
Develop and employ an effective home retrofit sales process.
Close and document the sale.

Table 4.43. Business practices—field activities infrastructure

Select, set, and enforce performance standards for subcontractors.
Maintain and use a variety of testing equipment.
Develop or use existing standardized installation specifications.
Deliver product specifications, warranties, and maintenance requirements.

Table 4.44. Business practices—onsite job management activities

Keep home clean and undamaged.
Use digital photos to document work and avoid damage claims.
Communicate job requirements to the installation crew.
Follow health and safety precautions.
Use an effective standardized job closeout process.

Table 4.45. Business practices—job follow-up activities

Develop and use an after-job evaluation form to learn from each job.
Close out the job with good customer relations.
Follow up periodically with customer after the job is done.

Table 4.46. Business practices—administrative business practices

Define business model to be used and develop business plan for the transition.
Secure adequate funding for cash flow management.
Provide training and continuing learning opportunities for staff.
Provide support and incentives to motivate and keep quality staff.
Develop professional and business relationships and access to knowledge.
Create supporting processes and activities.

5.0 Contractor Training and Verification

5.1. Introduction and Overview

This project's collaborative relationship with the CBPCA's Third Party Whole House Retrofit program for PG&E and the California Public Utilities Commission in 2002–2005 made it possible to incorporate the Best Practice Protocols into that project's ongoing home performance contractor training. The PIER protocols were employed from late 2003 through the present (fall 2006). During those three years, over 200 individuals were trained using the protocols, representing approximately 100 contracting firms.

Verification of the training's effectiveness was conducted routinely through the contractor training program's ongoing field mentoring process. The CPUC project's independent evaluation contractor also used contractor surveys to assess their views of the training's value.

5.2. PG&E/CPUC Home Performance Contractor Project Partnership

In the California Public Utilities Commission's solicitation of "third party" energy efficiency implementation proposals for 2002–03 and 2004–2005, CBPCA was awarded the opportunity to implement a Whole House Energy Retrofit program in portions of the PG&E service territory. In the first two-year period the CBPCA program focused on the Fresno and San Jose (South San Francisco Bay) areas, expanding into the full Central Valley and Greater San Francisco Bay Area in the 2004–2005 period. Those sequential programs followed the same model, including these main features:

- Unrestricted participation by any interested contractor in the PG&E area
- Extensive technical training and follow-up field mentoring plus business practices workshops
- Marketing to the public through home shows, public interest articles, and limited advertising
- Association with EPA "Home Performance with Energy Star" program and use of logo
- Contractor training in cost-effective marketing and sales methods
- Free training, mentoring, co-marketing and test equipment purchase assistance; no financial payments for job reporting or energy savings
-

Although the CPUC/CBPCA program has ended in the PG&E area, PG&E has continued to fund the technical training by CBPCA as a part of its own energy efficiency program. In addition, Southern California Edison and Anaheim Public Utilities have both awarded similar home performance programs to CBPCA.

This PIER project's consultant team has been closely involved in the design and management of the home performance programs for the CBPCA. This made it possible for the PG&E and PIER projects to be designed for compatibility and mutual benefit. The CPUC project provided excellent opportunities for field testing of the PIER protocols and assessing the effectiveness of the home performance retrofit concept, while the PIER project provided best practice research and protocols to strengthen the contractor training in the implementation program.

5.3. Incorporation of the Protocols into the Training

The PIER home performance protocols were developed specifically for use in California's climate range, and were intended for incorporation into the PG&E program's training curriculum. The protocols were reviewed by California experts and adjusted as needed to meet the program's training needs. Timing of the PIER project permitted the development of a training curriculum based on that research into best practices and their refinement into a set of best practices.

The protocols were incorporated into the PG&E contractor training primarily through the visual aids used. Those visual aids were primarily PowerPoint slides designed specifically to follow the protocols and provide cues to the trainers to cover specific protocol topics.

5.4. Use of the Protocols as Reference Documents

The PG&E contractor training included provision of a substantial set of reference materials to all trainees. The protocols themselves were included in CD form for convenience and economy. Other reference materials included copies of the slide set and several published books available on home performance-related topics. The original protocol set will be replaced with more advanced versions that may emerge from other efforts such as the HUD national protocol development and delivery project and the Building Performance Institute's standards development program.

5.5. Effectiveness of the Protocols

The primary use of the protocols in the PG&E program was as a basis for the content of the technical training curriculum. The training itself was consistently highly rated by trainees, and PG&E officials observed it to be effective enough to be incorporated into the utility's own broader contractor training program offerings after the original home performance program ended in early 2006. The CBPCA trainers are now conducting a series of eight six-day training sessions through 2006–2007 at PG&E's Energy Training Center in Stockton, California. That program is overbooked with students and receives high marks from the trainees.

Another indication of the training program's effectiveness is found in the results of the skill tests that are administered before and after each six-day training session. Those results demonstrate a major improvement in understanding of basic building science, home performance testing, and interpretation of results to prescribe solutions.

5.6. Update: Status of the Protocols in 2006

5.6.1. The HUD "PATH 36" Roadmap Project

A major result of this PIER project's development of the protocol set was a follow-on project by the U.S. Department of Housing and Urban Development. HUD was responsible for implementation of key parts of a strategic roadmap on improving the energy efficiency of existing housing nationwide under the multi-agency Program on Advanced Technology in Housing (PATH).

One element of the PATH roadmap called for development of best practice protocols for improving the energy efficiency awareness and capabilities of the entire industry of home repair and remodeling contractors. That goal was much broader than the PIER project's focus on relatively few and highly qualified comprehensive home performance contractors, but the California home performance protocols provided an ideal foundation. A research team including the PIER researchers was awarded the project, which is now completing its first phase. All states, including California, will benefit from the products of the HUD project, and California in particular will gain the capability to begin moving many more contractors toward its emerging programs in home performance contracting.

The first phase of the HUD project has resulted in a broadened array of some 60 protocols. An updated partial set of some 35 of those protocols have been drafted as of fall 2006, most of which are based directly on the PIER protocols. Those first 35 protocols include examples at three different levels of complexity, to begin building a self-guided path for contractors to gradually upgrade their skills. Eventually the project will produce a contractor-friendly web-based best practices resource that will allow them to move through the different levels and topics of protocols at their own pace and interest. Many will not rise to the level of true home performance retrofit capability, but all will learn improved skills to improve the energy efficiency of the homes they work in, and the path to further improvements will remain open to encourage further improvements.

5.6.2. The Southern California Implementations

The protocols are also being incorporated into a new and broader training curriculum for two new home performance implementation programs in Southern California. Anaheim Public Utilities, a municipal utility, has chosen a consultant team including the CBPCA, and Southern California Edison has also awarded CBPCA funding for a home performance program in which the field training and mentoring will be run in tandem with that of the Anaheim program. The shared training program will make use of the CBPCA's Northern California experience with the protocols and incorporate them into the Southern California training as appropriate. This will make broader use of the installation protocols in particular, since the Northern California training focused primarily on the diagnostics and business best practices.

With the inauguration of these new programs, home performance retrofitting based on the PIER protocols has been introduced in most of the state. This provides an important element of consistency in contractor outreach and training statewide and builds momentum toward the broader acceptance and use of home performance retrofitting.

6.0 Home Performance Retrofit Demonstration

6.1. Introduction and Overview

The home performance retrofit process, using the PIER protocols, was demonstrated through the activities of the CPUC-funded contractor training and mentoring program. This chapter describes the demonstration approach, contractor response, some example homes, energy savings, and homeowner perspectives on the program.

6.2. Field Demonstration Approach

To demonstrate the effectiveness of the actual home diagnosis and remediation process, data on several homes retrofitted at least one year earlier was provided by program-trained contractors. The homes selected were ones which had received a relatively comprehensive retrofit rather than a partial "phase one" improvement due to homeowner preferences or financial limitations. That data included home diagnostic test results before and after the retrofit work plus basic home descriptors, the specific retrofits done, and PG&E utility bill data for both electricity and gas covering the year before and the year after the improvements.

The prior year of monthly utility billing data was used as the baseline energy efficiency benchmark. The use of a full year of data permitted consideration of seasonal variations in energy use and estimation of cooling, heating, and baseload components of the annual usage. Those components of the energy use were estimated for both gas and electricity through conventional graphical disaggregation of the monthly usage variations.

The primary means of estimating energy and peak demand savings of the home retrofits was a direct comparison of the pre-retrofit and post-retrofit year of monthly data. Weather variations were reviewed and determined to be minor between the pre/post years (roughly mid-2004/05 and mid-2005/06). There were no major pre/post occupancy changes in the homes reviewed for this study, although there were some substantial changes in how the home was operated after the retrofit.

Building energy simulation models offer the possibility of more accurate estimates of HVAC versus baseload energy use. The TREAT home energy simulation model was used with the test-in home description and performance data (duct leakage, envelope leakage, insulation values, full thermal load calculations, HVAC equipment and insulation specifications, etc.) to estimate pre-retrofit home energy use. The TREAT developers noted that such simulation models typically are unable to make accurate estimates of energy use in poorly performing homes, and this was borne out by the study team's tests. Those results tended to greatly overstate all energy use compared to the actual bills. Therefore only the utility billing data was used to establish the baseline. The study team also found significant differences between the model's post-retrofit predictions and actual billing data, and those results are under further study by the model's developers for possible refinements in both model specification and use. We therefore made use of only the utility billing data for the post-retrofit energy use, and compared pre- and post-retrofit billing data to estimate the retrofit's effects.

Both contractors and homeowners were interviewed to assess their satisfaction with the home retrofit approach and results. In the case of the contractors, this report also makes use of the results of the PG&E program evaluation contractor's interviews with a broader sample of the trained home performance contractors. Results include responses to the concept as well as specific elements of that program.

6.3. Home A: Danville

6.3.1. Characteristics of the Home

This home is in Danville, a San Francisco Bay Area suburb in the East Bay on the east side of the hills separating the bay from the hot inner valley. Air conditioning is typical here. The home is a single story ranch house with an attached garage and a full attic. The conditioned space is 1860 square feet. The house was built in approximately 1960.

The owners contacted the CBPCA for help, with primary emphasis on the home's perceived poor indoor air quality, poorly conditioned bedrooms, and HVAC system noise. Energy use reduction was not a major goal although would be gladly received. The CBPCA contractor's inspection and testing revealed a variety of specific faults.

The attic connected the house with the garage, allowing the garage to be a major source of interior air and potential CO danger through the utility closet.

The 92,000-Btu furnace was installed in a very confined closet space (50 cubic feet [cf], versus 4600 cf required to qualify as unconfined air supply). Fully 90% of the two original combustion air sources were blocked. The ceiling of the closet was open to the attic and had a large opening to the living space in the closet door. This closet was found to be the source of over half of the home's excessive air leakage, and the attic insulation around the closet was blackened with dust and pollen from that inflow. The air supply must be corrected before any closing of this ceiling.

Ducts to bedrooms were crushed in the attic, probably causing the temperature problems in the bedrooms. Ducts were basically annulated or missing insulation in many places. There were also exposed and broken connections in both the supply and return systems.

The return plenum showed extensive evidence of leakage, causing dirty attic air to be pulled into the system and distributed through the house. Ceilings above the supply registers were discolored from these pollutants, which were transported through the attic, down into the furnace closet and into the home via the door grate, and from there through the house and back to the furnace filter through the return grille. The return capacity was too small.

The master bathroom vent fan was not ducted to outside, with potential moisture damage in the attic. The laundry room vent fan was malfunctioning and required replacement for moisture control. The guest bathroom had no fan.

The home had a number of unsealed recessed light cans, providing another source of uncontrolled attic air infiltration into the home as well as loss of conditioned air.

Other problems included major exterior drainage deficiencies, with some structural dry rot. The home was also missing adequate CO and smoke detectors.

It may also be noted that at over 11,000 kilowatt-hours (kWh) and 530 therms in energy use during the year prior to the analysis and retrofit, this home used far more energy than the estimated averages for homes of its size in its climate zone.

6.3.2. Home Improvements Made

The following retrofits were made to this home:

- Building envelope leakage reduced from 0.88 air changes per hour (ACH) (4146 cubic feet per minute [cfm] 50) to under 0.35 ACH.
- All new ducts, sealed to 4.3% total leakage (originally 31%) and insulated to R-8 (formerly estimated at R-2 or less). High efficiency registers.
- Addition of a second return inlet and new grilles and 2" filters for both returns.
- A new 60,000 Btu 80% efficient gas furnace placed in attic to replace the original 92,000 Btu unit in the confined closet (converted to shelved storage).
- A new 2.5-ton seasonal energy efficiency ration (SEER) 12 air conditioning unit with matched and resized coil and line set to replace the original 4-ton low efficiency unit.
- R-38 (12”) blown cellulose attic insulation to replace original R-14. Knee walls insulated.
- Extensive envelope air sealing. Garage sealed from attic.
- Three new vent fans installed in the two bathrooms and laundry room.
- Replacement of all recessed ceiling light cans with airtight UL rated versions.
- Structural dry rot and drainage correction.

In addition, the owners authorized a variety of further home improvements including remodeling of the laundry room, structural dry rot repair, drainage improvements, and addition of storage flooring and pull-down stairs above garage. No baseload changes were included in the home assessment or retrofit.

6.3.3. Estimated Energy Savings

This home’s utility bill history indicated an annualized reduction of approximately 27% in natural gas use and an *increase* of 10% in electricity consumption after the retrofit. The total utility bill rose by 12%. Closer analysis of the monthly usage showed that there were major HVAC electricity and gas reductions but also a substantial rise in year-round baseload electricity and gas usage plus a nearly 30% increase in the *price* of natural gas. Utility bill baseload vs. HVAC disaggregation indicated that air conditioning electricity use dropped by more than 2/3 and winter heating appears to have been reduced by about 24%. Explanation for the increased baseload usage for electricity is unclear, particularly since the gas baseload evidently declined by nearly 50%. However, the gas base vs. HVAC disaggregation is suspect; given the inherent imprecision of utility bill disaggregation, it is more likely that gas baseload remained reasonably constant and the gas heating use was reduced by 50-60%. The increase in the electric baseload usage is most likely due to changes in occupancy during the year, although no data is available to confirm that inference. More precise analysis could be pursued, but the point is clear: Both electricity and gas HVAC usage were greatly reduced as a result of the retrofit.

6.4. Home B: San Francisco

6.4.1. Characteristics of the Home

This home is in San Francisco's Pacific Heights district. The building is a single family home built in 1893. There are 12 rooms on two floors totaling 1929 square feet plus a partial basement including a garage and a crawl space.

San Francisco is in a mild heating-only marine climate with intermittent fog year-round. Despite generally low heating degree days, the City has a substantial evening peak load in fall and winter. A recent diagnostic study of older 1-4 unit residential buildings, some built in the 19th Century, showed extensive envelope air leakage, lack of insulation, outdated and ineffective heating systems (often supplemented by electric resistance space heaters), and code violations contributing to carbon monoxide dangers as well as discomfort and energy waste (CBPCA, 2006). The retrofitted Home C had utility bills totaling $1648, with $917 electric and $731 gas, for the year prior to a comprehensive retrofit in September 2005. Both gas and electricity were nearly level at their high points from August through January, then declining to a low in July. Envelope leakage was very high—equivalent to a five square foot opening, and over three times the recommended level of 0.35 air changes per hour. There was no insulation in the attic, walls, or floor. All windows were single pane, wood frame.

The house had a separate forced air furnace for each floor, with one in the attic and the other in the basement. The upstairs furnace was improperly installed as well as oversized, and produced so much noise that it disrupted sleep and was normally left unused. As a result, the upstairs rooms were typically cold and uncomfortable, and this was the main reason for the owners' interest in the retrofit. The downstairs furnace was also oversized, old, and rusty, indicating moisture problems.

Duct pressure testing indicated leakage of nearly 75% of total flow, largely into the attic. One supply duct was completely disconnected. The calculated heating load under these conditions was very high for this size house at about 102,000 Btu, largely due to the very leaky duct system. Despite that poor performance, room-by-room thermal load calculations indicated that the installed heating capacity, including the home's two furnaces and duct systems, was oversized by approximately 50%. Also, air discharge to rooms was highly unbalanced, resulting in under- and over-heated rooms.

Draft testing indicated negative pressures at the furnace, easily exceeding safe levels by several times under worst-case conditions. However, no carbon monoxide emissions were found in the flue gases. At 70% in the attic and 78% in the house, humidity levels were somewhat higher than desirable.

