PATH 36 Uniform Protocol for Energy-Efficient Remodeling of Existing Housing
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Baseline Standard Practices Survey

Task Report

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1. INTRODUCTION

This is the final report on the PATH 36/Phase 1 project's Task 3: "Baseline Standard Practices Survey." The report identifies industry-reported energy related deficiencies in current common practices of home repair and remodeling contractors. It also reviews existing remodeling industry and government initiatives for contractor improvement. Conclusions are drawn concerning needs and opportunities for PATH 36 to maximize contractor-driven energy savings in existing homes.

1.1. Context: Remodeling in the USA

Remodeling contractors are numerous and varied. To provide some context for the PATH 36 project, we note the large number of remodeling contractors. One thorough study (Belsky, 2001) put the number of home remodelers at some 117,000 (1992 data) which were large enough to have a payroll. Specialty contractors, such as those dealing with plumbing, heating, and air conditioning, accounted for about 55% of that total, with the remainder serving as general remodeling contractors. The range of awareness, motivation, and ability varies widely among those many contractors, and their work affects the energy efficiency of virtually all of the nation's over 120 million homes.

The remodeling market is large and growing. The following summary table indicates some of the most relevant characteristics of the home remodeling and repair market.

An Overview of the US Remodeling Market

- Remodeling expenditures almost doubled over the past decade
- Expenditures growing at about 5% this year (2005)
- Average growth has been 6%…slower than new construction at 10.2%
- 75% of market is spending by homeowners, 25% rental owners
- 2003: Total expenditures $138.1 billion, including $15.4 billion on replacements of systems and equipment including plumbing and HVAC
- In owner-occupied homes, 6.7% had major improvements (as % of home value), 39.1% had significant improvements, 44.1 % modest improvements, and 10.1% none
- High-income growth has kept pace with home price inflation; that group has been driving the remodeling market. Most interior upgrades have been in high-value homes
- Despite the passage of the baby boomer market, each generation is outspending its predecessor on home improvement.
- Sunbelt has many of the fastest growing markets for remodeling
- Still dominated by baby boomers—low 50%s
- Not much consolidation of remodelers, but top 3% did nearly 1/3 of billings
- Top 100 companies: 47 considered themselves specialty contractors
- Less than 1/3 of all remodeling spending is financed

(source: Kermit Baker, Joint Center for Housing Studies, Harvard University, presentation at 2005 NAHB Construction Forecast Conference (reported by Greg Mazurkiewicz, Air Conditioning, Heating, & Refrigeration News, November 21, 2005, p. 28)

The current housing stock will dominate for many years. This table suggests that the activities of contractors in existing homes are easily extensive enough to create opportunities for widespread energy savings, and in fact some 30 million homes had substantial remodeling activity in 2003 (Belsky *et al*). To underscore the significance of this number, the nation adds new homes at only about one to two percent of the housing stock each year, barely keeping pace with population growth. This means that most of the already existing homes will be not only with us for generations to come, but will also continue to dominate the housing stock. Energy saving improvements in new construction will help, but the existing housing stock has far greater potential for making a real difference. New homes do tend to be more energy efficient, yet often still also fail to include basic energy efficient practices and features—so they too are adding daily to the total of homes needing energy efficiency improvements.

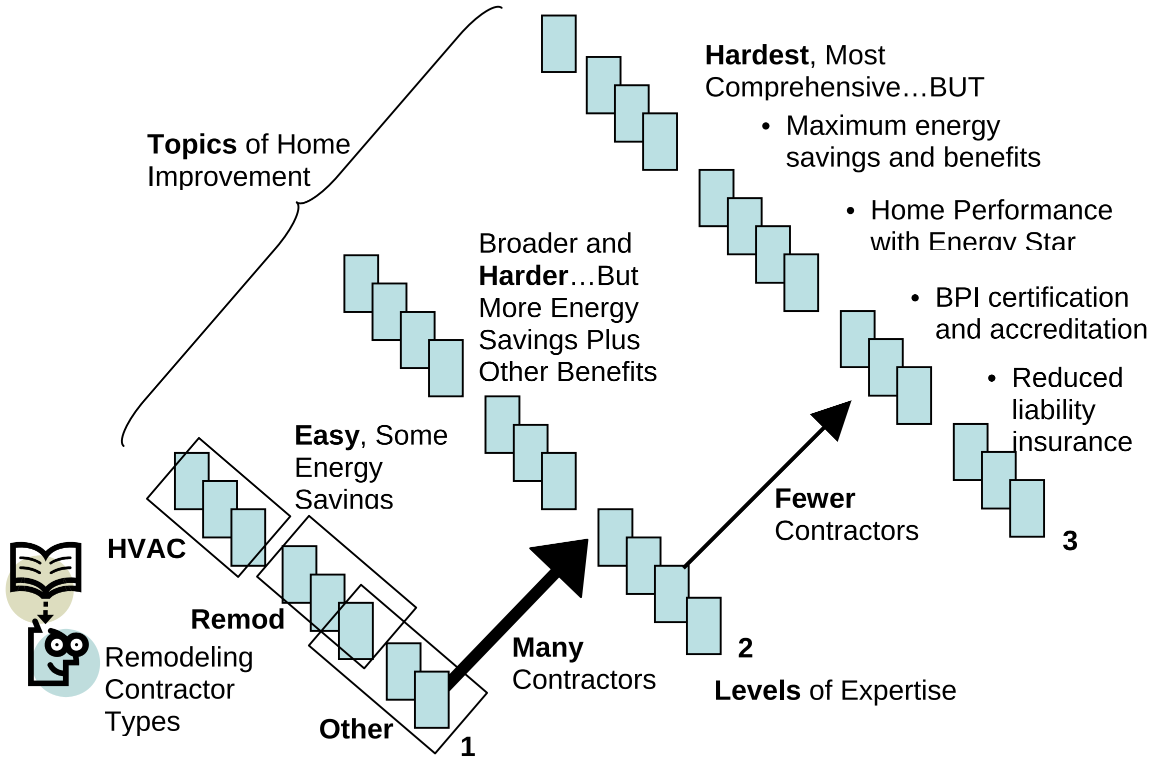
Opportunities for energy savings abound. The energy efficiency of the average existing home has much room for improvement: Homes account for approximately 33% of all U.S. energy consumption, and results of comprehensive energy retrofit efforts such as the various Home Performance with ENERGY STAR® programs around the nation indicate that a third or more of that energy could be saved through deliberate home improvements.

Major long-term opportunities for improvement occur daily. For example, US Department of Commerce manufacturing census data indicates that approximately 5 million furnaces and 3 million air conditioners are replaced annually, with widely varying effects on energy use as well as comfort, safety, and reliability. Many more homes are visited by heating and air conditioning contractors to repair or maintain equipment—but too often fail to see or correct serious deficiencies in efficiency. And since some 30 million homes are remodeled or expanded in a typical year, there are great opportunities to correct deficiencies in both the building and its energy-using equipment by incorporating energy saving construction practices and features into existing contractor activities.

1.2. Vision: PATH 36 and This Task's Role

How does this task contribute to the PATH 36 effort? The energy efficiency of contractors' remodeling and repair work on existing homes will be most improved through specific tools and training support to gradually increase the level of widespread energy-related expertise. This requires an understanding of the deficiencies in current common contractor practices and what programs are already in place to help provide the needed expertise. Providing that view of the current situation is the goal of this task. PATH 36 also encompasses the need for homeowner education to create the necessary demand for such services, and this task provides information on what additional understanding of energy efficiency opportunities and contractor capabilities that homeowners need.

The development of adequate energy-aware contractor capabilities will require more than a manual or a course. This task's findings indicate that there are major and widespread deficiencies in common practices. The ideal goal for contractors would be a level of comprehensive and detailed knowledge sufficient to sell and create maximum energy savings possible within each home, limited only by owner preferences and cost. But this goal is likely to be reached by only a small minority of the nation's contractors, at least in the near term, because of the broad scope of new capabilities required and the barriers faced by contractors in trying to make such major improvements. Therefore a path is needed for most contractors to make smaller changes and improve their performance to a lesser degree—yet still adequate to yield substantial energy savings in their routine work and to step them toward ever-better practices.



As illustrated in this graphic, the initial step beyond the deficiencies of current practices, as identified in this task, would focus on easily learned practices requiring no special testing or tools, but would also lead contractors to higher levels of expertise. Contractors would be able to learn the various topics and rise to higher levels at their own pace and preferences, and gradually expand into topics outside their original specializations.

1.3. Current Practices Assessment Approach

This report gives particular attention to describing current common contractor knowledge and practices in terms of ranges of behavior rather than single-point simplifications, since obviously not all contractors do any given task exactly the same way. The intent of this report is to identify the views of a broad range of industry experts on the most serious energy-related deficiencies in common contractor practices.

This task required several complementary research approaches. Literature and internet searches along with the Team's own libraries of relevant standards, guides, databases, and manuals were combined with in-depth interviews of Technical Review Panel members, other industry experts, and remodelers. In addition, the IBTS Team made extensive use of its own direct experience in observing, teaching, mentoring, and testing performance of contractors in elements of energy efficient home retrofits.

Beginning with major trade associations and existing programs, industry experts were contacted through networking and referrals. This was a "discovery" process, involving a gradual identification and verification of baseline practices through expert interviews and comparing information from different sources. This information was organized into a matrix according to type of contractor and home improvement topic or protocol. Progressive waves of interviews and further contacts were used to cover the full set of topics.

The resulting information was synthesized for each topic and contradictions were resolved through a combination of further interviews, clarifications, and the team's own relevant experience. For each topic and contractor type, the result was a statement of whether and to what degree major energy-related common practice deficiencies were identified. The resulting database was then reviewed for the topics of most promising potential energy efficiency improvement, and results were presented in Chapter 2 for each of five broad topical categories:

- General Business Practices
- Home Inspection and Testing
- Finding and Selling Solutions
- Home Improvement Practices
- Quality Assurance

Different types of remodeling and repair contractors were studied. The PATH 36 project intent is to provide guidance to the "remodeling" contractors who routinely make repairs and alterations to existing homes that influence their energy consumption. For this purpose, the term "remodeling" in fact must be interpreted to cover a variety of contractor specializations. For the baseline study, contractors were divided into three categories:

A. **Building Renovation and Additions** (broad renovations, targeted room upgrades, room additions)—very long sales cycle, general-plus-subcontractors model, broad focus on all building systems, often lengthy and costly jobs
B. **Mechanical** (Space Heating, Air Conditioning, Ventilation, Water Heating)—characterized by a very short sales cycle, narrow focus on equipment, few subcontractors if any, very brief jobs
C. **Other Specialty** (windows/doors, insulation, shell sealing, painting, roofing, decks, solar/PV, other)—moderate sales cycle, very narrow focus on specific building features, relatively little use of subcontractors, fairly short-term projects

The Task 3 baseline assessment process was based on a very broad topic scope. The study used a set of best-practice protocols designed for highly skilled home performance contractors (California Energy Commission, forthcoming). The purpose of these CEC protocols was to propose consistent best practices for energy-saving comprehensive home retrofits as well as high-quality installations of specific improvements.

Both technical and business practices are included. Protocols, as the term is used here, are *best-practice instructions and references for each energy efficiency topic and level of improvement*. As the assessment progressed, this initial set of topics was refined to focus on those of greatest value, including both merging of some of the original protocol topics and addition of others.

That protocol set was refined as the surveys proceeded, based on information received regarding the critical deficiencies in common practices. However, as a guide to PATH 36's eventual range of performance improvements, most of the original CEC set of topics were kept. The final set of Task 3 topics are listed in summary form in the following table (next page). These provide a comprehensive system of topics with a clear linkage to PATH 36's ultimate "ideal" high level of practice for each.

Category		***Topic***
A. General Business Practices	1	Business Goals/Objectives
	2	Typical Customer Benefits
	3	Marketing Strategies & Techniques
	4	Customer Sales Process
	5	Professional Networking & Industry Group Affiliation
	6	Incorporation of Customer Financing
	7	National/Regional Program Use, e.g. ENERGY STAR
	8	Company Management Structure/Organization
	9	Use of Systems Approach to Project Specification
	10	Available/Use of Training and Continuing Education
	11	Certification and Licensing Requirements
	12	Regional or National Codes
B. Home Inspection and Testing	13	Customer Interview Process
	14	Common Customer Concerns/Motivations
	15	Whole House Inspection Process
	16	Use Diagnostic Equipment (blower door, duct blaster, etc.)
	17	Inspection of Air Distribution System Performance (ducts)
	18	Inspection of Major Appliances and Lighting Performance
	19	Inspection of Mechanical Equipment Performance
	20	Inspection of Thermal Boundaries (insulation, windows)
	21	Inspection of Envelope Performance (air infiltration)
	22	Evaluating Home Moisture Issues
	23	Evaluating House Health, IAQ and Homeowner Safety
	24	Evaluating Combustion Appliance Performance and Ventilation Needs
	25	Determining Home Energy Usage
D. Finding/Selling Solutions	26	Use of Load Calculations/Formulas
	27	Estimating Energy Savings/House Modeling Software
	28	Determining Job Costs
	29	Customer Proposal Presentation/Delivery Process
	30	Determining HVAC Components Sizing and Specs
	31	Addressing Duct/Air Flow Needs
	32	Addressing Ventilation and IAQ Needs
	33a	Addressing Insulation and Air Sealing Needs
	33b	Addressing Moisture Management Needs
	34	Addressing Appliance and DHW Needs
E. Installation Practices	35	Incorporation of Diagnostic Tools
	36	Job Site Management Practices
	37	Common Practices for Installation of Combustion/HVAC/DHW Equipment
	38	Common Practices for Installation of Shell Sealing/Windows/Insulation
	39	Common Practices for Installation/Remediation of Duct Systems
F. Quality Assurance	40	Conducting and documenting “test-out” (including combustion safety)
	41	Providing Homeowner Operation Instructions
	42	Scheduling Maintenance & Follow-up (bill tracking, etc.)