A baseload energy use analysis was also conducted for this house. Lighting was estimated at 15% of the total electric load (well below average), but estimated electricity use by major appliances (refrigerator, dryer, and dishwasher) was extremely high at about 3600 kWh/year—over 85% of the usage of the entire house. The dishwasher in particular, though only five years old, was responsible for most of this usage, fully ten times over Energy Star estimates, apparently due to its powerful internal electric water heating feature and high water temperatures.

6.4.2. Home Improvements Made

Improvements made to Home B included the following:

- Removal of old asbestos duct covering (by separate hazmat specialist firm)
- Replacement of upstairs furnace with a properly sized high-efficiency unit
- Replacement and insulation of upstairs duct system
- Replacement of the downstairs furnace with the existing smaller upstairs unit
- All ducts sealed, with duct blaster test-out of 6% total envelope air leakage (very good)
- Room by room air balancing per ACCA Manual J for comfort
- Crawlspace ventilation to reduce indoor humidity
- Envelope air sealing, with blower door test-out showing 43% leakage reduction
- 10 inches of recycled cellulose attic insulation

No changes to baseload energy use were included in this retrofit, although the owners are expected to replace the dishwasher because of the retrofit contractor's assessment. That step alone could triple the energy cost savings achieved.

6.4.3. Estimated Energy Savings

Utility bill data for Home B showed about a 15% reduction in both electricity and gas use in the 11 months following the retrofit. After the retrofit, which resulted in newly quiet and comfortably heated bedrooms upstairs, the owners quickly took advantage of that new capability to heat that area adequately for the first time, increasing their comfort instead of operating the house as before. The result was that despite the much increased use of heating for comfort, the energy bills still declined somewhat—because of the more efficient building envelope, the improved ducts, air balancing, and the properly sized heating system. Without that full retrofit, energy use would have risen rather than declined. As with Home A, further analysis could be done, but it is clear that the retrofit produced significant energy savings.

6.5. Homeowner Responses to their Retrofit Experiences

Lutzenhiser & Associates conducted telephone surveys for both this project and the PG&E implementation program, with a broad cross-section of home retrofit customers including those reviewed here. The homeowners of the three homes studied here, as with essentially all others surveyed by Lutzenhiser, reported complete satisfaction with their home retrofits and their experience with the home performance contractors. This is of particular interest because the home retrofit projects cost their owners far more than could be justified by the energy bill savings achieved. The reported—and logically obvious—reason for the high levels of satisfaction despite the cost was the array of non-energy benefits received. Although homeowners varied in their reasons for satisfaction, a recurring theme was the perceived improvement in comfort, indoor air quality (often interpreted as healthier) and feelings of environmental responsibility in addition to any energy bill reductions experienced.

In the case of both Homes A and B, it is particularly significant that the energy savings achieved were not the homeowners' principal goal. The investments were made primarily for comfort, and the energy savings were a bonus. Application of an energy-focused benefit/cost analysis in both cases would be totally irrelevant despite the fact that significant savings were achieved. The homeowners were extremely satisfied with the results of that investment and would have been even if there had been no energy savings. So the private and public benefits represented by the energy savings were in effect virtually cost-free both to the homeowner and the utility.

6.6. Contractor Responses to the Program

All three contractors represented by the three test homes reported satisfaction with their experiences in home performance contracting, and all three are continuing in that work as their primary business.

This, however, was not the case with all contractors trained in the PG&E home performance program. As reported by Lutzenhiser, many of the contractors trained failed to adopt or stay with the comprehensive home performance model. There appear to be several contributing reasons, with combinations varying among contractors:

- Unwillingness or inability to master the variety of technical skills required for the home diagnostic visit
- The perceived risks of changing the existing business model, notably the possible disruption in cash flow—particularly among smaller contractors dependent on monthly receipts
- Satisfaction with current business and revenue, especially when compared to perceived risk or effort required
- Discomfort with the marketing and sales practice requirements of home performance contracting, compared to the contractor's current sales methods
- Unwillingness to deal with subcontractors or to invest in the additional staffing and equipment required to carry out comprehensive retrofits—particularly among HVAC contractors
- Lack of financial resources needed for diagnostic equipment, marketing, staffing, new managerial requirements, etc.
- Concern over possibly expanded liability exposure and insurance costs

The quality of the protocol-based curriculum and the effectiveness of the training were not cited as problems by the contractors who failed to commit to home performance. In addition, Lutzenhiser reported that all those contractors surveyed said that they had improved their basic practices as a result of taking the training course. Virtually all written student evaluations rated the training and trainers exceptionally highly throughout the program.

The results of the protocol-based training and subsequent contractor support, both for contractors who succeeded and those who left the program, suggest that while the training has been technically excellent there are still important barriers to success for many contractors. Future home performance implementation programs should consider steps to minimize those barriers. For example, it appears that larger contracting firms may be better candidates at the start of a program because of their likely greater financial strength, managerial expertise, marketing and sales practices, and risk-taking ability. Similarly, although HVAC diagnosis and retrofitting is crucial, often remodeling contractors may be better suited to manage a comprehensive home performance business due to their skills in job management, scheduling, cost control, and the effective use of specialty subcontractors—including HVAC.

But both of these observations must be tempered by the many exceptions found in actual practice. Sometimes larger and more successful contracting firms are satisfied with their current business and feel little incentive to invest in the complexities of home performance. And some HVAC contractors succeed and some remodelers fail. Ultimately, home performance contracting must be presented to a broad spectrum of contractors to find the required combination of capabilities and motivations. Early successes, properly publicized within the industry, will draw more and more contractors of all relevant types into this innovative path, either as comprehensive service providers or specialty participants.

7.0 Moving Into the Mainstream in California

7.1. Introduction and Overview

This project's technology transfer goal is to derive a practical strategy for statewide implementation of home performance contracting in California, with a focus on existing rather than new homes. Since 2003, when most of the research of this project was completed, the project has had some significant effects and other events have occurred that make it possible to define such a statewide strategy with much greater assurance than would have been possible in 2003. This chapter will discuss those effects and events, leading to the construction of a stepwise strategy for accelerated stepwise introduction of home performance retrofit contracting in California on a mass-market scale.

The project team conducted a variety of other technology transfer activities, ranging from publication of technical papers to conference presentations, regulatory testimony, and active participation in related professional society and trade association activities in support of home performance retrofit contracting. This chapter also provides an overview of those activities.

7.2. Technology Transfer Strategy

This project's efforts to maximize the use and value of its findings and products were based on these conditions confronting the home performance concept and this PIER project:

- Home performance contracting is still in an early and developing stage, with substantial experimentation in both content and delivery methods.
- The "industry" of home performance practitioners is still fragmented in practices and affiliations, with no clear organizational center or foundation, resulting in repetitive and often unproductive conflicts and a loss in overall efficiency of the industry.
- The typical homeowner knows nothing about this concept, and is typically unaware of some serious problems of the home and that solutions to known as well as unknown problems are feasible.
- The energy efficiency communities largely unaware of the existence of home performance retrofit contracting or skeptical of its practicality, largely due to simplistic conventional approaches to cost-effectiveness.
- Unaddressed long-term problems of many existing homes, such as specific HVAC system faults, excessive indoor moisture, air quality deficiencies, carbon monoxide emissions, and chronic comfort problems, constitute widespread dangers, costs, and also opportunities for high-value corrective services.

This project has produced several results to help address those conditions and move the industry forward, with particular emphasis on California. The technology transfer strategy that was developed to move those results into effective use was to focus on the industry's structural and regulatory needs and seek to improve the awareness and capabilities of key groups and organizations that could make a difference. In particular, the technology transfer strategy targeted energy efficiency professional groups and the home performance community nationally and home performance program developers, utilities, and program regulators in California.

One major goal was to provide the project's derived best practice protocols as a basis for industry debate and professional organization nationally. Another was to place and test those protocols in an ongoing home performance implementation program in California. Yet another was to begin a regulatory debate concerning the conventional practices of energy efficiency program choice and evaluation, primarily in California but with national value as well. A final goal of the strategy was to use this project's results to help promote further home performance programs in California and to build a consistent approach and identity of the emergent profession in order to educate the public without confusion.

7.3. Principal Technology Transfer Activities

Issue—Problems of conventional benefit/cost tests: Two papers were presented and published through American Council on an Energy Efficient Economy (ACEEE) in 2004 and 2006, both dealing with the project's findings on homeowner motivations versus the failure of standard benefit/cost tests to allocate project costs between energy savings and the array of non-energy benefits that homeowners rely on in making home improvement investments. Copies of the most recent paper were circulated to state energy regulatory personnel. Another presentation on the home performance concept was made to the 2003 national conference of the AESP (Association of Energy Services Professionals). Presentations on this topic were also made at three annual national Affordable Comfort conferences in 2004-06 to audiences of program administrators, utility staff, regulators, and contractors.

Issue—Lack of policymaker awareness of home performance: Oral testimony was provided in relevant proceedings of the California Energy Commission and California Public Utilities Commission. These proceedings included Assembly Bill 549 (Underutilized energy efficiency opportunities in California), the State Energy Policy Report (high-level recommendations for policy adjustments), and the CPUC's hearings on statewide energy efficiency program planning.

Issue—Testing of the project's best practice protocols: The best practice protocols developed in this project were used as the basis for the contractor training curriculum used in the home performance diagnostic and retrofit training provided by the California Building Performance Contractors Association to Northern California contractors beginning in 2003. This final project report also includes a separate Appendix developed for distribution to other program sponsors, administrators, and trainers.

Issue—Public identity and market presence of home performance: Using this study's findings and the related field experiences of the Northern California home performance programs in 2002-05, this study's principal author worked with the CBPCA to propose and secure two major home performance contractor training programs to introduce the concept in Southern California beginning in 2006. PG&E also elected to continue funding of the Northern California training based on the project's best practice protocols. This expansion and continuation of the CBPCA home performance programs serves to promote a uniform image and common practices in home performance contracting across the state.

Issue—Lack of contractor awareness and expertise: Although raising contractor awareness and capability was a goal of this project, it was implemented in California primarily through the separate funding and activities of the CBPCA implementation programs. Those efforts included informational outreach to contractors using print materials, website information, email newsletters, and direct mail and phone contacts. But a much more far-reaching national effort is the US HUD project to provide best practice protocols not only for comprehensive whole-house retrofits but also in less complex guidance for contractors seeking to make incremental improvements in the energy efficiency of their conventional home repairs and renovations. That project involves the PIER study team and is based directly on the California protocols developed in this project. When complete, it will provide online education to tens of thousands of remodeling and repair contractors nationwide.

Issue—Need for a statewide California strategy for accelerated introduction: The remainder of this chapter presents the remaining technology transfer activity, a recommended approach for moving home performance retrofitting into greater public awareness, acceptance, and adoption throughout the state.

7.4. Principles For a Successful Statewide Introduction Strategy

This section suggests a framework of key principles and strategy for ultimate statewide success in home performance program design and implementation. Key points include these:

Market image: Home performance contracting should be closely allied or merged with the Green Building and Solar Roofs initiatives in California. This alliance would benefit all three movements and simplify the public education message, promoting more rapid acceptance.

Homeowner benefits: Homeowners appear to justify the relatively high average expenditures on home performance retrofits by a combination of their energy and non-energy benefits. Solid proof of the importance of each motivation is needed.

Public benefits: Program experience indicates that comprehensive whole house retrofits achieve much higher energy and demand savings than any other existing-residential program. In addition, there are substantial non-energy benefits that may be more important than the energy savings in motivating homeowner investment.

Program management: Programs in different regions of the state can be initiated and managed by different organizations, as long as they are operated on similar principles and practices. It is likely that these organizations must be independent of the local power utilities in order to contain any risks of lawsuits arising from customer-contractor disputes.

Professionalism: Home performance contractors need association with a professional group to provide access to latest developments nationally, reliable standards and practices, public education support, certifications, a consistent image and marketing, mechanisms for sharing knowledge, and a sense of professionalism.

Program support: Key legislators, utility managers, and public advocates must be educated. Implementation support must be substantial and sustained for several years, although not permanent. Research is also needed to characterize the homeowner decision-making process and the influence of both energy savings and the full range of other benefits. Those results are needed to justify refinement of the CPUC benefit/cost tests to avoid bias.

Geography: The program should be staged among the state's major geographic regions, starting in limited core areas with highest payoffs in hot-climate energy and demand savings.

Contractors: Need alternative transition paths with flexible schedules to reach full home performance; also screening, financial assistance for equipment and training, and field mentoring, and incentives for program compliance.

Quality assurance: Field mentoring support and independent job quality inspection are needed; training and certification are not sufficient.

Retrofit scope: Probably necessary to include partial home performance retrofits, at least initially, but focus on complete whole house contracting as the single ultimate goal

Program scope: Contractor training and mentoring is the core need, backed by initial consumer education and lead development plus active quality assurance using both contractor capability testing and home performance verification.

Use of incentives: Contractors need incentives such as initial customer leads, readily available training and support, access to consumer financing, and assistance in covering equipment investment costs. Once initial programs become established in a major region of the state, utility financial incentives to consumers (in financing cost buydowns or direct rebates) can accelerate the rate of adoption by homeowners and hence the benefits to the public.

Program growth: Gradual, stepwise spread of State coverage in keeping with annual public funding limitations as contractors in initial areas become self-sufficient and the level of required local support declines.

Learning curve: Provision for contractors to offer less than comprehensive home retrofits as a step toward full whole house contracting, with a clear distinction drawn in program marketing. Contractors should be rewarded for offering broader workscopes, either by controlling access leads or through incentives.

Utility involvement: Active coordination and cooperation between local power utilities (gas and/or electric), for marketing and some of the training, and independent providers of the contractor training and field support.

Flexibility for contractors: Pathways into home performance contracting for a variety of residential contractor types as well as home inspectors and energy raters. This involves different business models and degrees of training required.

Estimated program duration: Full statewide success is likely to require between five and ten years at $1-2 million per year for public education, contractor participation and training, incentives, quality assurance, and ongoing program evaluation. This should be followed by an indefinite period of lower-level public support for quality assurance activities—primarily periodic random job inspections and testing, complaint reviews, continued public education, and training of new contractor entrants, and contractor skill updating.

The following paragraphs elaborate on some of the most important principles.

7.4.1. Homeowner Benefits of Home Performance Contracting

Experience has shown that homeowners typically have been willing to spend far more on home performance retrofits than in other energy efficiency programs: Jobs have averaged some $8000 in New York and $12,000 or more in California. These expenditures often cannot be realistically justified by energy cost savings alone. However, surveys and anecdotal reports indicate that homeowners value other benefits (safety, health effects, comfort, home value) highly enough to make these more extensive home repair jobs attractive to them.

This obviously has significant implications for program marketing. These consumer investments in non-energy benefits increase the number of consumers willing to make investments in energy efficiency as well and increasing the depth of savings achieved by each household. The entire retrofit package may not be cost-effective based only on energy savings, but consumers are satisfied that they are receiving a good combined energy and non-energy value for their investment.

7.4.2. Public Benefits and Bias

To date, benefits of home performance programs have been judged only with respect to their forecast energy savings using before/after simulation modeling. Some stronger evidence is also being gained from before/after utility billing data now becoming available. These current sources suggest that test-based whole house retrofits often yield very high energy savings—well beyond those of more conventional and limited home energy retrofit programs relying on single measures such as lighting, appliance replacements, or insulation.

Although non-energy benefits of whole house retrofits are substantial (enough to apparently justify the total homeowner cost), they have not been directly included in program benefit/cost evaluations. This is in part due to the lack of data for measuring such benefits, but also to the CPUC's mandated focus only on energy savings. Consequently such important public benefits as home safety, health, job creation, and tax revenue are not considered.

In addition, the current process fails to recognize the long-term expansion of energy savings due to future jobs of program-trained contractors after the program ends. These barriers are further discussed in the following paragraphs.

7.4.3. Program Support Levels

The establishment of retrofit home performance contracting is unavoidably a major market transformation effort. Experience both in California and elsewhere demonstrates that despite the benefits to homeowners, contractors, the economy, and the environment, a transition away from conventional home repairs and renovations to widespread adoption of home performance contracting will require several years or even longer. During that time of extensive public education, contractor training, and field support, substantial and sustained programmatic support will be needed.

The California Home Performance Program funded by the California Public Utilities Commission for the PG&E service territory began operation in 2003 and was re-funded and expanded for 2004-05, but still covers only the bulk of the PG&E service territory—a fraction of the state's area and population. Because the scope of the training in that PG&E area program was so broad as well as deep in detail, and the need for field quality assurance was so important to public confidence, the logistical requirements were too great and the annual level of possible funding too limited for rapid deployment statewide. Without larger funding commitments, it is likely that 10 years or more will be required to achieve significant levels of market penetration across the entire state. Increased program support must also be sustained if that goal is to be reached. In New York State, the successful pioneering NYSERDA program is now in its sixth year at a much higher annual level of financial support (about $3 million per year on average) than has been the case in California.