An appendix provides many references on specific best-practice standards. Appendix B provides a detailed listing of the standards used in the derivation of the California Energy Commission protocol set. These include best practices as defined by a variety of authoritative organizations such as the following:

- American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE)
- Air Conditioning Contractors of America (ACCA)
- National Association of Home Builders—Remodeler's Council (NAHB-RC)

These standards and their sources will be important elements of the eventual PATH 36 best-practices guidelines for contractors and training organizations. In addition to providing evidence of authoritative sources, these references provide access as needed to the actual text of the related standards and best practices for further details, clarifications, and possible revisions.

A broad range of industry representatives were interviewed. The study sought their views and further contacts on the most critical energy-related common contractor practices in existing home repairs and remodelings. These included a variety of contractors nationwide, representatives of trade and professional groups, energy efficiency program personnel, and researchers in the field of contractor improvement.

Appendix B provides a listing of the 60 organizations and individuals who were valuable participants in the baseline study, providing insight and opinions based on their first-hand knowledge of common practices as well as the existing efforts at improvement.

1.4. Existing Contractor Improvement Programs Review

There are many existing programs and private efforts to improve the level of remodeling contractor knowledge and performance, in specific trades as well as in general remodeling and new construction. Many are very useful, although as a group they tend to be uncoordinated and not focused on energy-related issues. Examples of those most relevant to energy savings include the following:

- Home Performance with *ENERGY STAR*® and its local implementations
- Building Performance Institute performance standards and certification
- U.S. Department of Energy best-practices research and education
- National Comfort Institute
- North American Technician Excellence (HVAC)
- Regional whole-house contractor training programs
- NEMI/SMACNA training for HVAC technicians
- RESNET training for energy raters and consultants
- Other specialty training programs for contractor personnel

The most relevant programs were identified through industry inquiries, and available information on each was reviewed, including interviews as needed. Chapter 3 provides an overview of some of these existing efforts and how they are being incorporated into the PATH 36 project.

2: FINDINGS—Common Current Contractor Practices

2.1. General Business Practices

Sources agree that the home repair and remodeling businesses tend to be small and typically—though not always—not professionally well managed. There are major exceptions, particularly in the relatively rare large firms in specialties such as kitchen renovations and HVAC. These may be national, regional, or local in scale, but are large enough to involve full-time management staffs and expertise. Results of this widespread shortfall in management expertise and attention include a high incidence of marginal financial capability, lack of capital and planning for growth or diversification, inadequate marketing and sales skills, limited in-house technical training or quality assurance, and a high degree of aversion to the risks of innovation in work practices and business initiatives. These problems are often the most serious barriers to learning and using methods that can save energy even in small ways, let alone comprehensive approaches to the house as a system.

Business goals and objectives
"Best practice" or high priority business goals for residential contractors include some of the following ideas: get the job, make money, train staff, find new staff as needed, do great work and use it for marketing, provide customer care and use for marketing, keep learning, and take time to learn and do it right. But too many contractors—remodelers as well as specialists—find it necessary to compete primarily on price, resulting in low margins, staff instability, cash flow problems, and pressures to cut corners, eliminate training time, and focus on management of the customer's expectations rather than do true quality work. The low-bid market scarcely allows them to do otherwise.

Despite this general situation, there are many contractors who emphasize quality, targeting customers who appreciate and will pay for it. But too often their vision is limited by the available education and training support. Few contractors of any type understand building science—how buildings actually move air, moisture, and energy—and how badly most homes perform. They have no good way to learn how to incorporate energy efficiency (as well as comfort, safety, health, etc.) into their work or to change their business to emphasize those benefits.

Company management structure and organization
The residential contracting industry is extremely localized and splintered, despite recent publicity on some efforts to consolidate firms. The vast majority of remodeling and repair firms are small. In such firms the owner or manager began as a technician with no business training. Such owners typically have to be directly involved in all aspects of the business, from marketing, sales, staffing and field supervision to purchasing, accounting, legal matters, payments and collections. Cash flow and profitability concerns limit the owner's options. The result is often a static or unplanned business that innovates only when forced by regulation or market demand.

If and as smaller firms continue to consolidate or are replaced by larger and more business-oriented companies, a greater emphasis on more strategic and innovative business models may emerge. But at present the financial and managerial constraints and price-competitive pressures on many contracting firms tend to be major barriers to the kinds of improved business and technical practices that are needed to create major energy savings in remodeling and home repair.

Licensing, certification, and codes

In many states, no contracting license is required; in some cases none is offered, or focuses entirely on credit history or other non-technical factors. Even where licensing is required, there is no emphasis on energy-related capabilities in the training or testing used. Certifications of various kinds are widely used by contractors, particularly in specialty areas such as HVAC. Some are rigorous, such as NATE or BPI's (See Appendix A for more details), but too often it is possible for a contractor to display certificates and logos that imply certification but in fact have little substance. (In addition, we note the distinction between "certification" and "certificate" programs; the former imply technical rigor while the latter carry no such assurance and are often valuable only as marketing aids. More public education is needed on the identification and value of effective certification as confirmed by Theresa Ford-Crahan of the *NAHB Remodelor's Council* "the demand is not there yet for green or energy efficient remodeling. That's one of the reasons they have not offered a stand alone green or energy efficient remodeling credential".

Building codes and regulations generally do not deal with energy efficiency. Nationally, an upgraded 13 SEER minimum air conditioner efficiency standard is in effect as of January 23, 2006. However, this is unaccompanied by any requirement regarding installation performance, so much of the potential energy savings that customers expect will not be attained. California's Title 20 and 24 energy efficiency codes are a major exception and model for the rest of the country despite the limitations of their compromise-based adoption process. Through Title 24's October 2005 update, California now requires targeted levels of duct sealing when installing/repairing AC systems in certain climate zones; further improvements contemplated for the 2008 update include airflow and refrigerant charge confirmation as well as proper equipment sizing. For energy efficiency to be a standard factor in every contractor's work, mandates such as California's may be required to overcome the many barriers to change.

Professional networking and industry group affiliation

Contractors routinely network to find reliable subcontractors and colleagues to provide new work and flexibility in managing workload variations. Some join trade or professional groups such as NAHB or ACCA, although these are small minorities. Many others subscribe to journals and information services to help keep abreast of new tools and techniques. A small but growing number join mutual-support groups who meet and share critiques and ideas for improving their success. However, energy efficiency has not been a significant aspect in virtually any of these activities apart from the efforts of whole-house contracting support groups such as ACI (formerly Affordable Comfort, Inc.) through conferences and training seminars for a very small part of the contractor population.

Typical customer attitudes toward contractors

Customer attitudes toward contractors vary widely, but our interviewees tended to perceive a dominant skepticism regarding contractor competence, reliability, and even honesty. Contractors must exert themselves to overcome this customer bias, and they do so through various combinations of strenuous marketing for name recognition, emphasizing customer management, and cultivating customer satisfaction and referrals. Contractors who can distinguish themselves effectively from their competitors have the best opportunities for avoiding the low-bid "race to the bottom" and introducing new services successfully.

Marketing strategies and techniques

ACCA estimates that more then 2/3 of all HVAC contractors promote and market services based solely on price—with little emphasis placed on quality installations, expanded value, and service. This results in smaller jobs and more lost opportunities for energy savings and other benefits. Web-based contractor locator services are also becoming more widely used by both consumers and contractors; with companies like www.servicemagic.com (more than 30,000 contractors listed) leading the way. The North American Technician Excellence (NATE) association confirmed that follow-up service contracts are widely used among successful contractor companies, and help to eliminate the peaks and valleys of traditionally seasonal business models—but these business practices focus on small performance improvements and low-cost service, still missing major opportunities for energy savings.

Recent research on buyers of comprehensive energy retrofits by IBTS team members suggests that most of the motivation for such energy efficiency projects is attributable to non-energy benefits, notably family health, safety, comfort, home value, pride of ownership and environmental values. This was best captured in a discussion with George Sullivan of *Eco-Smart Building* in the Chicago area: "Customers don't know what questions to ask, realtors can't sell anything other than granite counter tops and stainless steel appliances, and remodeling and building trade contractors in the Chicago area don't know much, if anything, about energy efficient practices. Lack of education for realtors and trade contractors about energy efficiency is a huge issue." So far there is no evidence than any conventional contractors take such benefits into account in their marketing of home improvements—resulting in more limited job scopes and further lost opportunities for increased energy savings in each home

Customer lead handling and sales process
All contractors get customer inquiries (leads) through marketing or referrals. The survey and team experience indicate that *most contractors do not have an organized process for receiving, recording, qualifying, and responding effectively to them.* This appears to be particularly true for small local contractors, especially in specialties such as HVAC repair/replacement. Leads are opportunities for selecting qualified customers, providing education, and selling energy-saving solutions such as whole-system HVAC upgrades (instead of only equipment replacements) or complete building thermal load reduction (rather than only window replacement). Easier access to lead forms designed to include energy-related information and simple instructions on their value and proper use could significantly improve

Use of diagnostic testing and inspection
In whole-house energy retrofitting, as practiced in programs such as Home Performance with Energy Star, comprehensive diagnostic testing and inspection of the home is a key component. This involves a variety of tests on the building envelope as well as the HVAC system and combustion appliances plus direct inspection for problems such as moisture retention and mold, improper combustion appliance location or venting, and inadequate insulation. In contrast, common contractor practice is to respond to a homeowner's perceived problem and focus only on a quick remedy without a broader perspective on the house as a system.

ACCA estimates that no more than 5% of all national HVAC contractors are using a "whole system" approach to their jobs. True comprehensive "whole house" approaches are even more rare. Anecdotal information suggests that unless part of either a utility-sponsored program or mandated by a state or regional code, HVAC contractors are not currently using a comprehensive systems approach. NATE confirms that view.

The National Association of the Remodeling Industry (NARI) says that comprehensive home diagnostics and repair is simply not happening in the industry, unless mandated by some sort of program sponsor as a requirement. It is estimated that less than one percent of all remodeling contractors use this approach.

Licensing requirements provide no help. ACCA estimates that less than half the states have any type of recognized licensing requirement, and of those, very few require any sort of contractor testing or training. NATE agrees, and confirms that around 30 states have licensing requirements to be an HVAC contractor, but that most are just business licenses without any sort of technical requirement. None requires or even encourages home performance testing and diagnosis.

Incorporation of customer incentives and financing
The Electric and Gas Industries Association (EGIA), for example, noted that *all home repair and remodeling trades incorporate utility, manufacturer, or third-party sponsored financing*. Those conventional sources tend to have many limitations in loan amounts and items covered. Except for some of the utility incentive programs, most tend to be focused on specific equipment or tasks such as insulation, with little emphasis on proper installation or full-system scope. Re-packaged/easy to use loan processing (for both homeowners and contractors) makes a tremendous impact on job scope and closure rate. The training of contractors in how to use financing is just as important as providing it, and the lack of that training is probably the major reason why even the most promising financing opportunities for energy-saving improvements are not more widely or properly used. An easy early step might be to make contractors more aware of available customer financing options for their use, reassure them of ease of learning and use, and provide online training and access. Other possibilities include expanded utility marketing of energy efficiency incentive programs through contractors and guidance to contractors on their effective use.

Involvement in national and regional programs
There are almost no national programs supporting contractors in existing-home energy retrofits or inclusion of energy-saving features in other home improvements. The primary exception is the EPA Home Performance with Energy Star program (see Chapter 3), which encourages the local development of support for training and encouraging both HVAC and remodeling contractors in whole-house energy retrofits. At present this model requires all participating contractors to go far beyond individual energy-saving improvements, emphasizing comprehensive whole-house retrofits.