7.4.4. Non-Energy Benefits are Crucial

The CPUC has a responsibility to assure that its total energy efficiency program benefits exceed its costs. "Benefits" and "costs" have specific definitions per the CPUC's use of standard benefit/cost tests. In the CPUC program screening and selection process, which depends heavily on the standard Total Resource Cost (TRC) test, virtually the only benefit considered is the present value of anticipated avoided energy costs (that is, savings) over the life of the measures installed during the program. Costs include program management and delivery as well as the homeowner's full cost. These definitions tend to create a bias against home performance programs, since the costs of those programs are actually justified by homeowners on broader grounds including valuable non-energy benefits.

Energy savings are only a small part of the rationale, as indicated in surveys done in the recent PG&E-area home performance retrofit programs (Lutzenhiser 2006). The results of nearly 60 homeowner interviews who invested in home performance retrofits are summarized in the following table:

Table 7.1. Results of homeowner interviews

Motivational Factor	Rated Very Important	Priority Among "Very Important" 1st	2nd	3rd	Total in Top 3	3-2-1 Weight
Improve home's comfort	**50**	**15**	**8**	**8**	**31**	**69**
Replace older equipment	**47**	**14**	**1**	**3**	**18**	**47**
Save energy & resources	**47**	**5**	**15**	**5**	**25**	**50**
REDUCE ENERGY BILLS	**45**	**8**	**14**	**12**	**34**	**64**
Improve indoor air quality	36	4	1	4	9	18
Increase / preserve home value	31	4	5	4	13	26
Contractor Affiliated with E-Star	26	0	0	1	1	1
Address Health issues	25	1	5	1	7	14
Rebate Available	24	0	1	2	3	4
Retrofits indicated by contractor	15	0	0	0	0	0
Improve home's appearance	13	1	0	2	3	5
Work recommended by HP test	11	0	0	1	1	1
Add additional space	2	0	0	0	0	0
Interest buy down program	1	1	1	0	2	5
Customer choice (Home Depot)	1	0	0	1	1	1
Reliable windows	1	0	0	0	0	0
Contractor's knowledge and rep	1	0	1	0	1	2

As shown in Table 7.1, there were 17 motivations reported by the homeowners for their decisions to undertake retrofits. Respondents rated each as Very Important, Somewhat Important, and Not Important, and also rank-ordered their top three Very Important choices. The choices are presented in order of the number of respondents who rated them Very Important (first numeric column). The next three columns indicate the number of respondents who rated each motivation as their first, second, and third most important. The last two columns provide two different scoring methods: first, the sum of votes for those three top choices; and second, the sum of those choices but with the first choice rated at a score of 3, the second at 2, and the third at 1.

This results in three scoring methods, including the first-column totals. Note that the top four motivations all scored above all others on all three methods although their order of importance (as defined by their scores) among themselves varied slightly for the different methods. The principal implication to be drawn from these results appears to be that “Reduce Energy Bills” accounts for no more than about a quarter of the total reported motivation for investing in home performance—and if the scores for choices 5 through 17 were also considered, the “Reduce Energy Bills” share of total motivation would be even less of the total. Non-energy motivations clearly dominated.

7.4.5. Near-Term vs. Long-Term Benefits

In home performance programs, each contractor trained may require a year or more to fully transition and become effective, so early evidence of energy savings tends to be sparse. The state’s perspective now omits the long-term benefit-multiplying effect of the trained contractors continuing to add more home performance jobs (and their energy savings) every year after the program ends—in addition to the continued savings of prior jobs. This effect is shown in Figure 7-1.

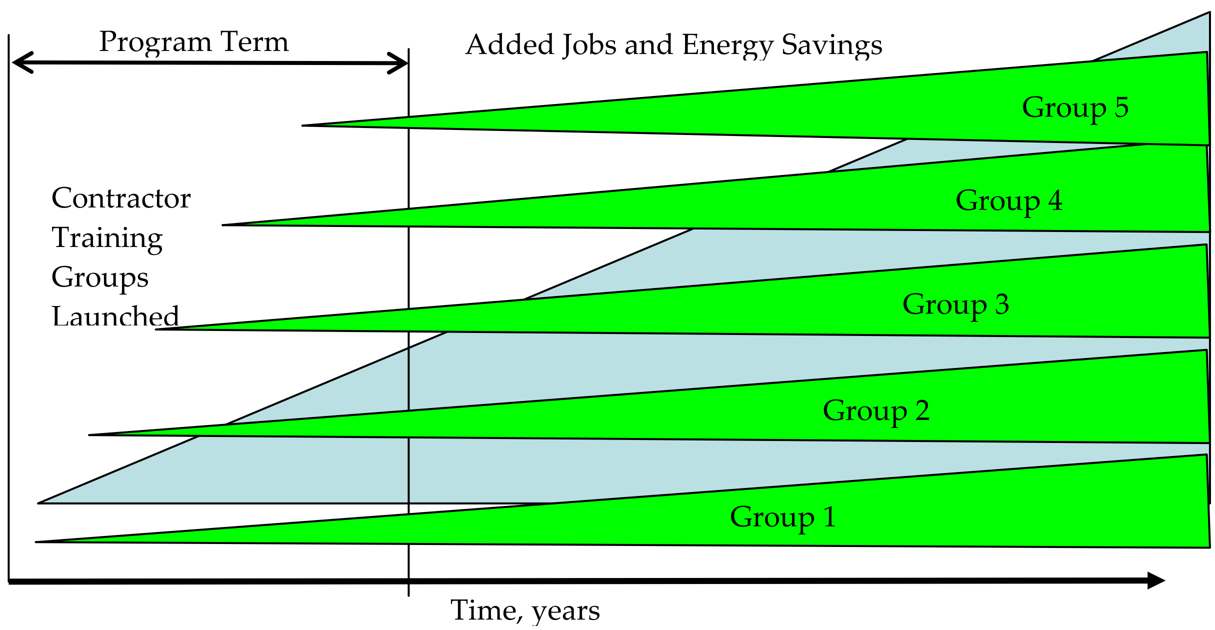

Figure 7-1. The multiplying effect of contractor training

This program-term restriction clearly produces a major bias against any program that creates a lasting capability to keep generating new energy savings, rather than simply installing energy savings for the program’s duration and then ending, as most conventional incentive programs do. Since comprehensive home performance retrofits inherently produce the greatest available savings, in addition to the long-term nature of its savings in each home, the bias against that concept is particularly counterproductive. Modernization of the current evaluation practice is essential.

7.4.6. Getting Contractors Involved

There are many serious barriers to contractor acceptance of home performance contracting despite the potential benefits to them. These range from training time and learning style constraints to lack of financial strength, acceptance of innovation and change, and willingness or ability to surmount the difficulties of technical complexity, different business management requirements, and marketing skills. It is essential to recognize the barriers and incorporate solutions such as financial aid, technical support, and active public education and marketing. As the program builds public momentum, market pressures will also be helpful in recruiting contractors. Certification helps to create this market pressure.

In California in particular, Green Remodeling and Solar Roofs programs are increasingly popular. The contractors as well as their customers involved in those activities are also likely to be most open to comprehensive energy efficiency retrofits as a closely related concept. It will be especially important to encourage the participation of those specialty contractors.

7.4.7. Quality Assurance

Experience nationwide in current home performance programs indicates that formal inspector and installer testing and certification may be valuable indicators of ability. However, job assessments suggest that certification alone is inadequate to assure quality. Both field mentoring of new trainees and independent job reviews are needed. Formal training cannot be both short enough to be reasonable for contractor personnel yet extensive enough to assure ability, particularly in the sophisticated skills required for comprehensive home testing and inspection. And without subsequent on-the-job testing and an independent random quality inspection process, experience indicates that even highly qualified personnel can unknowingly fail to achieve quality targets. However, mentoring and field quality inspections are costly. Programs may need to impose fees on contractors who require more than a base level of such support, justified by program features such as the value of its name recognition (including Home Performance with Energy Star) in advertising.

7.4.8. Educating the Market

Almost universally, homeowners have never had access to a comprehensive home performance inspection and retrofit process. The entire concept must therefore be introduced and taught, relying on their imagination and understanding to understand its value. This is inherently a tall order. Its success relies both on high-quality marketing materials and activities, and must take advantage of the conventional market penetration sequence for most new products: The earliest adopters tend to be few but enthusiastic, and can be used as “success stories” to induce increasingly risk-averse segments of the homeowner population.

Experience also indicates that direct person-to-person market education and solicitation, such as home show presentations and booths, may be most effective. Other useful approaches include local media coverage of “demonstration” home inspections and referrals from initial customers. If resources permit, high-quality media advertising can be effective but is often too costly. For example, New York has focused on recruiting contractors in smaller media markets, in part due to the cost of media access in the larger market. This has allowed the program to generate initial success at a lower cost.

As noted in an earlier section, homeowners interested in Green Remodeling and Solar Roofs are prime candidates for home performance retrofits. Marketing convergence among all three of these initiatives would be beneficial to all as well as a convenient way to simplify the marketing message for home performance. This convergence among contractors (and programs) should be encouraged by program managers and their sponsors.

7.4.9. Defining Home Performance

Experience seems to indicate that for most contractors the transition from conventional practices to full whole-house contracting cannot be made in a single step. The extent of new managerial as well as technical knowledge and practice is too extreme for all but rare cases. This often results in failure of contractors to complete the training or to implement the whole house approach once trained, thus wasting program resources on such candidates. Program managers are also finding that some trained contractors are tempted to limit their retrofit recommendations to the specialties they know best. For instance, an HVAC contractor may avoid building shell improvement measures because of the need to employ and manage subcontractors without a substantial return on that part of the job. This typically results in much lower energy savings as well as loss of some valuable non-energy benefits.

Rather than blaming the contractors for these failures, it is best to accept the reality and design programs that provide slower and more flexible pathways to full home performance contracting. Training might focus first on the basic principles of home performance and then emphasize the importance of testing and diagnosis—even if the contractor's scope is limited to one specialty such as HVAC or insulation. Continuing education and assistance could then be provided in various ways over time to allow such contractors to adjust their business, gain broader skills, and perhaps—though not necessarily—to gradually expand their job scopes as they gain experience and see value.

7.5. A Strategy for Advancing Home Performance Contracting in California

The lessons gained in the PG&E home performance retrofit program, coupled with a review of the results of other similar programs around the country and subsequent relevant events in California, led to the derivation of the principles just cited and a recommended strategic approach to accelerating the adoption of home performance retrofit contracting in California. Those considerations point to a program strategy that combines several major elements, as discussed in the sections below.

7.5.1. Program Support

- Gain state and federal support for key research efforts to prove value of non-energy benefits as well as a broader range of public benefits in home performance contracting
- Provide program incentives for contractors' routine collection and submittal of job scope and results data, for use in demonstrating value of home performance programs
- Develop alliances with organizations having related interests, especially public-good advocates and equipment suppliers; also educate key state legislators

- Use research results, contractor job data, and allies to achieve improvement in CPUC benefit/cost tests and evaluation procedures to permit fairer treatment of home performance proposals in utility program selections
- Encourage home performance programs by different sponsors, but preferably all linked to a shared professional identity such as CBPCA
- Use proven utility program successes to gain foundation grants and supplier support for program transitions and expansions

7.5.2. Contractor Development

- Develop and deploy multi-stage training pathways to full-scale home performance contracting, to engage more contractors and avoid time pressure (such as HUD 3-level protocol set)
- Create a portfolio of diverse effective contractor business models, involving a variety of specialists as well as full-service integrators
- Develop a strong statewide professional identity (CBPCA or similar, with national affiliations), providing valuable contractor support services supported by dues, fee-based services, and donations
- Encourage an open market for contractor training and related utility programs by different providers, with CBPCA serving as a professional support organization for all
- Work with the Contractors State License Board to get a specialized contractor license established for home performance
- Support national home performance professionalism efforts (such as BPI) to standardize quality, reduce liability risks, and obtain more economical liability insurance

7.5.3. Public Education and Market Development

- Emphasize importance of direct marketing by contractors, and teach low-cost "guerilla marketing" techniques.
- Merge marketing and delivery efforts with those of related initiatives such as green building and solar roofs, in addition to Home Performance with Energy Star, to maximize the environmental sustainability of residential lifestyles
- Propose and implement a series of stepwise utility-funded public education and contractor training programs plus financial incentives focused on contractors
- Collaborate with building equipment and supplies manufacturers for intensified educational outreach to contractors and the public
- Establish and maintain contractor-funded quality assurance and field support backed by credible standards-based national authorities

Four strategic phases for gaining market development are outlined in Table 7.2.

Table 7.2. Phases of the strategy

Phase 1: FOUNDATION		Start motivational research, build field data proof of public as well as private value, refine and complete current SoCal programs, educate key legislators, potential allies, and utilities statewide; conduct current home performance programs per strategy; develop and begin initial member services to contractors.
Phase 2: PARADIGM SHIFT		Fully integrate with Green Building and Solar Roofs programs; achieve expanded State/utility program support; complete and introduce combined public education campaign; expand contractor base and services.
Phase 3: CONSOLIDATION		Emphasize strengthening of professionalism and professional association (CBPCA or similar); further expand contractor base; refine contractor practices and standards; continue funding activities.
Phase 4: MAINTENANCE		Deliver expanded support services routinely to trained contractors; seek continuing support for public education and contractor awareness; keep supporting organizations informed of progress and value of support.

7.6. The Value of a Successful Strategy

Payoffs of that strategy could be extensive, both for the homeowners and contractors involved as well as their communities and the general public good in California. By 2010 the state will have approximately 10 million single-family homes, including attached townhomes as well as detached houses. About 95% of those homes already exist, since the annual rate of new construction is only 1–1.5% of the total stock—just about enough to house population growth and assure that virtually all existing homes will continue to dominate the housing stock for decades to come. Virtually the entire housing stock, including many of the homes being built today, will have significant built-in energy-wasting characteristics, and many of those may also have serious health and safety risks as well as comfort and durability issues.

With effective implementation, the proposed strategy could result in substantial market penetration in all major California population centers within five to ten years. For every *1%* of that housing stock that is comprehensively diagnosed and retrofitted, the energy and peak demand savings are likely to be very large. If the average retrofitted home reduces its peak summer afternoon electricity demand by 2 kilowatts (kW) (and its gas and electricity use by 25% (proven achievable levels) the resulting savings would be 200 megawatts (MW) in peak electricity load (avoiding construction of a major utility-scale peaking power plant and major upgrades to power transmission and distribution facilities) and gas and electricity use reductions equal to the totals for 25,000 homes. There would also be many other benefits, ranging from increased construction jobs, economic activity, and increased local tax base, to public health gains, reduced energy resource use, and gains in air quality and climate change reductions. This contrasts sharply with existing single-measure energy efficiency upgrades such as insulation, compact fluorescent lights, and high-efficiency furnace and air conditioner replacements, which may reach more homes but produce far less savings.

A ramp-up to that one percent per year retrofit rate and beyond is possible—if the population is educated to understand the benefits and contractors are motivated, trained, equipped, and organized to meet the ensuing demand. There are approximately 30,000 contractors in California who could be candidates for home performance delivery; for perspective, if ten percent of them were trained and delivered one retrofit per week, the resulting total retrofits per year would exceed the one percent of homes by 50%. And with effective public education and demand pressure, that ten percent of contractors could actually deliver far more retrofits.

8.0 Conclusions and Recommendations

8.1. Introduction and Overview

This PIER project has been very influential in shaping the course of home performance contracting in California and beyond. The project's diagnostic protocol set has been used in home performance contracting curricula, as an interim technical reference for contractors, and as the foundation of a national-scale project sponsored by the U.S. Department of Housing and Urban Development to promote more energy-efficient practices by home repair and remodeling contractors nationwide under the multi-agency PATH program. The program's field training and energy savings studies have demonstrated the feasibility of the concept, resulting contractor capabilities, and the value of comprehensive home retrofitting. In addition, its technology transfer activities have advanced the state of the art in understanding the value of non-energy benefits in home retrofitting and the inadequacy of commonly used benefit/cost tests for utility selection and evaluation of residential energy efficiency programs. This chapter summarizes a variety of conclusions and recommendations based on those results.