Regional energy-related programs involving many contractors tend to be dominated by utility energy-saving incentives. Widespread but far from universal among energy utilities, these programs encourage contractors to market their cash or financing incentives to homeowners for specific improvements such as high-efficiency air conditioners, furnaces, windows, and insulation. The major problem with such programs is that they tend to miss important energy-saving opportunities and often also suffer in quality of installation due to misdirected incentives and lack of contractor training.

Very few utilities or energy-related agencies offer special incentives for more integrated energy efficiency retrofits. The primary exception is the New York State Energy Research and Development Commission (NYSERDA), which sponsors a statewide home performance retrofit program with a mix of mass marketing, low-interest financing, contractor qualification, and direct incentives to contractors for whole-house energy efficiency testing and assessment.

Use of a systems approach to project specification
Our interviews and experience indicate that many contractors are readily able to plan and schedule projects such as major remodelings. It is in their interest to develop that organizational capability, since the efficiency of trade interactions, materials deliveries, and task budget adherence determines their profitability as well as much of their clients' satisfaction. In smaller projects such as an air conditioner replacement, such systematic job planning and execution may be less critical. But this has little bearing on the incorporation of energy savings features, except for the potential for a systems analytic approach to assessing and scoping the project to include such features. Chad Garner of Wise *Choice Construction* in Maryland mentioned that "for most contractors, the jobs are piece

work – the more jobs they do, the more they get paid. Quality is not the driving factor." Home performance contractors, whether operating independently or as a part of a local program such as Home Performance with Energy Star, routinely apply such a systematic and comprehensive analysis to homes. We have seen no evidence of any such effort in the broader residential home improvement community.

Contractor staff training and education
Many individual contracting industry tradespeople seek training where it is available, and many contractors support such training efforts through membership dues and/or fees and send staff members to training sessions. Some areas of the country have vocational schools or training in community colleges, and various trade associations offer training nationwide. Other progressive contractors conduct their own in-house training to provide continuing education to their staff.

Staff training and upgrading are often seen skeptically by contractors, who fear that a more trained technician will then seek a raise or shop for a job with a competitor. There is widespread reporting of a shortage of well-trained specialists in some building trades, which encourages some contractors to invest in training despite the risk of losing the trainee.

2.2. Home Inspection and Testing

Our sources confirm that comprehensive diagnostic testing is rarely done and that the relevant equipment is rarely used unless in a state or utility run program that requires it. Depending on each contractor's area of specialization, deficiencies in various aspects of the home might be noted (but usually not). Examples include lack of insulation, poor duct performance, major envelope air infiltration and thermal bypasses, and extreme sun exposures with poor windows. Instead of addressing the issue properly, the typical contractor will either ignore the problem or just increase the space conditioning system size.

Customer interview process
Few contractors take the time to probe for homeowners' perceptions of problems with the home. This results in major missed opportunities for improvements incorporating energy efficiency, comfort, and health.

Common customer concerns and motivations
The principal customer concern is their apparently widespread lack of confidence in home remodeling and repair contractors. Other than word-of-mouth recommendations and advertisements, the customer has little ability to evaluate contractor competence and reliability. Trade certifications (North American Technical Excellence, etc.) may offset this to some degree, as well as the contractor's professionalism and courtesy in initial contacts, but for most contractors this mistrust remains a significant barrier to success.

Homeowner concerns about their homes are, according to our sources, more limited than they should be. Most homeowners assume that many aspects of their homes such as indoor air quality and its health effects, comfort issues in unduly hot or cold rooms, duct/air handler and street noise, HVAC equipment repair needs, and structural deterioration due to uncontrolled air movement and moisture entrapment are not amenable to correction, even though comprehensive energy assessments and retrofits can remedy such problems routinely while dramatically reducing energy costs. Brian Harvey, a former ACCA area chapter president and now owner of H&C Cooling, shared customer concerns can be more complicated than just addressing a simple comfort issue, as "for example, if someone complains that they have a cold bedroom since they moved into the house – even if it's been that way for years -- they still don't want to spend the money to tear into a wall, build a bulkhead, run proper ducts, etc. to fix the problem. They'll just put on an extra sweater." Consequently the expectations of homeowners are unduly low. This represents a major marketing opportunity for contractors trained in comprehensive home assessment and repair.

Whole house inspection process
Interviewees agree that virtually no contractors do whole-house inspections and performance testing, other than the very few trained in comprehensive home performance contracting and energy rating. This is essentially a missing element in the market. It is the key to maximum energy and peak demand savings in each home.

Use of diagnostic equipment
Besides home energy raters and home performance contractors, few other contractors have or use major diagnostic equipment. Exceptions are the gauges for checking refrigerant charge, CO meters, and flow hoods for air balancing that many HVAC contractors have, although even those are not widely used. Virtually no contractors are equipped or trained to use additional equipment such as blower doors for shell air leakage testing, duct blasters for duct leakage, digital manometers for differential pressures in the home and backdrafting of flues, and IR cameras for detection of hidden insulation deficiencies, entrapped moisture, and uncontrolled air paths.

Inspection of ducts and air distribution system performance
Interviewees and team experience indicates that most HVAC contractors avoid dealing with ducts except to the extent necessary to connect a new furnace or air handler to the existing ductwork. Even contractors specializing in duct cleaning avoid inspection of duct runs in attics and crawl spaces. Duct work tends to be perceived as low-return activity, having no extra equipment sales payoff and frequently encountering buyer resistance; both buyers and many HVAC contractors seem to have little understanding of the importance of an effective duct system and how likely it is that their house has serious duct deficiencies.

Inspection of major appliances and lighting
Major appliances and lighting are often outdated, inefficient, and wasteful of energy without the homeowner's awareness. Such inspections are an easy and valuable service to the homeowner, yet appear to be virtually never offered by contractors. Education is needed to show contractors the value of such services in goodwill as well as differentiation from competitors for both remodeling and HVAC equipment replacement or repair projects.

Inspection of mechanical equipment
In most homes, heating, air conditioning, and domestic hot water systems are typically ignored until they malfunction. Service contracts tend to make little difference. Because of poor specification and installation, HVAC equipment tends to operate inefficiently and deteriorate faster than necessary through problems such as leaky or faulty ducts, oversized equipment, excessive cycling, and improper operating temperatures. All these problems could be eliminated through improvement in contractors' installation practices and marketing strategies to educate homeowners on its importance.

Inspection of thermal boundaries (insulation, windows)
Contractors are typically untrained and unequipped to properly inspect the home's thermal envelope and its resistance to uncontrolled air and heat movements. Moreover, they have no knowledge of the importance of such factors in the home's energy costs as well as comfort, health, and safety. This is a particular problem in HVAC replacements since HVAC contractors tend to avoid building envelope inspection and correction, thereby missing a major opportunity to reduce the thermal load and reduce the HVAC equipment requirement and its associated energy use.