8.2. Program Theory and Strategy

The basic theory of home performance retrofitting is that maximum energy savings as well as non-energy benefits can be gained in the hard-to-reach existing residential market by training contractors to understand basic building science, inspect and identify energy-related deficiencies in homes, and offer and execute comprehensive home energy retrofits. The challenges to this theory are numerous. Homeowners might not trust the trained contractors, fail to appreciate the benefits, and refuse to accept the costs, which are relatively high per home due to the extensive nature of the improvements involved—heating, cooling, ventilation, water use and heating, insulation, windows, air sealing, baseload appliances, and more. The contractors might not be able to learn the required concepts and procedures, or not be willing to follow them properly. The difficulties of adjusting to a new business model might be too great for many contractors. Utilities and other funding sources might not be willing or able to support the startup of this new approach, due to personal beliefs as well as regulatory limitations. Incentives, whether in the form of monetary support or intangible benefits, might be inadequate for either contractors or homeowners.

Some of these concerns proved to be justified. The program's field studies demonstrated some continuing challenges. Foremost was the contractors' unwillingness to report their home diagnostic results for either research or program justification reasons. It became clear that a public-benefits sponsored home performance retrofit program must provide direct positive incentives to contractors to induce adequate reporting. Also, many contractors failed to transition into a home performance business after training. Evaluation surveys indicated that the principal reasons were both technical and managerial: Some contractors were unable to master the diagnostic procedures, while others, particularly the smaller businesses, found the time and financial investments as well as the selling and other business process changes beyond their ability. This suggests that home performance programs should focus initially on larger and more professionally managed contracting firms—both remodeling/home improvement and mechanical. Those firms are much more likely to see and value the business proposition of energy retrofit contracting, and to be able to invest adequately to start and sustain it.

But the positives outweighed those problems. This project, in coordination with the parallel implementation of a startup home performance contractor training program under California Public Utilities Commission auspices by the California Building Performance Contractors Association, demonstrated that the challenges to home performance contracting are real but can be overcome. The project successfully demonstrated the training of many contractors, and even firms that did not succeed in implementing home performance contracting reported that they had improved the energy savings and quality of their work practices because of the training. The joint California Energy Commission and CPUC projects also saw the completion of many home retrofits, the achievement of major energy and peak demand savings, and a very high degree of homeowner satisfaction despite costs much higher than could be justified by the energy savings alone. Surveys proved that non-energy benefits inherent in comprehensive home retrofits were widely perceived, valued, and provided the dominant rationale for many homeowners' decisions to have the work done.

8.3. Contractor Engagement and Training

Many contractors did respond to the availability of home performance retrofit training and support. In the initial four years of the CPUC implementation program, nearly 200 persons were trained, representing over 70 firms. A substantial effort and investment was required in marketing the program to contractors, however. Two innovations accelerated the acceptance of the program by contractors. The first improvement was in using databases of commercial "list brokers" to identify more precisely the contractors most likely to be capable of success: larger, longer in business, and in the right specialties and locales. The purchased custom lists of candidates also identified the business owner, manager, personal contact information (phone and email), and evidence of freedom from customer complaints or litigation.

In the second innovation, after an initial period of low response to mass-mail and phone invitations, a two-day conference was developed, marketed more heavily, and held with over 250 attendees who were mostly contractor personnel. That conference included demonstrations of basic principles, tools, diagnostic methods, and prior contractor success stories, was very successful in creating broader interest in the training. After the conference the program had no further difficulty in attracting contractors to the training courses, although it has still been difficult to attract larger contractors who are already successful in their conventional specializations.

The training itself was largely successful. Firm owners first attended a one-day orientation on the business and marketing aspects of home performance retrofit contracting, to encourage interest in attending a six-day technical training course for themselves and their key marketing and technical field staff. That initial management workshop was based in part on this PIER project's business practice protocols. The six-day course, modeled on this PIER project's protocols for diagnostics, provided a strong technical basis for field practitioners. Although it included 1½ days in the field (in homes volunteered as training sites), however, it was found that substantially more field experience was required to master the tools and test procedures. The CPUC project provided extensive field mentoring for this purpose, and the process produced a broad range of contractors committed to incorporating home performance retrofitting into their business.

8.4. Marketing and Quality Assurance

The marketing of home performance retrofits to potential customers was done in a variety of ways. Because of the unacceptable expense of intensive mass advertising, the CPUC program's strategy was to train contractors in economical and cost-effective marketing techniques, restricting its own marketing activities to providing marketing materials, placing stories in local newspapers and broadcast media (generally reporting on a home demonstration of the concept) and organizing joint display booths at local home shows throughout the Northern California (PG&E) region. HVAC contractors tended to find this adequate, largely due to their long lists of past and current customers for their conventional installation and service offerings. Remodelers tended to have fewer such contacts, but those most successful invested in limited and targeted direct advertising efforts to attract customers.

Obviously more direct utility assistance would be extremely valuable in marketing this new service to homeowners. Often legal liability concerns can make that utility support unlikely, as it did with PG&E in the CPUC program, but current CPUC policy is encouraging stronger utility support for independent "third party" energy efficiency initiatives. The single greatest help to home performance contracting for public benefit would be for the utilities to make energy usage and billing data more easily available to contractors or program administrators, in order to focus their marketing on neighborhoods and individual homes with the strongest evidence of excessive use and potential energy and demand reductions.

It also appears natural for home performance retrofitting to be marketed together with related advanced environmental concepts such as Green Remodeling and Solar Roofs. To date, that approach has been only tentatively applied in the California programs but should be pursued among the various sponsoring groups as well as utilities and regulators. A variety of business models could be applied to this combination, with several contractors complementing one another's specialties to build teams capable of any combination of services. Verification of energy savings is essential in all State-funded programs, notably both solar photovoltaic installations and associated energy efficiency retrofits in any combined photovoltaic/energy efficiency program.

Quality assurance is closely related to marketing, since if quality is inadequate in early contractor jobs testimonials and word-of-mouth support will be lost. The CPUC/PG&E program emphasized the importance and appropriate methods of internal quality assurance by the contractors themselves, and also conducted sample-based re-inspections and tests of jobs completed as an independent assurance of quality. In general, quality of work was high among the contractors who remained active in the program. One difficulty—also found in other home performance programs elsewhere—was a tendency among many HVAC contractors to avoid the building shell measures and focus instead on quality testing and improvement of the HVAC system only. That is, they tended to want to remain in their original specialization rather than broaden their licensing and managerial scope to include the use of subcontractors or new in-house specialties. Testing and improvement of the building shell is vital in reducing a home's thermal load and therefore its need for energy consumption, so this reticence is a serious issue. It was addressed primarily through further mentoring and consulting advice on the best methods and benefits of broadening each job to be truly comprehensive.

8.5. Program Sponsorship Strategy

In California new concepts such as home performance retrofitting find great potential opportunities in the State's uniquely broad and well-funded energy efficiency mandates. However, the major utilities under the CPUC's jurisdiction (PG&E, Southern California Edison, San Diego Gas and Electric, and Southern California Gas Company) are subject to stringent near-term energy savings goals that force them to choose only the programs—both their own and independent offerings by "third parties"—that provide the greatest and surest kW and kWh savings before 2009. In addition, the selection of programs is largely determined by their projected energy and energy cost savings as determined by a CPUC methodology that ignores the non-energy benefits that provide most of the consumer motivation to undertake comprehensive home energy retrofits. Consequently such home performance retrofit programs cannot be competitive despite their very large energy savings and consumer satisfaction with their costs versus benefits. Part of this program's technology transfer activities included an ACEEE-published paper on this topic (Knight et al. 2006), concluding that the major share of the motivation for buying a comprehensive retrofit tended to be the variety of non-energy benefits rather than utility bill savings.

The strategy for increasing utility support for home performance retrofit programs, therefore, must be based on providing the strongest possible evidence and argument for a change in the current method of project assessment and selection that the major utilities are required to use. Some initial evidence was provided through surveys of satisfaction and motivation among buyers of home performance retrofits in the PG&E/CPUC home performance program. However, that initial evidence must be tested and supported by more extensive studies of homeowner motivations for undertaking home performance retrofits as well as other energy-saving measures. That more credible evidence will be necessary to support a statewide policy change on the handling of non-energy benefits that will be the key to the broader adoption of home performance retrofit programs by utilities.

Behind that element of the program sponsorship strategy is the need for utility sponsorship to support the large-scale public education, contractor enlistment, training, and quality assurance that will be needed to move the retrofit home performance concept into the mainstream. The home performance concept deserves the same kinds of utility incentive support as more limited single-measure programs, including incentives for contractor participation as well as customer investment. No other source of support can provide that large-scale statewide financial backing. Equipment and materials suppliers can help, but their support capabilities are limited and are best targeted at home performance contractor professionalism through trade and technical associations, certifications, and their own marketing.

Time is critical in this strategy. Research support is needed now in order to provide results that can be incorporated into the 2009–2011 statewide energy efficiency program design to open the door to home performance retrofit programs in that period. Development of alliances with other parties in the energy regulatory process are also crucial to supporting policy change, and must take place during that same time—the next two years.

The appropriate leadership for this change is logically within the California Energy Commission, as the state's champion for energy-related research and the implementation of its results and products in state energy efficiency activities. That leadership can be supported by the California Building Performance Contractors Association in its current home performance programs and related energy rater training through its status as an Energy Commission–certified Home Energy Rating System (HERS) provider. The CBPCA is the only emergent organization in California specifically representing and supporting home performance retrofit contractors. CBPCA representatives promote home performance retrofitting by operating utility-funded implementation programs as well as participating actively in CPUC energy efficiency regulatory proceedings, utility working groups, and other related industry organizations both within California and nationally.

8.6. Process Design and Management

This project's field studies showed that the home performance retrofit process used in the PG&E/CPUC program in 2002–2005 succeeded in its basic goals of engaging contractors and producing large per-home energy savings through those contractors. In particular, the protocols provided by this project were shown to be practical and effective as the foundation of technical training and reference. However, as noted earlier in this chapter, those field studies also showed that a variety of refinements appeared needed to maximize the program's results. Among those needed refinements in process design and management are incentives to contractors for job reporting, a more extended and stepwise approach to training, screening for improved contractor commitment, and contractor management process aids (such as software systems for job control, skill upgrading, and energy savings tracking).

8.7. Public Policy Needs and Strategy

This area of project conclusions and recommendations is focused on the revealed bias against retrofit home performance programs in the current CPUC program assessment and selection process, notably ignoring the non-energy benefits that the project showed to be the primary drivers of homeowner participation and satisfaction. The required strategy for overcoming that bias is broad-based advocacy in the utility program regulatory process backed by research findings that authoritatively confirm the relative importance of non-energy benefits in homeowner decisions to do such comprehensive retrofits (if that indeed proves to be true, supporting this project's initial findings).

That research should be given very high priority within the PIER program as well as in Federal energy-related R&D programs. It should involve both home performance experts and specialists in the assessment of personal decision making, motivations, and values through sophisticated social science research methods such as psychometric surveys.

8.8. Industry Organization

Home performance retrofit contracting is not yet an identifiable organized industry, nationally as well as in California. Too few contractors are active, processes and standards are not yet agreed, and there is no formal organizational support structure. The step up to a professional organization of the industry, analogous to others such as ACCA or National Association of the Remodeling Industry, will be an important step in raising broad awareness of home performance improvement opportunities among contractors as well as the public at large. In California, the California Building Performance Contractors Association is acting as an "incubator" for that function through its broad training programs and technical/managerial support to the contractors trained. As the number of involved contractors grows, the CBPCA may become the de facto industry association for California, but that will depend on many factors not yet visible.

A national organization is needed to create and enforce standard practices, promote professional advancement, and enhance the identity and credibility of home performance contracting with the public and the home improvement element of the contracting industry. Such a national organization may emerge instead (or in addition) out of the current mix of supporting entities such as ACI (formerly Affordable Comfort, Inc.), the principal forum for the emerging industry's professional communications and convocations, and the Building Performance Institute, a nonprofit group dedicated to professional home performance standards and certification.

The formation of such a national professional society or trade association may be accelerated usefully by the current HUD-managed PATH 36 project to build an online easy-access information system of home energy-related best practices for use by contractors nationwide. That project's product will require continuous review and updating as practices and technologies evolve, and it offers the opportunity for creation of a system of topical review committees that could evolve into a professional organization much like ASHRAE or other groups that promote consistent standards of professionalism through voluntary committee structures.

8.9. Conclusion: The Future of Home Performance Contracting in California

Chapter 6 of this final report presents a strategy for accelerating the adoption of home performance retrofit contracting throughout the State. That strategy builds on the current situation following this project's completion, including the recent awarding of two further home retrofit programs by Southern California Edison and the Anaheim Public Utilities board. Both programs are closely linked to the CBPCA's ongoing home performance training for PG&E's Energy Training Center in Stockton. Other utilities are watching these new programs and considering their own versions. In addition, some manufacturers of building materials and particularly HVAC equipment are beginning to show interest in building science and more comprehensive retrofits in their own contractor marketing and education. These suppliers should and are likely to become allies and financial supporters of the home performance industry.

A principal obstacle to further programs in home performance is the current CPUC approach to the judging and selection of new energy efficiency programs. That approach fails to properly consider the market effects of non-energy benefits in its standard screening tests for proposed programs. Those tests, especially the current version of the TRC test, need to be adjusted to make allowance for the portion of the homeowner's cost that can be justified by a project's non-energy benefits such as indoor air quality, health and safety, home and equipment durability, comfort, and environmental stewardship. That policy change in turn is likely to require more definitive research results on the reasons for homeowner motivations to make such home improvements. That research should be undertaken as early as possible, in concert with the new home performance programs in Southern California as test sites.

Despite obstacles, the home retrofit contracting model is now established and increasingly visible in California, in large part due to the activities of this PIER project. If carefully targeted research is undertaken to strengthen the home performance concept and to remove specific structural obstacles, along with the advancement of related programs such as quality HVAC installations, public education on home performance, integration of home energy performance into the green building movement, and tie-ins with emerging California solar energy initiatives, the coming decade should see the emergence of comprehensive energy-related home upgrading as a mainstream energy efficiency strategy with broad utility support and public acceptance.

8.10. Benefits to California

Effectively strengthening and gaining acceptance for the whole house energy performance model, along with its integration with the green building and solar energy movements, will require the emergence of a comprehensive energy-related home upgrading strategy. As this approach gains political and public support, the state will realize substantially increased residential energy savings. The reductions in home energy use and peak-period electricity demand across the state will mean greater energy security, reduced energy costs, avoidance of unnecessary investment in electricity system expansion, new skilled jobs in home improvement, and a host of environmental benefits.

Finally, homeowners and occupants will realize major non-energy benefits, such as increased comfort, safety, and indoor air quality (IAR) and resulting health improvements, as well as savings in home repairs—all of which will increase individual motivation to invest in these improvements and thereby to create a level of energy savings otherwise lost through conventional practices.

9.0 Selected References

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Reed, J., L. Lutzenhiser, R. Kunkle. 2003. *Evaluating Programs Targeting the Commercial Buildings Sector*. International Program Evaluation Conference: Short Course in New Evaluation Techniques.

Walker, I. 2003. *Draft Best Practices Guide for Residential HVAC Retrofits*. Energy Performance of Buildings Group, Lawrence Berkeley National Laboratory. April.