These envelope inspection skills can be readily taught, and the required equipment is available. Insulation inspection via UV thermography (via laser probe or video camera) thermal imagery of walls and ceilings is particularly valuable: Deficiencies that appear minor can dramatically reduce the assembly's insulating value, yet are often readily corrected once identified.

Window replacement specialists are widely perceived, whether accurately or not, as inclined to oversell the energy-saving benefits of their products and ignore related factors such as shading opportunities. This results in a skeptical public. Insulation contractors operate under the same danger of overselling. Both are valuable but only as aspects of a more complete retrofit.

Infrared thermograph showing hot attic air being pulled into interior wall cavities (Florida Solar Energy Center photo)

Inspection of building envelope performance (air filtration)
This is an important extension of the prior review of thermal boundaries. Air infiltration occurs in many unexpected ways and well beyond the public's impression of caulking baseboards and weatherstripping doors. *Some of the most substantial air infiltrations occur through mechanical piping chaseways, unsealed joist spaces, floors, and framing penetrations throughout the structure. Few contractors understand this phenomenon or how to find and correct such structural faults*, but many such deficiencies are readily found through blower door testing plus visual inspection and repaired simply.

Evaluating home moisture issues
Home moisture-related problems such as mold growth or structural rot often occur through entrapment of moisture within walls and other building assemblies due to improper air and moisture barrier installation (or omission) and poor home ventilation. *Too often, contractors remove and rebuild the deteriorated assemblies but fail to understand or correct the underlying problem*...so the moisture problem reappears. A basic understanding of building air and moisture movement would provide the basis for identification and correction of those problems. Such education is provided in home performance contractor training, but relatively few contractors are involved in such programs.

Mindful of liability concerns, contractors are often counseled to avoid mold infestations and instead call in a mold analysis expert. Such experts can identify the characteristics of the mold species and safely remove it, but typically they cannot diagnose or correct the underlying cause. Contractors could readily be trained—even through web or manual self-instruction—to understand, find, and correct the causes of moisture problems.

Evaluating house health, indoor air quality, and homeowner safety
There is virtually no instruction widely available to contractors on health and safety-related home deficiencies, diagnosis, and correction. This is a vitally important topic for contractor education. One major component needed is combustion appliance safety testing, ideally including testing for potential flue backdrafting and carbon monoxide production in any combustion appliances such as gas water heaters and furnaces within the building envelope. Such conditions may exist in the home before contractor activity or may be created by the contractor through alteration of the building's airflow, for example by reducing uncontrolled air infiltration and duct losses.

This is a major deficiency in much current contractor training, both for HVAC and building shell renovation contractors. Although its correction does not directly result in energy savings, the underlying causes may have been created by energy efficiency efforts such as air sealing. Therefore combustion safety testing is a key part of energy efficiency efforts and should be taught to all contractors.

Determining home energy usage
Home energy savings are agreed to be a major motivation—along with comfort, health, and other benefits—for making improvements in overall home performance through equipment and structural systems repairs. There are several possible approaches to determining home energy use as well as projected energy savings, involving various combinations of utility bill analysis, computer simulation modeling, and manual calculation. Interviewees agree that few contractors know or use these methods, not only because most are untrained but also because they do not include energy savings concerns in their projects—or in the case of HVAC replacements, they assume a percentage improvement in energy use similar to the efficiency rating increase of the new equipment.

Energy savings estimation can be taught to contractors. The simulation models such as TREAT are not difficult to use, and utility bill analysis and manual calculation methods are also straightforward if somewhat time consuming. Of greater concern is whether such estimations are of value to the homeowner. Collective experience by contractors in other homes, using similar calculations or before-after utility bills, could provide adequate forecasts of savings in a given home without the need for special calculations, data, and modeling. Utility needs for data to justify efficiency program expenditures could also be met in other ways. This is an issue that the PATH 36 project will need to consider and resolve in its recommendations.

2.3. Finding & Selling Energy Efficient Solutions

It has been estimated that a successful HVAC contractor may sell up to 500 agreements for every $1 million in gross revenue—averaging only $2000 per job. Remodelers may do much larger projects in which the added cost of energy improvements would be minor, but they lack the understanding and capability to offer such improvements. Both situations represent major lost opportunities for both contractor and homeowner. But few contractors routinely increase their job sizes and value through broader energy-related inspection and homeowner education.

Load calculations and HVAC equipment specification
Very few HVAC contractors use assessment and replacement practices (such as deriving consistent load calculations and duct requirements with ACCA Manual J and Manual D analyses) for every job prior to recommending changes. Standard best practices include the calculation of the room-by-room thermal load of the home to provide an accurate basis for sizing replacement HVAC equipment and ducts. This is particularly important since units are often oversized and ducts undersized or otherwise inadequate. Survey respondent reports and team experience indicate, however, that load calculations are rarely done in HVAC replacements. Common practice is to replace with units of the same rated output or higher, leading to short-cycling, excessive duct noise and leakage, and early equipment deterioration as well as high energy bills due to low unit efficiency in short-cycle operation. Chris Strand of Strand's Remodeling in Austin, TX, confirmed that "the fundamental problem is that 99% of trades will just bid the same size unit (HVAC) as they are taking out. They don't go through the analysis needed to properly size the unit based on the loads, duct configuration, etc. Most old systems are already oversized. This ensures that the new system will be too."

Note that this topic is related to building envelope sealing, insulation, and other techniques for reducing the thermal load before sizing replacement HVAC equipment. Envelope improvement can often dramatically reduce the size and energy use of air conditioning and heating equipment while improving comfort, but in common practice the HVAC contractor does not consider—let alone improve—the thermal load. This is one of the most widespread and energy-wasting practices found in existing home improvement.

A further widespread HVAC specification deficiency is the improper matching of air conditioner compressor/ condenser units with indoor coils or air handler/furnace units. Each outdoor unit can be matched with a wide variety of indoor coils, but many choices are inappropriate and inefficient in specific climates due to unbalanced latent vs. sensible heat capacities. In other common cases, an attempt to save money by upgrading only the outdoor unit or by using a cheaper replacement indoor coil inevitably leads to inefficient operation as well as degraded capacity. Many HVAC contractors have inadequate understanding of the relevant principles of unit specification and merely keep using the same wrong choices without analysis, assuring that the replacement unit's nominal SEER rating will never be approached and causing major long-term losses in energy efficiency. The required knowledge is available and readily learnable.