Websites for further information:

www.cbpca.org (California Building Performance Contractors Association)

www.affordablecomfort.org (ACI, the national forum for home performance specialists)

www.energystar.gov (portal to reach *Home Performance with ENERGY STAR* program pages)

www.bpi.org (Building Performance Institute, national credentialing and standards source)

10.0 Glossary

ACCA	Air Conditioning Contractors of America
ACEEE	American Council on an Energy Efficient Economy
ACH	air changes per hour
BP	building performance
BPI	Building Performance Institute
Btu	British thermal unit
CAZ	combustion appliance zone
CBPCA	California Building Performance Contractors' Association
CDD	cooling degree days
cf	cubic feet
cfm	cubic feet per minute
CO	carbon monoxide
CPUC	California Public Utility Commission
DHW	domestic hot water
Energy Commission	California Energy Commission
HDD	heating degree days
HERS	Home Energy Rating System
HUD	U.S. Department of Housing and Urban Development
HVAC	heating, ventilation, and air conditioning
IR	infrared
kW	kilowatt
kWh	kilowatt-hour
MW	megawatt
NFP	not-for-profit
NP	non-participant
PATH	Program on Advanced Technology in Housing
PG&E	Pacific Gas and Electric Company
PIER	Public Interest Energy Research
PP	partial participant
RD&D	research, development, and demonstration
SEER	seasonal energy efficiency ratio
TRC	Total Resource Cost
VOCs	volatile organic compounds
WAP	Weatherization Assistance Program
WH	whole house

Appendix A: Project Advisory Committee

Name	Qualifications	Contact Information
Steve Baden RESNET Executive Director (San Diego)	Works closely with energy raters; highly knowledgeable in HP	Steve Baden [sbaden@natresnet.org] (760) 806-3448
Rick Chitwood Chitwood Energy Management (Mt. Shasta, CA)	Highly qualified building performance contractor /consultant	Rick Chitwood [chitwood@inreach.com] (530) 926-3539
Dale Gustavson California chapter director, Air Conditioning Contractors of America (San Leandro, CA)	Highly experienced in HVAC contracting, important industry association	Dale Gustavson [dale@calacca.org] (866) 602-2900
Peter Lai Technical staff, CPUC Energy Division (LA)…(now PG&E) alt: Jay Luboff, SF	Important California agency for energy efficiency program implementation	Lai, Peter [ppl@cpuc.ca.gov] (213) 576-7087
Courtney Moriarta (former) Executive Director, Building Performance Institute (NY), now with Steven Winter Associates	HP certifications, standards, ties to NYSERDA etc.	Courtney Moriarta [courtney@bpi.org] (518) 899-2727
Dave Robinson President, Renaissance Inc. (Fresno)	New and active BP contractor in CBPCA program	David J Robinson [djr@RENAISSANCEINC.NET] 559.444.0777
Mike Rogers National field director, EPA Home Performance with Energy Star (DC)…now with GreenHomes America	National BP process and image used by CBPCA, NYSERDA and others	Mike Rogers [rogers.mike@verizon.net] (802) 860-7825
Charles Segerstrom Director, PG&E Training Center (Stockton)	Trains HP contractors, committed to HP, on CHEERS board	Segerstrom, Charles [CFS1@pge.com] (209) 932-2510
Dr. Iain Walker Lawrence Berkeley National Laboratory (Berkeley, CA)	Active in research on home performance contracting	Dr. Iain Walker [ISWalker@lbl.gov] (510) 486-4692
Rick Wylie President, Buetler Heating &Air (Sacramento)	Major HVAC contractor, innovator, supportive of HP principles	Rick Wylie [wylier@beutler.com] (916) 646-2222

Appendix B : National Contractor Survey Results, Task 2.1

Background

The online survey provided a baseline view on the types of services being provided and on the types of testing being used. The sample was not random, but the diverse response provides an interesting look at what type of work is being done by these self selected contractors and how they use testing. The survey used is provided in Appendix B.

Respondents to the survey were separated out into private contractors, not-for-profits (such as weatherization agencies) and not-for-profits offering fee-for-service installations. After completion of the survey, respondents were individually categorized as being in a region with or without a home performance program.

The survey response was also used to help expand the range of contractors who were contacted for the phone survey.

Summary Charts

The following charts summarize the results of the survey.

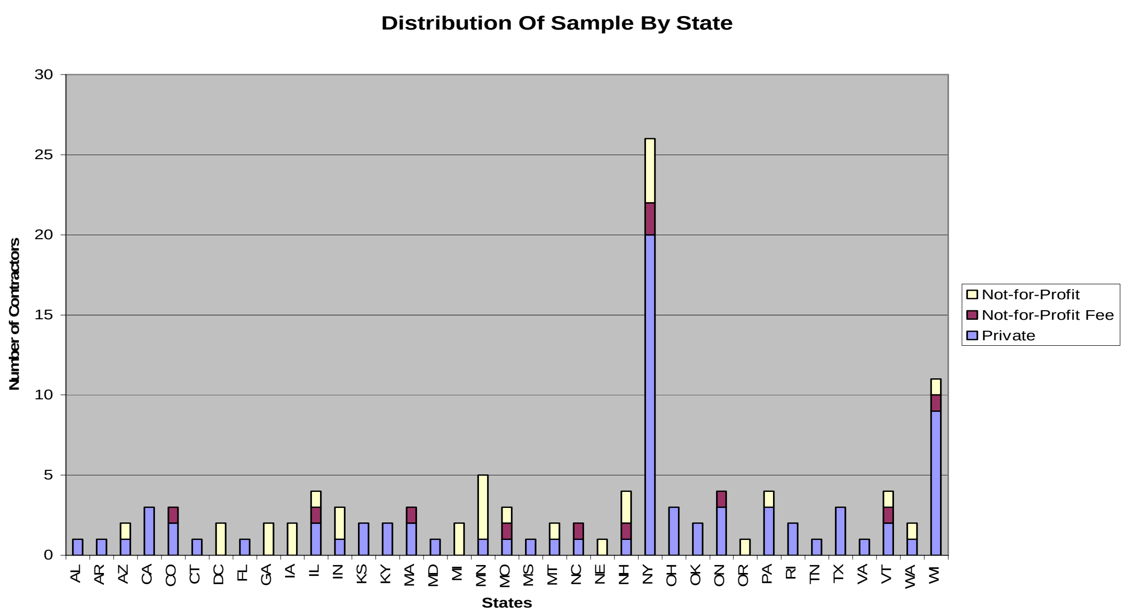


Figure B-1—Geographic Distribution

The respondents to the online survey represented a surprising cross section of the country and included some Canadians (ON). States with longer term home performance market development efforts are clearly indicated.

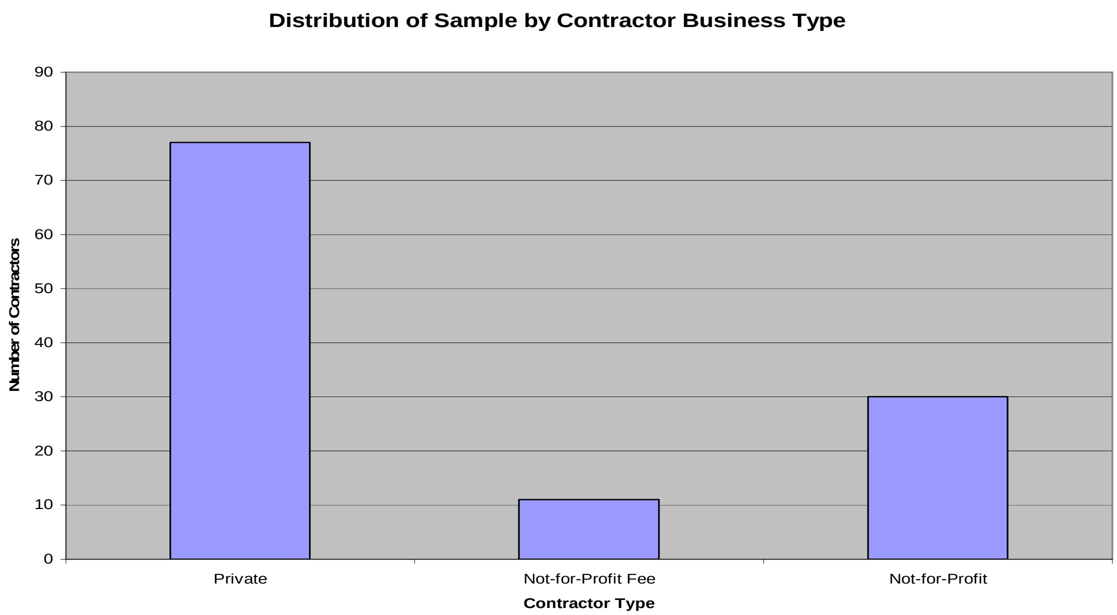


Figure B-2—Distribution of Respondents by Contractor Business Type

The majority of the respondents to the online survey indicated that they were private contractors. Not-for-profit contractors were asked to indicate if they offered fee for service work.

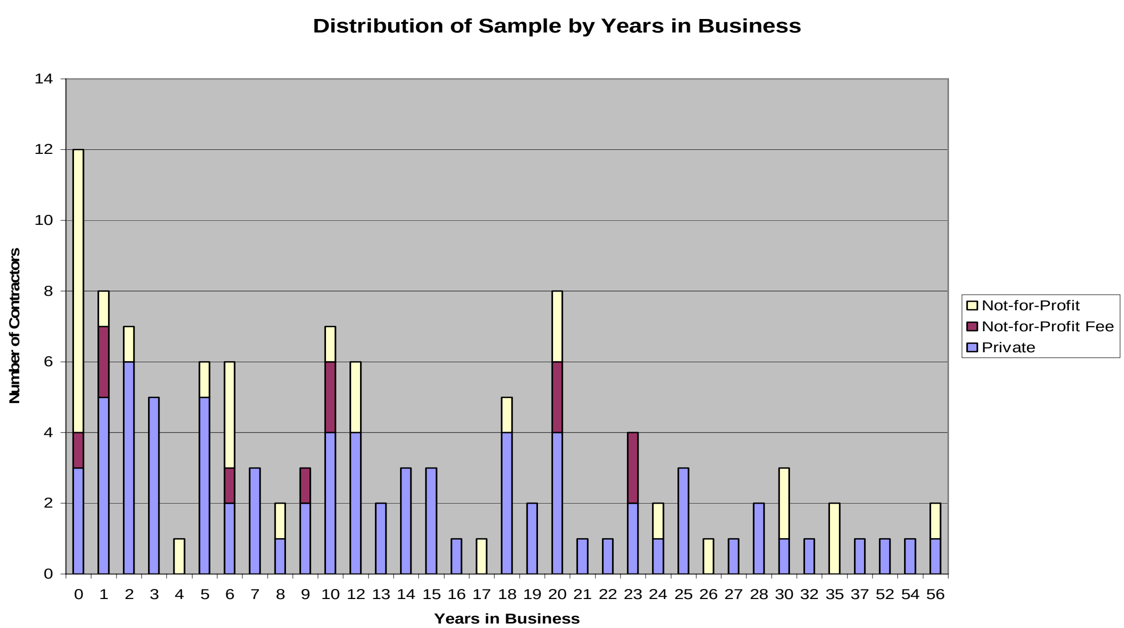


Figure B-3—Distribution of Respondents by Business Experience

The respondents to the survey represented a wide range of business experience. A surprising number of the private home performance contractors had been in business for five years or more.

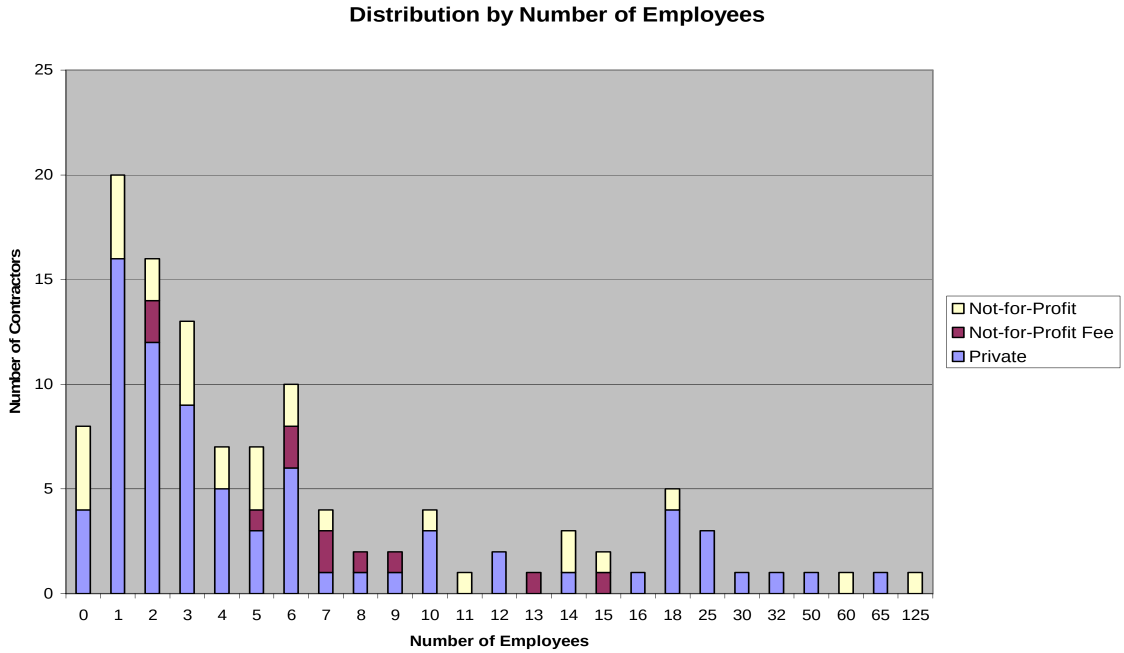


Figure B-4—Distribution of Respondents by Number of Employees

The respondents to the survey tended to be mostly smaller companies.

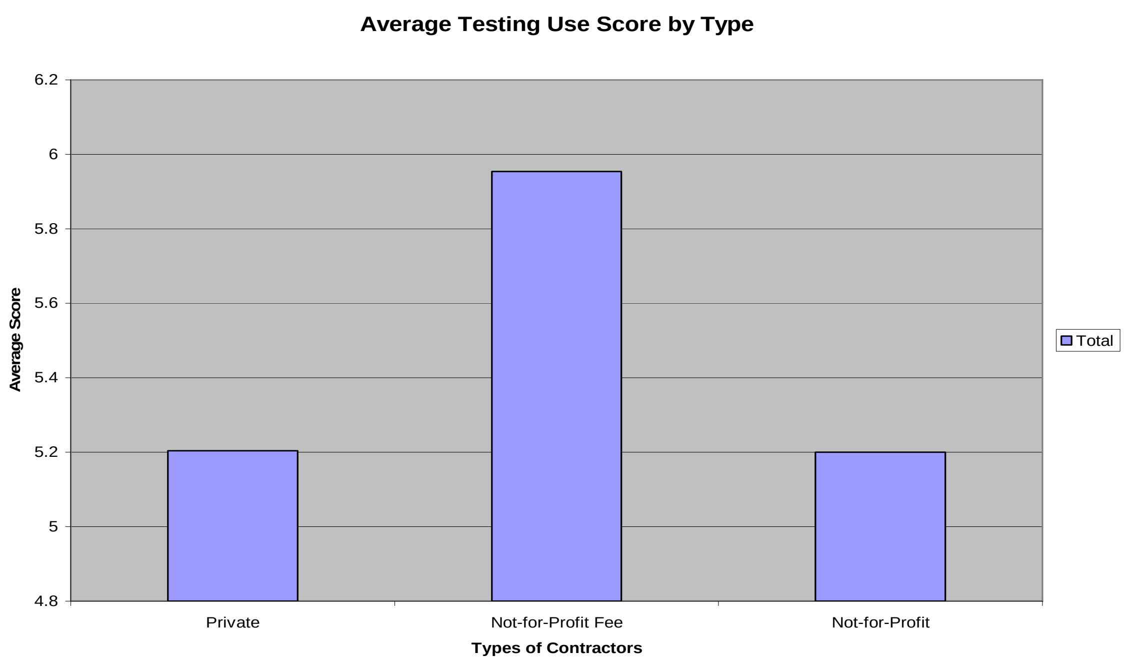


Figure B-5—Average Testing Use Scores

The testing score for each contractor was generated using a value of 0 for tests used rarely, .5 for tests used sometimes and 1 for tested used always. The maximum possible score was 10. The highest score reported was 9.5. The larger whole house contractors had an average score of 6.75.

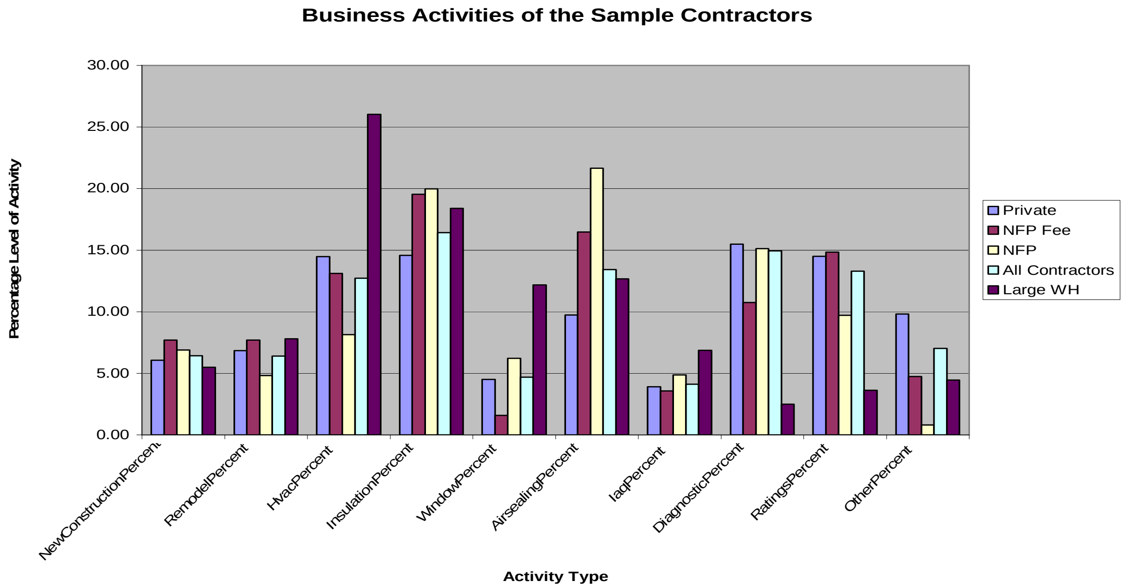


Figure B-6—Contractor Business Activities

The business activities of the contractors show some interesting trends, most notably the dramatically increased percentage of HVAC installation activities for what were identified as larger whole house contractors. These contractors were selected based on having non-zero activity in both HVAC and envelope work, including windows, air sealing and insulation. These contractors were also selected based on a minimum score for the use of testing of 5.5 or higher.