Estimating energy savings and use of house modeling software
Almost no contractors do this, except for home performance specialists and a relatively few quality-oriented/high-end HVAC specialists. Opinions differ even among those experts as to the value of using modeling tools to estimate potential energy savings in the home, for two reasons:

1. Both manual techniques and simulation models are not reliably accurate, so the homeowner may find that the actual results differ substantially from the modeled prediction. This can be a source of disappointment for the homeowner and controversy for the contractor.
2. There is sufficient experience to indicate approximate energy savings from varying degrees of home retrofits, and home improvement sales should use such estimates plus the many non-energy benefits that also typically occur and are often more important to the homeowner than the direct utility bill reductions.

PATH 36 will need to consider the pros and cons of any such energy modeling techniques, as noted in the previous chapter.

Completely disconnected air conditioning return plenum - easily avoided through independent inspection. (Florida Solar Energy Center photo)

Addressing duct performance and airflow needs
If ducts leak badly, are inadequately sized, or poorly installed they will impede airflow far beyond industry standards, requiring longer unit cycles and excessive fan stress as well as potential indoor air quality problems. *Survey respondents overwhelmingly cited duct deficiencies as a major source of excessive HVAC energy use and cost.* Corrections of such deficiencies should be a part of every HVAC installation for health and comfort reasons as well as energy efficiency. In addition, if airflow is significantly impeded it will be impossible to verify the correctness of the air conditioner's refrigerant charge. In a high proportion of installations, the refrigerant charge is found to be incorrect and typically results in excessive energy use.

Addressing ventilation and indoor air quality needs
In best practice, after an inspection has identified building infiltration rates, duct leakage, and combustion safety issues as discussed in the previous chapter, appropriate solutions to deficiencies can be derived readily. However, as noted, *very few contractors conduct such detailed home inspections, and in common practice it is assumed that ventilation and indoor air quality are adequate*. The contractor therefore does not consider thorough air sealing, duct repair, or ventilation improvements. Training is needed in connecting home performance testing to ultimate desirable energy and comfort improvements through the identification of specific structural and equipment system modifications that are now being largely ignored in common practice.

Addressing insulation and air sealing needs
Insulation faults identified through testing and observation can be addressed in a variety of ways. Additional attic insulation may be specified, along with closing of bypasses and chases, improvement of attic ventilation, injected foams and other techniques to cure faults found in closed-wall insulation, proper insulation of knee walls, skylight wells, and soffits, and prevention of ice dams with careful insulation and sealing of truss heels. Dave Tyson, of Tyson Remodeling in North Carolina explained that, "penetrations between basements and crawlspaces don't get sealed when they enter into interior partitions. This creates perfect path for drafts with moisture and heat or cold to circulate through out the house." *These corrections are obvious to trained contractors but in common practice most are typically ignored due largely to lack of understanding of their importance.*

Addressing moisture management needs
Solutions to moisture problems are often misunderstood by contractors not trained in identifying such problems. Such training is needed to correct the common practice of removing and replacing the damaged components without understanding or correcting the causes of the damage, particularly when moisture sources are not obvious ones such as a water piping leak. Once locations and sources are determined, the moisture imbalances and barrier failures must be corrected through improvement of interior humidity (typically by addition of ventilation fans or energy recovery ventilators) and/or the improvement of the structure's vapor barrier system. These are often ignored or installed incorrectly. Bob Bell of Bell's Remodeling in Minnesota shared that in his experience, "bath fans are often vented to the attic. This creates major condensation problems. I have seen an attic with 1" of frost on the inside due to humidity from the bath fan."

Addressing appliance and domestic hot water needs
Contractors can generally only recommend replacement of major energy-wasting appliances such as refrigerators and clothes dryers, but should be trained to be observant and ready to make such recommendations as a customer service. *Virtually no contractors do this as a common practice.*

When domestic hot water system deficiencies are found, either in energy use, water waste, and/or inconvenience, recent experience is providing practical solutions involving tankless water heaters, pipe insulation, and on-demand recirculation pumps to return cooled water in the hot water line back to the source via a cold water line crossover valve. Standards and training are still developing but will soon be established and available. Results can include water and energy savings as well as increased convenience. Some HVAC and plumbing contractors are specifying and installing various solutions that save water and add convenience but increase energy use substantially; these will fade as standard best practices emerge. At present, the most common contractor practice is to do nothing.

Determining job costs
Despite availability of costing guides, many contractors underestimate their overhead costs. In common practice, contractors generally use flat rate (fixed) pricing for both remodeling jobs and small repairs; in some states the alternative of “time and materials” pricing is specifically prohibited. For remodelers, NAHB produces and publishes market survey and cost data based on business type and locale. This includes templates and software guidance for costing and business management. BNi Home Remodeler's 2005 Costbook is widely used, published in conjunction with NAHB. The cost data are presented as unit prices listing all components of home construction, including the unique intricacies of remodeling. These cost data are used for detailed estimates, bids, checking prices, and change orders.

In the HVAC industry, contractors typically use a standardized rate book to permit sales personnel and even technicians to quote repair and replacement prices in the field. The use of flat rate pricing reduces the customer’s risk and eliminates later “sticker shock.” The only need in job costing for energy-saving improvements is to add flat-rate prices for any new work tasks. However, too many contractors either do not use the available guides or underprice their work due to lack of awareness of their true costs of doing business. This contributes substantially to poor product quality.

Customer proposal presentation and delivery
Different types of contractors use very different sales techniques. HVAC contractors may provide homeowners with a very quick and brief written estimate to complete the proposed installation/repair project. Literature provided by specific manufacturers may also be included for the homeowner's review to explain differences in product operating efficiencies and performance. However, the information provided to the customer is often inadequate or incorrect, especially regarding expected energy savings.

The window replacement contractor or volume kitchen/bath renovator is likely to require a longer sales process, often involving more than one visit and requiring negotiation of technical design details. At the point of the final sales presentation, window sales people may provide brochures, videos and extensive literature with an official computer generated estimate and a formal contract. These businesses must contend with an overall industry image of high-pressure sales practices.

The remodeler’s sales process tends to be much longer and highly individualized, often with several consultations, design work, and subcontractor involvement before arriving at a specific final proposal. At that point, common remodeler practice is to deliver a handwritten or otherwise visually poor quality proposal to homeowners in person, after hours. Best practice involves a more professional presentation with references, quality assurances, photos, testimonials, and a detailed proposal. In any such presentation, energy-saving can be included or offered as options, but should be used as a unique sales tool and differentiator.