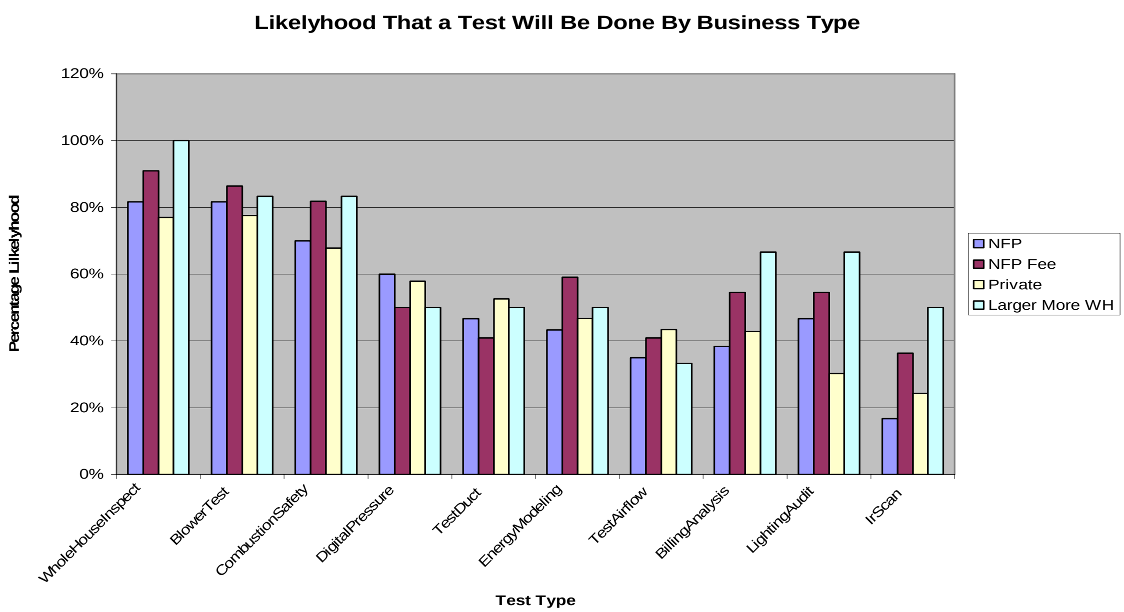


Figure B-7—The Likelihood of Contractors Using Various Tests

The likelihood that a contractor would use a specific test was analyzed across the various types of contractors. Of interest here is the correlation between not-for-profits with fee for service operations and larger whole house contractors. Also of interest is the commitment of the whole house contractors to billing analysis and lighting baseload analysis, tasks that are much less common for the typical home performance contractor.

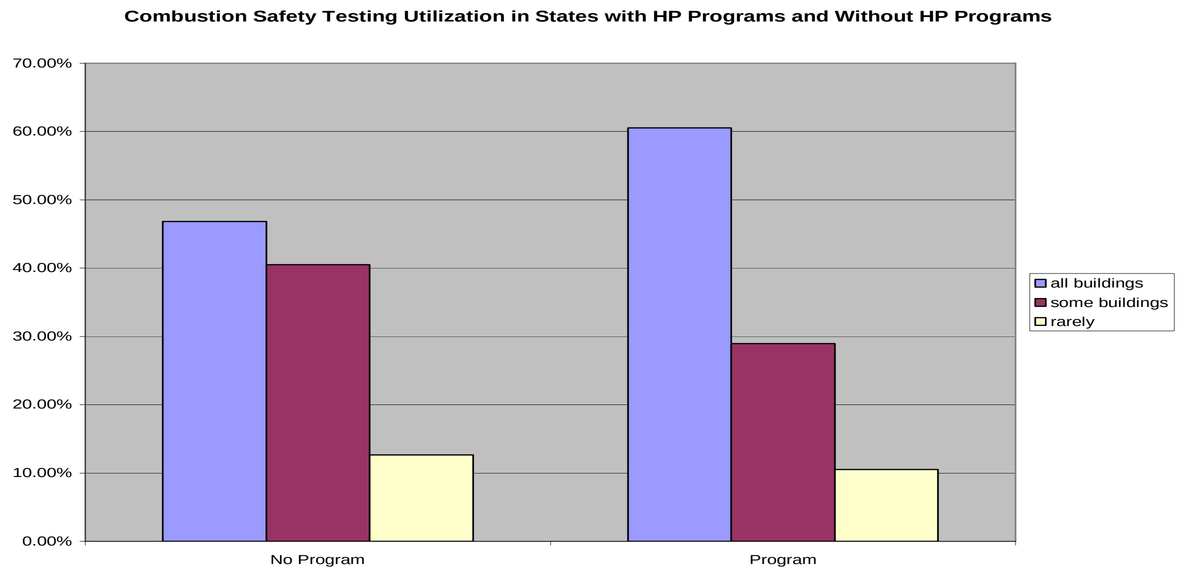


Figure B-8—Combustion Safety Testing by Contractors in States With and Without Home Performance Programs

Private contractors working in states with programmatic support for home performance were more likely to do combustion efficiency testing. But only 13% of the private contractors in other states rarely tested combustion safety, a rate just slightly higher than reported by the contractors from states with home performance programs.

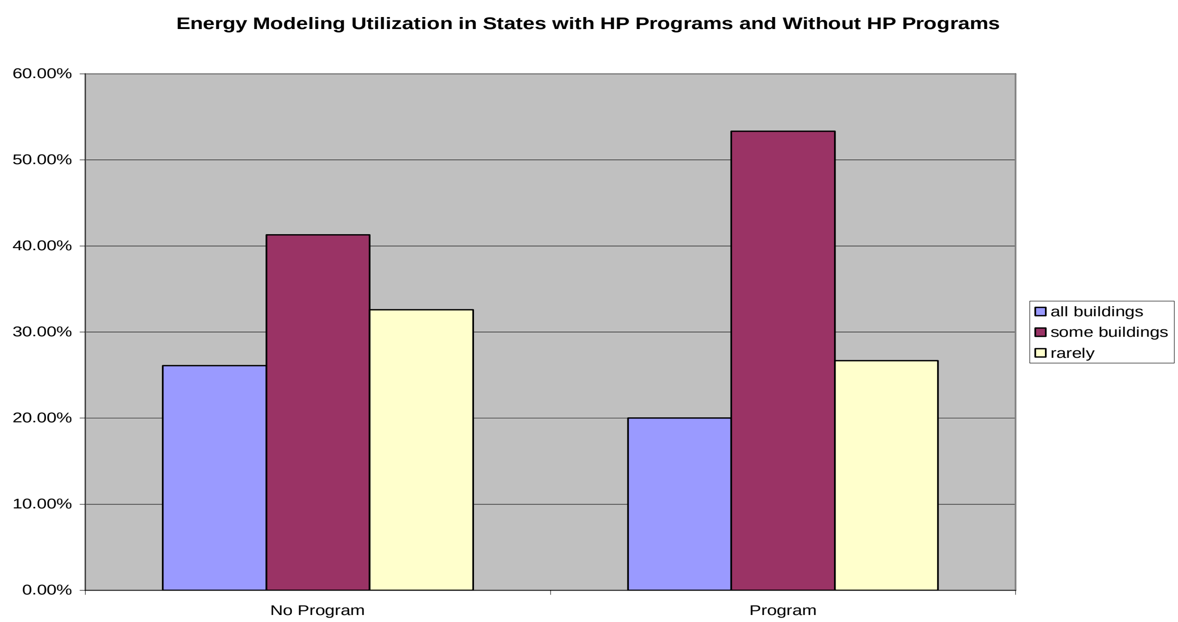


Figure B-9—Energy Modeling by Contractors in States With and Without Home Performance Programs

Energy modeling was surprising prevalent in private contractors outside of states with program support for home performance.

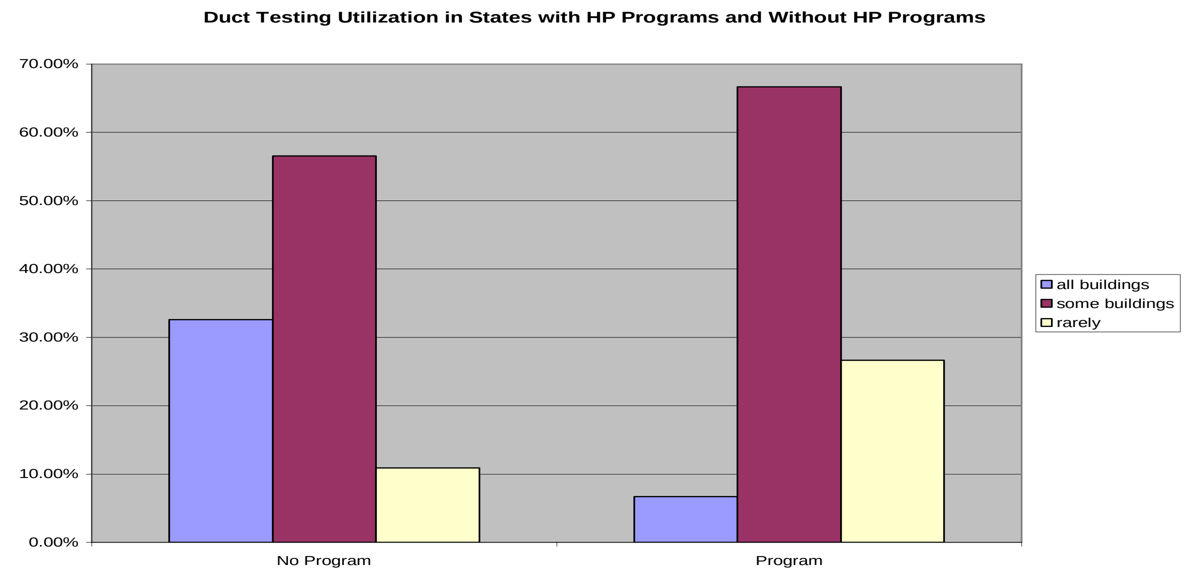


Figure B-10—Duct Testing by Contractors in States With and Without Home Performance Programs

Probably as a result of the northern states (NY and WI) lead in supporting home performance, the use of duct testing in programs is actually stronger outside of the funded programs. Other testing types were fairly consistent between contractors in funded states and those outside funded states.

Appendix C: Online National Contractor Survey Form

Home Performance Contracting Services
Research Survey

Contact Information

Your Name: First [ ] Last [ ]

Company Name: [ ]

Address: [ ]

City: [ ]

State: [Please select State/Province OR International ▾]

Zip: [ ]

Telephone: [ ]

Email Address: [ ]

Website: [ ]

Your Job: (•) Owner ( ) Auditor/Inspector ( ) Other [(please specify)]

Business Information

Years in business as a contractor: [0]

Company size ($ per year) [Please select a value ▾]

Type of business (•) Private ( ) Not-for-Profit Doing Fee-for-Service

Number of employees doing this type of [ ]

Please indicate the types of services your company offers: % of Total Volume

New Home Construction [0 % ▾]

Remodeling [0 % ▾]

HVAC [0 % ▾]

Insulation [0 % ▾]

Windows [0 % ▾]

Air Sealing	0 %
IAQ Remediation	0 %
Diagnostic Investigations	0 %
Energy Ratings	0 %
Other	0 %

Basic Performance Testing Information

Do you:

Do a blower test in:	○ All Buildings	○ Some Buildings	◉ Rarely or Never
Test the duct systems in:	○ All Buildings	○ Some Buildings	◉ Rarely or Never
Do combustion safety testing in:	○ All Buildings	○ Some Buildings	◉ Rarely or Never
Test the airflow of ducts in:	○ All Buildings	○ Some Buildings	◉ Rarely or Never
Do a whole house inspection on:	○ All Buildings	○ Some Buildings	◉ Rarely or Never
Do an IR scan in:	○ All Buildings	○ Some Buildings	◉ Rarely or Never
Do a lighting & appliance audit	○ All Buildings	○ Some Buildings	◉ Rarely or Never
Do digital pressure diagnostics	○ All Buildings	○ Some Buildings	◉ Rarely or Never
Do energy modeling on:	○ All Buildings	○ Some Buildings	◉ Rarely or Never
Do a billing analysis on:	○ All Buildings	○ Some Buildings	◉ Rarely or Never

General Comments on Home Performance and Your Business:

Submit Survey

<< Return to previous page

Appendix D: Phone Survey Form

Home Performance Contracting Services Survey
Company Name:
Name:
Interviewer:

How did you transition to Home Performance? (Circle one)

New Business Existing NFP Other

What led you to make the transition?

What was the transition like?

Describe the structure of business model:

% of total work that is Home Performance

# of persons employed and their tasks

Tasks

Describe Task	Number of Persons
General Manager	
Repair and Installation Manager	
Account Manager	
Air conditioning replacement crews	
Wx. crews	

Circle one of the following:

Full service contractor

Specialty contractor allied with subcontractors

Diagnostic services with subcontractors

Other

Annual gross sales:

What provided you assistance when making the transition? (Keys to success) Circle those that apply:

What barriers/hindrances exist to your business?

Are there business practices you recommend be part of any Home Performance service?

What are your customer demographics and what are their concerns?

Areas of Customer Concerns

	High, Medium, or Low	Description
Energy Efficiency		
Customer Comfort		
Health and Safety		
Building Preservation		
Other (describe)		

Business Practices

	Always/Usually	Occasionally	Never/ Seldom	Special Considerations
Use fees for inspections				
Report to customer in addition to estimate				
Average days from inspection to estimate/report				
Estimating software				
Commercial				
Spreadsheet				
Performance Guarantees				
Energy				
Comfort				
Other				
Job Pricing				
Fixed Price				
Time and Materials				
Unit Pricing from preset numbers				
Performance Incentives for :				
Sales				
Other				
Crew				
Employee Costs				
Pay Scales Relative to Competition				
Benefits				

Capitalization

Source of funding for new:	Enter Explanation:
Installation Equipment	
Diagnostic Equipment	

Partnering

Do you partner with	Always/Usually	Occasionally	Never	Comments
Insulators				
HVAC				
Roofers				
Diagnostics provider				
Other – Solar window screens				

Marketing and Sales Practices

Five biggest sources of leads in order	High-Medium-Low	Comments	Special Considerations
Yellow Pages			
Customer Referrals			
Third Party Referrals			
Return Customers			
Workshops			
Home Shows			
Mailing			
Email			
Web			
Radio			
TV			
Print Ads			

Do you use a presentation book?

Do you provide references?

Who talks to customers first? (Staff Position):

Do they use a script or have training to ask certain in depth questions?

Who sets appointments?

How many inspections or estimates per week? #__

Estimated closing rate on jobs: %

Average job size: $

Average job workscope:

How long is your inspection? Hrs

How long before they get a report or an estimate?

Is the customer present for the inspection?

Do they assist in the process?

Do you offer financing?

Do you encounter questions about up selling (selling more than customer wanted)?

Do you encounter questions about credibility?

Does the crew get performance feedback after the job is complete?

Testing

Testing Procedure/Protocol	Always/ Usually	Occasio nally	Never/ Seldom	Circumstances When Testing is Not Required
How often are diagnostic tests conducted at the beginning of each building inspection? (standardized test in…)				
How often are diagnostic tests conducted at the end of each day that work is in progress?				
How often are diagnostic tests conducted at the completion of all scheduled work? (standardized test out…)				
Within the vents of combustion appliances				
Within combustion appliance zones				
Oven vents and range tops				
Ambient house levels				
Building interior moisture level				
Mold identification/sampling				
Volatile organic compounds				
Radon monitoring				
Lead (sampling/XRF)				

Combustion Appliance vent pressure (draft)				
Duct leakage – total				
Leakage – to outdoors				
Pressure drops at supply and return registers (pressure pan)				
Total airflow measurements for heating/cooling distribution				
Combustion efficiency (SSE)				
Heat exchanger testing				
Cooling efficiency (EER)				
Thermostat & anticipator				
Exhaust fan flow measurements				
Blower door testing				
Pressure balance testing of conditioned zones				
Zonal pressures for transition areas				
"Worst case" combustion appliance zone testing				
Intrusive inspection (probing/core sampling)				
Infrared imaging				
Moisture metering				

Refrigerator watt/hour				
Water heater efficiency (SSE)				
Water flow rates				
DHW temperatures				
Wattage measurements of lighting				

What did you use for technical standards early on or before home performance?

Any particular order you think is best for home performance diagnostics?

Short Cuts

Are shortcuts taken or steps omitted?	Enter Description:
To save time:	
That come with experience:	
That come from inexperience:	

Design Practices

Design Procedure	Always/ Usually	Occasio nally	Never/ Seldom	Specific Software or Calculations Tools Used	Circumstances When Design is Not Applied
Energy modeling					
Energy use analysis (billing)					
Building air flow standards calculated for specific buildings					
Ventilation rates calculated for specific buildings					
Manual J (heat load analysis)					
Manual D (distri-bution design)					

How do you fell about the value of computer generated modeling and analysis?

Describe how you use computer generated modeling and analysis (types of reports and to whom):

Installation Practices

	Always / Usually	Occasionally	Never/ Seldom	Special Considerations / Installation Standards
Heating				
Energy Star appliances selected				
High efficiency sealed combustion installations				
Mid efficiency combustion atmospheric/ powered installations				
Ventless gas fireplace installations				
Vented gas and solid fuel fireplaces/stoves				
Combustion appliance clean and tune				
Combustion appliance general servicing				
Air Conditioning				
Energy Star appliances selected				
High efficiency (SEER 13 or greater)				
Mid efficiency (SEER 10 – 12)				
Clean/tune service				
Refrigerant charge/ general servicing				
Heat pump installations				
Distribution Systems				
Hard duct installed				
Flex duct installed				
Sealed with metal tape				
Sealed with mastic				
Supply duct insulation				
Ventilation				
Energy Star appliances selected				
Bathroom exhaust fans				

Kitchen range hoods				
Central exhaust system				
Whole house fans				
Supply only ventilation				
Balanced supply and exhaust				
Combustion make-up				
HRV & ERV				
Insulation				
High density cellulose				
High density fiberglass (BIBS)				
Lead safe work practices				
Windows				
Energy Star labeled units selected/installed				
Lead safe work practices				
Air Sealing				
Blower door assisted				
Lead safe work practices				
High density cellulose used in air sealing (interstitial framing)				
Appliances & Lighting				
Energy Star labeled appliances/lighting				
High efficiency appliance installations				
High efficiency lighting Fixture installations				
Compact florescent lighting installations				
DHW clean and tune				
Oven/range clean & tune				
Health & Safety				
Lead abatement				
Asbestos abatement				
Radon mitigation				
Smoke, fire, carbon				

monoxide detectors				
Moisture control				
Mold remediation				
Hygrometer installation				

Quality Assurance

	Always/ Usually	Occasio nally	Never/ Seldom	Special Considerations
Standardized building report completed for all work				
Quality assurance inspections performed during work in progress				
Quality assurance inspections at completion of work				
Tracking fuel/energy consumption on completed buildings				
Comprehensive "testing out" of completed buildings				
Customer satisfaction survey utilized				
3rd party inspections				

Training

Where have you gotten training on building science and performance testing?	Primary Source	Secondary Source	Never	Comment
Conferences				
Fee Based Workshops				
Low Income Weatherization				
Community College				
Vocational School				
Apprenticeship				
Online				
Books				
Other (What)				

Where do your employees get trained?

What do you consider the most important training resources?

How many days a year of training do your employees get, on average?

Problems and Barriers

What do you see as your core problem areas in developing this business model?	Primary Barrier	Secondary Barrier	Not An Issue	Describe Issue
Training				
Diagnostics				
Sales				
Marketing				
Business				
Installation				
Other				

Summary Information on Contractors Interviewed

Climate	Type	Origin	Size	Had Existing Contracting Business	Years HP	Average Job Size	NFP
Heating	Shell+	Shell	Large	Existing	3	9000	
Heating	Shell+	Shell	Large	Existing	3	8000	
Heating	Shell+	Shell	Large	Existing	4+	4000	NFP
Heating	WH	Remodeling	Large	Existing	2	12000	
Heating	WH	WH	Large	New	2	9000	
Mixed	WH	HVAC	Large	Existing	4+	18000	
Mixed	WH	Shell	Large	Existing	1	20000	
Heating	WH	Shell	Large	Existing	2	5000	NFP
Mixed	WH	GC	Large	New	4+	8000	
Cool	WH	Shell	Large	Existing	4+	5000	
Heating	General	GC	Med	New	2	2000	
Heating	Shell+	Shell	Med	Existing	2	5000	
Heating	General	GC	Small	New	3	5000	
Heating	General	Shell	Small	Existing	2	2000	
Heating	General	GC	Small	New	3	2000	
Cool	General	Shell	Small	New	2	3000	

Appendix E: California Contractor Survey on Home Performance Contracting

Interviewer name		
Contractor name/phone		
Respondent name (ADD)		

SCREENING FOR RIGHT RESPONDENT
(Use names of contracting firms from Steve's lists; keep track of time and results of each call)

Hello, is this (USE NAME OF CONTRACTOR FIRM). I'm calling for a State program that trains contractors in a new service to homeowners. Are you the owner or manager? (IF NO: May I speak with the owner or manager briefly? (ARRANGE FOR A LATER APPOINTMENT IF NECESSARY)

Call results:

Call	Date of call	Start Time	Minutes	Result or Comment
1				
2				
3				
4				

SURVEY INTRODUCTION

This is a noncommercial survey for a state-funded research project to help contractors expand their business. We're working on something new for several kinds of contractors in the home repair and improvement business. We aren't selling anything, and we're not asking for any money—just a little information to help us do our work, and maybe to help you develop your business.
Your answers are completely confidential and will NEVER be published or used with your name; they will always be combined with other contractors' responses, so that you can't be identified. BUT you might find some benefits for your business in what we are researching…although you won't know that until you finish hearing our questions and giving your answers.
I'll be as quick as I can; this will probably take about 15 minutes. Is this a good time, or do you want me to call back some better time? (PRESS FOR DEFINITE DATE/TIME)

(continue next page)

SURVEY QUESTIONS
Description of Current Business

Can you describe your present contracting business for me?
Type of contracting:
Number of people working:
Your city and ZIP code:
How long have you been in business?
How long have you personally been in this general line of work?
What contractor licenses do you have? (some have more than one)
(CIRCLE ALL THAT APPLY) heating, air conditioning, windows, remodeling, mechanical, electrical, general, weather sealing, insulation, siding, other (WRITE IN ANY OTHERS)
How important is lowest price in your work?
Would you like it to be less important?
Do you hire subcontractors?
What types?
What do they do for you?
How do you get most of your jobs? (referrals, prime contractors, advertising (what sort?), competitive bid vs. sole-source, etc.)
Are you satisfied with how well your business is doing financially?
Is it up or down from a year or two ago?
What sort of long-term plans or hopes do you have?
What are some of the biggest problems you face routinely in your work?
(examples: suppliers, subs, staffing, scheduling, difficult clients, competition, getting quality work, callbacks, overhead costs, advertising cost and hassles)

B. Knowledge and Interest in Home Performance Contracting

Do you use any home inspection techniques? What techniques?
Do you know what a blower door is? A duct blaster?
Do you have either? Any other home inspection equipment?
If it were potentially profitable, professional, and helped move you away from low-price competition, would you consider taking on a new line of services to your existing customers?
Why or why not?
Let me describe this specific possibility: Integrated home-performance improvement to both existing and new homes, under the Energy Star logo. This involves testing to understand how air, heat, and moisture flow through the home, finding the problems those movements can cause, and learning how to fix the whole house to perform as it should.
You then sell the job to the client as a trained home performance expert rather than just another contractor.
Benefits include safety, health (such as allergies), comfort, and energy cost savings as well as increases in home life and value.

What you'd have to do in this line of work:
Cost: training, equipment, marketing, and practice;
business practices: more direct sales, use of diagnostics, maybe more advertising, routine skill upgrading, computer analysis and reporting.
Does this sound interesting? Why or why not? (GET DETAILS ON REASONS)
There are different possible approaches: As a prime specialty contractor doing all the diagnostics, selling, and use of subs to do the work; as a remodeler, adding this service to your jobs as a unique extra; as a specialty subcontractor, doing parts of the home performance work for another prime contractor; as an integrated full-service provider.

Potential benefits to you: High sales rate, not low bid, less cost stress and higher quality work, more business growth, less seasonal variation, higher-class reputation, less competition…and pride.
What benefits do you see as especially important? Not so important?

What problems would this give you?
What risks?
Which are the most serious?
Do any seem like definite or probably show-stoppers?
What would it take to get you to try this business? (we can't pay you to do it, but we can provide different kinds of support)
Would access to easy funding sources help?
What if you could be the loan agent in an easy approval process?
Would new customer referrals from us or others (e.g., Lung Association) be important to you? Or do you prefer to rely entirely on your own marketing?
Is the Energy Star connection useful?
What about the connection to the State of California's energy efficiency programs?
How about training and mentoring to help you get started?
What sort of support or help would be most valuable to you?
What would you pay for this opportunity to be trained and supported in this new business?
A: staff training cost per person trained;
B: annual certification and updating support (maybe use multi-choice ranges)
After hearing all this, are you interested in learning more about this and getting some training?
How strong is your interest? (scale)
Can we pass your name on to our training program? (mention websites too)
Thanks very much! Do you have any other comments to add?

Appendix F : Home Performance Diagnosis Data Collection (Training Form)

Contractor: ____

Date: ________________

Customer Name: ____________________________________ Phone: _______________________

Address: ____ Fax: _________________________

City: ____ Cell: ________________________

E-mail: ____

Source of Lead: ____

Customer Reason for Calling: ____

____

Directions to home: ☐ Mapquest print-out attached

____

Section 1: Pre-Diagnosis Tasks

☐ Customer will have house plans available

☐ Customer has 12 months of utility bills available

☐ PG&E authorization faxed to customer

☐ PG&E authorization signed and returned

☐ PG&E billing history received

Heating degree days for loc

Cooling degree days for loca

Section 1: Pre-Diagnosis Tasks

Interview Date: ______________________

Inspection Start Time: ______________________

Interviewed by: ______________________

Inspection Completion Time: ______________________

Shoe Policy: ______________________

Pet policy: ______________________

Misc restrictions: ______________________

Utility bills or history available? Y / N

Floor plans available? Y / N

Outside temperature: [ ]

Outside relative humidity: [ ]

Wind speed & direction: [ ]

Outdoor CO: [ ]

Indoor CO: [ ]

Indoor relative humidity [ ]

Indoor Temperature [ ]

Number of occupants: ______________________

Occupant ages: ______________________

Occupied hours: ______________________

Type of building: ☐ Attached ☐ Detached

House square footage: ______________________

Number of floors: ______________________

Age of house: ______________________

Occupied since: ______________________

Smokers in home: ______________________

Pets in home: ______________________

Temperature desired by each occupant: ______________________

Customer concerns, questions and observations:

 Cold rooms?
 Hot rooms?
 Drafts?
 Closed rooms?
 Closed supply vents?
 Dust?
 Odors?
 Radiant temperature?
 Humidity?
 Set-back temperatures?
 Stratification?
 Respiratory problems?
 Child or elderly health?
 Moisture damaged areas?
 Open windows?
 Storage of cleaning products?
 Condensation on windows?

Other customer concerns:	Customer solutions:

Section 2: Customer Interview

From Utility Bill Disaggregation (use space below for manual disaggregation calculations:

Date	KWh	kWh $$	Therms	Therm $$

Base load cost $/year

Heating load cost $/year

Cooling load cost: $/year

Section 3: Site Inspection

Section 3: Site Inspection

Orientation: ____________________ Solar shading: ____________________ Overhangs: ____________________

Trees: ☐ Decidious ☐ Conifers

Landscaping close to house: ____

Water management:

☐ Gutters ☐ Downspouts ☐ Foundation drains

Annual precipitation: __________________________

Site slope & barriers to drainage: ___________________________

☐ Sprinklers next to house

Sprinkler run times: ______________________________

Total inches: ____________________________________

LBNL Factor for Site (see attached A1 & AC)

____

Roofing fitness: ___________________________________

Roof type: __________________________________

Water Damage on Exterior:

☐ Peeling paint ☐ Water stains ☐ Dry rot ☐ Mold

Windows:

Frame: _________

Glass:_________

Doors:

Type: ☐ Patio doors ☐ French doors ☐ Vertical ☐ Horizontal ☐ Fixed

Insulation: ___________ Glass: ____________ Frame: __________________

House piping: copper / galvie

Crawl space

Crawl access: ____________________ Number of vents: _________________ Vent sizes: ______________________

Combustion Safety:

Check vent terminations

Clearances must be at least 24"

Building openings? Y / N Above roof? Y / N

Obstructions? Y / N All vents go outside? Y / N Bushes by vent openings? Y / N

Notes: ____

Section 3: Site Inspection

Section 3: Site Inspection

4 Combustion Safety Testing (Refer to PG&E "CAS Testing Guidelines")

First Step – Visual Inspection
Check for:
- ❑ Missing components
- ❑ Indicators of incomplete combustion (soot and aldehydes)
- ❑ Note and mark thermostat settings
- ❑ Close windows, open registers, open interior doors, close fireplace and damper

Second Step – Ambient Tests

House Ambient 1 – Center of house All equipment in pilot only, 10 feet away from registers and equipment		CO (PPM) (10+ PPM = fail)
House Ambient 2 – Same Location Heater on for 5 minutes		CO (PPM) (10+ PPM = fail)
House Ambient 3 – Closest supply register		CO (PPM) Any increase over Ambient 2 test = fail

Worst Case tests

1. Set-up House:
❑ close exterior doors and windows
❑ close fireplace dampers
❑ turn off HVAC system
❑ turn off exhaust fans and devices
❑ open all interior doors
❑ fully open supply registers (note original configuration in section 10)
Record "Base Case House Pressure" [ ] Pascals (10 second average – longer average on a windy day)

Test A Set-up:
❑ close all interior doors
❑ turn on all exhaust fans and devices
❑ turn on forced air unit air handler
❑ position interior doors for worst case.
Record Test A pressure [ ] Pascals (10 second average – longer average on a windy day)

Test B Set-up:
❑ turn off air handler
❑ recheck position of interior doors for worst case.
Record Test B pressure [ ] Pascals (10 second average – longer average on a windy day)

Test C Set-up:
❑ turn on air handler
❑ turn off all exhaust fans and devices
❑ recheck position of interior doors for worst case.
Record Test C pressure [ ] Pascals (10 second average – longer average on a windy day

Did the worst depressurization from tests A, B, or C exceed combustion appliance depressurization limits for any appliances in the zone? Record pass/fail on list below.
With the house set-up in the worst case depressurization from tests A, B, or C above measure other combustion appliance zone pressures with-respect-to outside. Record pass/fail on list below.

______________________________ **Test-in:** ❑ **Pass,** ❑ **Fail**
Test-out: ❑ Pass, ❑ Fail

______________________________ **Test-in:** ❑ **Pass,** ❑ **Fail**
Test-out: ❑ Pass, ❑ Fail

______________________________ **Test-in:** ❑ **Pass,** ❑ **Fail**
Test-out: ❑ Pass, ❑ Fail

Furnace (or other space heater)

Name/ Location	CO PPM	Draft Tactile	Draft Smoke	Draft H2O	Eff. %	O2 %	Temp ˚F	CVA	Confined Space?			
________		P / F	P / F					P / F	Y / N	Test-in:	❑ Pass	❑ Fail
________		P / F	P / F					P / F	Y / N	Test-out:	❑ Pass	❑ Fail

Notes: ______________________________
____

Water Heater

Section 4:Combustion Safety

Name/ Location	CO PPM	Draft Tactile	Draft Smoke	Draft H2O	Eff. %	O2 %	Temp ˚F	CVA	Confined Space?			
____________		P / F	P / F					P / F	Y / N	Test-in:	❑ Pass	❑ Fail
____________		P / F	P / F					P / F	Y / N	Test-out:	❑ Pass	❑ Fail

Notes: ____

____

____

Other Name/ Location	CO PPM	Draft Tactile	Draft Smoke	Draft H2O	Eff. %	O2 %	Temp ˚F	CVA	Confined Space?			
____________		P / F	P / F					P / F	Y / N	Test-in:	❑ Pass	❑ Fail
____________		P / F	P / F					P / F	Y / N	Test-out:	❑ Pass	❑ Fail

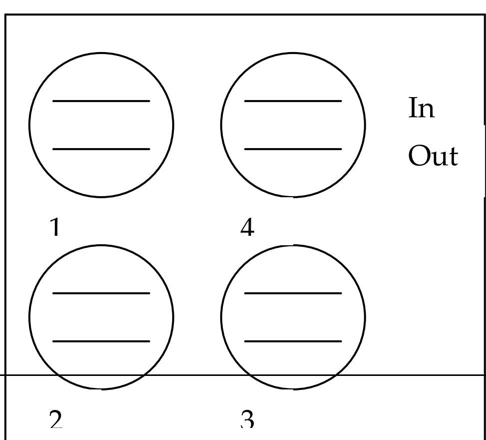
Notes: ____

____

____

Oven & Cooktop Name/Location	Oven CO PPM			
________________		Test-in:	❑ Pass	❑ Fail
		Test-out:	❑ Pass	❑ Fail

Cooktop CO PPM



Fireplaces: Name/Location	CO PPM			
________________		Test-in:	❑ Pass	❑ Fail
	____________			

Test-out: ❑ Pass ❑ Fail

Other:

Name/Location	CO PPM			
		Test-in:	❑ Pass	❑ Fail
		Test-out:	❑ Pass	❑ Fail

Section 4:Combustion Safety

5. Infiltration (Envelope Tightness)

❑ Improvements Recommended

Dominant duct leakage observation [ ] Pascals (pressure pan test is optional, record results on register flows in section 10.)

Test-In [ ] cfm_{50}

ACH_{NAT} = (cfm_{50} * 60 minutes/hour) / ($20_{or N}$ * House Volume $feet^3$) = [ ] ACH_{NAT}

Rule-of-Thumb guidelines for an average tightness house: 1 cfm_{50}/square foot of floor area, 0.35 ACH_{NAT}.

Test-Out [ ] cfm_{50}

ACH_{NAT} = (cfm_{50} * 60 minutes/hour) / ($20_{or N}$ * House Volume $feet^3$) = [ ] ACH_{NAT}

Improvement Target [ ] cfm_{50}

Δ cfm_{50} [ ] cfm_{50}

Heating Fuel Cost [ ] Dollars/Btu (Example: $0.90/therm = 0.90/100,000 Btu/therm = $0.000009/Btu

Furnace AFUE [ ]

Cooling Fuel Cost [ ] Dollars/KWH (Example: $0.15/KWH = 0.15/3,413 Btu/KWH = 0.0000439 $/Btu

AC SEER [ ]

$$\text{Annual Heating Savings (\$)} = \frac{\Delta cfm50 * 15.6 * HDD * \$/Btu \text{ (fuel price)}}{20 \text{ (or N)} * AFUE}$$

$$\text{Annual Cooling Savings (\$)} = \frac{\Delta cfm50 * 0.0222 * CDD * \$/KWH \text{ (fuel price)}}{20 \text{ (or N)} * SEER}$$

Connected Spaces: With the house depressurized to 50 Pascals measure the pressure in all connected spaces with-respect-to outside.

Garage	[ ]	Pascals	❑ Potential Repair ______________________
Crawlspace	[ ]	Pascals	❑ Potential Repair ______________________
Attic	[ ]	Pascals	❑ Potential Repair ______________________
Porch Attic	[ ]	Pascals	❑ Potential Repair ______________________
______________		Pascals	❑ Potential Repair ______________________
______________		Pascals	❑ Potential Repair ______________________
______________		Pascals	❑ Potential Repair ______________________

Notes & Potential Improvements:

(list areas that are candidates for air sealing, take digital photos, show with smoke)

Section 5:Infiltration

6. Ventilation

Home Exhaust Ventilation Devices

Exhaust Fan Location	Exhaust cfm	Control	Termination	Notes

Total Flow

Mechanical Ventilation Rate For the House:

ACH_{VENT} = (cfm_{VENT} * 60 minutes/hour) / (House Volume, $feet^3$) = ______ ACH_{VENT}

ACH_{NAT} = ______

(from section 4)

Total Possible ACH = ______

(ASHRAE target 0.35 ACH)

Notes & Potential Improvements:

(list areas that are candidates for ventilation improvements)

Section 6:Ventilation

Section 6:Ventilation

7. Insulation and Air Barrier Performance Inspection

Ceilings: ❑ Need Improvement, ❑ Perform Well, ❑ No Access

		Ceiling Description	Area	Existing R	Improved R
❑ Needs Improvement	❑ Performs Well				
		Ceiling Description	Area	Existing R	Improved R
❑ Needs Improvement	❑ Performs Well				
		Ceiling Description:	Area	Existing R	Improved R
❑ Needs Improvement	❑ Performs Well				
		Ceiling Description:	Area	Existing R	Improved R
❑ Needs Improvement	❑ Performs Well				

Check areas that apply: Descriptions:

❑ Installation quality improvement

❑ Voids present

❑ Compressions at wiring, plumbing, ducting, etc.

❑ Interstitial spaces present

❑ Attic ventilation

❑ Access hatches size and insulation

❑ R-values, type, inches

❑ I.R. for R-value and air movement

❑ Framing size and on centers

(take digital pictures to show home owners)

Walls & Windows: ❑ Needs Improvement, ❑ Performs Well, ❑ No Access

Wall & Window Description	Area	Existing R	Improved R

❑ Needs Improvement ❑ Performs Well

Wall & Window Description	Area	Existing R	Improved R

❑ Needs Improvement ❑ Performs Well

Wall & Window Description:	Area	Existing R	Improved R

❑ Needs Improvement ❑ Performs Well

Wall & Window Description:	Area	Existing R	Improved R

❑ Needs Improvement ❑ Performs Well

Check areas that apply: Descriptions:

❑ Installation quality improvement ______

❑ Voids present ______

❑ Compressions at wiring, plumbing, etc. ______

❑ Interstitial spaces present ______

❑ R-values, type, inches ______

❑ I.R. for R-value and air movement ______

❑ Framing size and on centers ______

Floors: ❑ Needs Improvement, ❑ Performs Well, ❑ No Access

Floor Description	Area	Existing R	Improved R

❑ Needs Improvement ❑ Performs Well

Floor Description	Area	Existing R	Improved R

❑ Needs Improvement ❑ Performs Well

Floor Description:	Area	Existing R	Improved R

❑ Needs ❑ Performs Well

Section 7: Insulation

Improvement

Floor Description	Area	Existing R	Improved R

❑ Needs Improvement ❑ Performs Well

Check areas that apply: Descriptions:

❑ Installation quality improvement

❑ Voids present

❑ Compressions at wiring, etc.

❑ Interstitial spaces present, balloon framing

❑ Crawlspace ventilation

❑ Access hatches size, rodent barrier

❑ R-values, type, inches

❑ Rodent presence or damage

❑ Framing size and on centers

❑ Odor present

❑ Moisture present

❑ Vapor present on soil

(take digital pictures to show home owners)

Improvement Savings Calculations:

Existing R-value

Improved R-value

Area (A) square feet

Heating Fuel Cost Dollars/Btu

(Example: $0.90/therm = 0.90/100,000 Btu/therm = 0.000009 $/Btu

Existing Window U-value

Improved window U-value

HDD

CDD

Furnace AFUE

Section 7: Insulation

Cooling Fuel Cost ________ Dollars/KWH AC SEER ________
(Example: $0.15/KWH = 0.15/3.413 Btu/KWH = 0.00439 $/KWH

Insulation Improvements: Walls, Floor, Attic, etc.

$$\text{Annual Heating Savings (\$)} = \frac{A * 24 * HDD * \$/Btu}{R_{EXISTING} * AFUE} - \frac{A * 24 * HDD * \$/Btu}{R_{IMPROVED} * AFUE} = \$ \underline{\qquad} \text{ per year}$$

$$\text{Annual Cooling Savings (\$)} = \frac{A * 24 * CDD * \$/Btu}{R_{EXISTING} * SEER} - \frac{A * 24 * CDD * \$/Btu}{R_{IMPROVED} * SEER} = \$ \underline{\qquad} \text{ per year}$$

Window Conduction Improvement:

Annual Heating Savings ($) = $U_{EXISTING}A * 24 * HDD * \$/Btu$ - $U_{IMPROVED}A * 24 * HDD * \$/Btu$ = $ ______ per year

$R_{EXISTING} * AFUE$ $R_{IMPROVED} * AFUE$

$$\text{Annual Cooling Savings (\$)} = \frac{A * 24 * CDD * \$/Btu}{R_{EXISTING} * SEER} - \frac{A * 24 * CDD * \$/Btu}{R_{IMPROVED} * SEER} = \$ \underline{\qquad} \text{ per year}$$

Window Solar Gain Improvement:

$$\text{Annual Cooling Savings (\$) North} = \frac{A * \Delta SHGC * 15 * \$/KWH}{SEER} = \$ \underline{\qquad} \text{ per year}$$

$$\text{Annual Cooling Savings (\$) South} = \frac{A * \Delta SHGC * 32 * \$/KWH}{SEER} = \$ \underline{\qquad} \text{ per year}$$

$$\text{Annual Cooling Savings (\$) East \& West} = \frac{A * \Delta SHGC * 73 * \$/KWH}{SEER} = \$ \underline{\qquad} \text{ per year}$$

Section 7: Insulation

8. Heating Equipment:

❑ Consider Replacement, ❑ Equipment to Remain, ❑ Other Improvements
Equipment Specifications:
Furnace Model ____________________
Furnace Serial ____________________
Equipment Age ____________________
Signs of Deterioration (soot, rust, etc.) ____________________
Furnace Size BtuH input [ ]
Input Temperature [ ] °F, Output Temperature [ ] °F, Furnace Δ T [ ] (35°F – 70°F)
Measured Combustion Efficiency (from section 6) [ ]

Measure Static Pressures: ❑ Static Pressure Too High, ❑ Static Pressure OK
Static pressure filter: Pascals [ ] Inches H_2O [ ]
Static pressure across coil: Pascals [ ] Inches H_2O [ ]
Static pressure across air handler only: Pascals [ ] Inches H_2O [ ]

Thermostat: ❑ Consider Replacement, ❑ Thermostat to Remain, ❑ Other Improvements
Thermostat Make & Model ____________________
Thermostat Type ____________________
Heat Setting [ ]
Cool Setting [ ]
Setback Used **Y / N**
Cool Setback [ ]
Heat Set-back [ ]

9. Cooling Equipment:

❑ Consider Replacement, ❑ Equipment to Remain, ❑ Other Improvements

Equipment:

Outdoor Unit Data Plate Capacity [ ] tons

Outdoor Unit Model # ____

Outdoor Unit Serial # ____

Outdoor Unit Condition: fins clean, fin air flow ____

Equipment Age ____

Cooling Coil Model # ____

TXV Installed ____

Coil Condition: dirty, pan functional ____

Input Temperature [ ] °F, Output Temperature [ ] °F, AC Δ T [ ] (15°F – 21°F)

❑ **Needs Improvement,** Measure cooling total efficiency (cooling delivered at each supply grille wet bulb temperature and cfm – need a big table and an Enthalpy chart)

Total air flow with a flow plate (optional)

❑ **Needs Improvement,** Check refrigerant charge *(need information to do both superheat and subcooling),* (optional)

❑ **Needs Improvement,** Run-time % on hot day for AC sizing check (optional)

Electrical Service:

Make ____

Size [ ]

Amps

Breakers Labeled: Y / N

Spare Breaker spaces: Y / N

Estimated Delivered Sensible SEER:

Delivered Sensible Capacity * Nominal SEER = Est. Del. Sens. SEER

[ ]

Nominal Sensible Capacity

Delivered Sensible Capacity = Delivered cfm * ΔT * 1.08 (delivered cfm & ΔT from section 10)

Nominal Sensible Capacity = Nominal Tons * 12,000 * 0.7

(duct leakage, duct conduction, refrigerant charge and line set sizing, low evaporator air flow, coil selection)

Section 10:Ducts

10. Ducts

Duct Leakage: Test-In ________ cfm_{25}
Duct Leakage to the outside: Test-In ________ cfm_{25} (Optional)

Duct Leakage Target: ________ cfm_{25} (6% of fan flow or 60 cfm whichever is less)

Duct Leakage: Test-Out ________ cfm_{25}
Duct Leakage to the outside: Test-Out ________ cfm_{25} (Optional)

Room-to-Room air flows:

Supply Grilles:

Room	cfm	Grille size	Velocity	Location, Grille Type,	Pressure Pan	Temperature	WB Temperature

Sum of the Supplies ________ (Measured with: ________________________________)

Return Grilles: Room | cfm | Grille size | Velocity | Filter Type

Room	cfm	Grille size	Velocity	Filter Type

Sum of the Returns [ ] (Measured with: ______________________________)

❑ **Needs Improvement,** Fan Flow [ ] (Measured with a True Flow or Duct Blaster)

System capacity in tons from section 9 [ ]

❑ **Needs Improvement,** Air flow cfm/ton [ ]

❑ **Needs Improvement,** Static pressure across filter (Measurement or from Section 8) [ ]

❑ **Needs Improvement,** Duct Insulation levels, duct system location, and accessibility [ ]

Improvement Savings Calculations:

Duct Existing R-value [ ]
Duct Improved R-value [ ]
House Floor Area (A) [ ] square feet
Temperature Difference (DT) [ ] supply temperature – duct location ambient temperature
HVAC System Run Time [ ] hours/day
HDD [ ]
CDD [ ]
Heating Fuel Cost [ ] Dollars/Btu (Example: $0.90/therm = 0.90/100,000 Btu/therm = 0.000009 $/Btu
Furnace AFUE [ ]
Cooling Fuel Cost [ ] Dollars/KWH (Example: $0.15/KWH = $0.15/3,413Btu/KWH = 0.0000439 $/Btu
AC SEER [ ]

Duct Conduction Improvement:

Annual Heating Savings ($) =

$$\frac{\text{Floor Area} * 0.4 * \Delta T * \text{Run Time} * \$/\text{Btu}}{R_{\text{EXISTING}} * \text{AFUE}} - \frac{\text{Floor Area} * 0.4 * \Delta T * \text{Run Time} * \$/\text{Btu}}{R_{\text{IMPROVED}} * \text{AFUE}} = \$ \text{[ ]} \text{ per year}$$

Annual Cooling Savings ($) =

Floor Area * 0.4 * ΔT * Run Time * $/KWH - Floor Area * 0.4 * ΔT * Run Time * $/Btu = $ [ ] per year

Section 10:Ducts

$R_{EXISTING}$ * SEER $R_{IMPROVED}$ * SEER

Duct Leakage Impact:

Annual Heating Savings ($) =
(Annual Heating Costs ($) (from bill dis-agg.)) * ((Duct Leakage to Outside cfm_{25}) * (0.75 (default loss factors from Duct Blaster Manual))

System Air Flow (cfm)

= $ ________ per year

Annual Cooling Savings ($) =
(Annual Cooling Costs ($) (from bill dis-agg.)) * ((Duct Leakage to Outside cfm_{25}) * (0.75 (default loss factors from Duct Blaster Manual))

System Air Flow (cfm)

= $ ________ per year

11. Appliances

Name/Location	Description	Volts	Amps	Watts	Improvement Possible?

Water Heater:
Water Heater Model ______________________
Water Heater Serial ______________________
Storage Gallons ______
Water Heater BtuH input ______
Water Heater Age ________________________
Signs of Deterioration (soot, rust, etc.)
____
Measured Hot Water Temperature ______ °F
Set Temperature ______ °F (mark setting with a pencil before moving)
Measured Combustion Efficiency (%) ______
Recirculation Present Y / N
Pump Make, Model, Wattage
_________________________ Pump run hours ______

Water Flow Rates:
M. Shower ______ gpm
M. Vanity ______ gpm
M. Toilet per Flush ______ gpm
Bath 2 Shower ______ gpm
Bath 2 Vanity ______ gpm
Bath 2 Toilet per Flush ______ gpm

Kitchen Sink ______ gpm

Consumer Education Opportunities & Appliance Operation Education:
____
____
____
____

12. Lighting

Location	15 – 40 W	40-75 W	75+ W	Improvements Recommended