The contractor’s use of consumer financing can be a valuable sales tool in many home repair or remodeling projects. Homeowners without access to home equity lines of credit, savings, or other sources may prefer the terms of contractor-provided financing to high-interest alternatives such as credit cards—or foregoing the energy efficiency improvements altogether. Many equipment manufacturers offer special financing commonly used by HVAC and other specialty contractors, and there is an increasing array of third-party non-mortgage financing for almost unlimited energy-related home improvements through organizations such as the Electric and Gas Industries Association. In some cases utilities may also offer financing that is easily marketed and delivered through the contractor.

2.4. Home Improvement Practices

Installation quality by most contractors (particularly HVAC) is widely felt to be seriously inadequate. HVAC equipment is oversized. Newly installed or sealed ducts often leak excessively. Return ducts are almost always too small. Refrigerant charge and airflow are not accurately established. And too often in general construction, insulation is badly installed, air infiltration is excessive and uncontrolled, window flashing is poorly done and leads to rot, and no attention is paid to combustion safety testing.

Incorporation of diagnostic tools
Home energy performance diagnostic tools are seldom used. In addition to the use of diagnostic tools in an initial home assessment, as covered in an earlier chapter, those same tools should be used during installation and remediation work to assure proper energy-efficient results at a point when corrections can be made easily. This is virtually never done in common practice. Even contractors who pride themselves on quality work are often shown to be unknowingly failing to meet best-practice standards in key energy savings steps such as duct sealing, insulation, and envelope air sealing—all of which can readily be confirmed with standard testing equipment such as duct blasters, blower doors, and IR cameras. Few contractors even own such tools or know how to use them, although both the tools and training in their use are readily available.

Job site management practices
Remodeling and repair contractors' difficulties with scheduling, cleanup, and quality assurance are widely acknowledged. These projects are often done with the occupants living at the job site. This places special importance on job site management practices include reliable scheduling commitments, constant cleanup, and consideration for occupant needs. In energy-related projects, close coordination and cooperation among trades is crucial to ensuring that the desired performance improvements are actually achieved. For instance, specifications must require plumbers and electricians to minimize and seal all structural penetrations for pipes and wires to reduce uncontrolled air movements within the framing.

Structural framing practices
Common framing practices offer many opportunities for improvement in energy use. There are opportunities for improved insulating value in exterior walls built in innovative ways using more efficient framing or structural insulating panels. These are well established in standards and proven practice, but not always accepted in local codes or understood by most contractors. These innovations contribute directly to energy savings.

The most common deficiencies in modern interior framing during remodeling involve the use of architectural features such as cathedral ceilings, plywood-framed arches open above, double-framed walls for plumbing (with open chaseways to the attic or joist space), and features such as knee walls and complex roof configurations that are inaccessible or otherwise inadequately insulated. Unsealed framing penetrations for various pipes and wires also cause undesirable air movements. All can be corrected readily through a basic knowledge of air intrusion and air sealing.

Installation of shell sealing, windows, and insulation
Interviewees and team members agree that shell sealing is typically ignored in most contractor projects, although some homeowners attempt basic improvements in keeping with recommendations by utilities and energy efficiency advocates. The principal deficiency in shell sealing is that some of the most important sources of uncontrolled air and thermal intrusion are not included in such recommendations. Contractors could be readily educated in treating this topic comprehensively.

Photo of improperly installed insulation. Insulation loses effectiveness when compacted (EnergySense photo)

Most common window replacement deficiencies are in improper glass and frame specification and failure to install flashing properly to protect against outside moisture intrusion and structural deterioration. Other problems include incorrect framing of the window opening and skewed positioning of the window, both causing insulation, moisture control, and operational problems. All these are well understood in standards and best practices; only improved education of contractors and enforcement of standards are required.

In insulation, interviewees' experience indicates that installation is often done incorrectly. Small air gaps and voids of a few percent can cut the effectiveness of the insulation in half, and insulation leaving air gaps along the interior wall or ceiling face can result in major effects on surface temperature. Here again, existing standards are adequate but need to be trained and used more widely.

Installation of HVAC equipment

Testing and correction of refrigerant charge is a key part of air conditioner tuneup or replacement, but is often done incorrectly. Best practice includes proper airflow verification and instrumented subcooling or superheat tests. Although many contractors observe proper refrigerant-check procedures such as those taught by NATE or other authorities, it is all too common for technicians to shortcut or omit these steps to save time and expense. The result is typically degraded long-term system performance and excessive energy use. (Note that replacement HVAC equipment sizing was covered in an earlier section.)

Installation and repair of duct systems

In common equipment replacement practice, most HVAC contractors do not deal with the existing ductwork except as needed to connect the supply and return ducting to the new air handler or furnace. Reasons include the contractor's concern with price competition (hence quick installations), a distaste for the actual work of sealing or replacing ducts in attics, crawl spaces, and other difficult locations, and perceived buyer resistance to unexpectedly costly duct repairs.

Yet many if not most residential duct systems perform poorly, due to leakage, inadequate sizing (especially returns), room-by-room airflow imbalances, and excessive resistance due to bends and long runs. These duct deficiencies are major sources of wasted energy as well as comfort and indoor air quality problems. Best practices involve analysis and correction of the duct system's leakage, delivery rates, return capacities, filter capacity, and obvious installation deficiencies such as tortuous runs and disconnects. Simple duct sealing is a valuable improvement, but often for optimal energy performance at least parts of the duct system must be resized and replaced.

2.5. Quality Assurance

Project test-outs to assure quality and safety are almost never performed. Codes and other mandatory guidelines do not adequately cover energy issues. Few contractors do adequate post-project followup with their clients to assess and assure home energy performance and demonstrate quality commitment.

Local and national codes
Most local as well as national building codes tend to provide little if any guidance on quality assurance. The new California Title 24 requirement for duct sealing and verification through duct pressurization testing is only a first step in assuring that energy-related home improvements actually perform as planned and expected. Even in new homes, testing often demonstrates poor performance in virtually all energy-related matters from HVAC system efficiency to building envelope management of air, moisture, and heat movement.

Field staff quality assurance education and motivation
Contractors and their field crews are generally uninformed on the value of testing to confirm quality and reduce callbacks or legal conflicts arising from even inadvertent mistakes. Contractors must be taught the importance of testing and how to assure adequately trained and motivated field staff in both proper installation and confirmation through performance tests.

Conducting and documenting test-outs, including combustion safety
The concept of completion quality testing is almost unknown. Combustion safety testing has been covered in an earlier chapter, but is a vital aspect of job quality assurance. Other appropriate tests, depending on the scope of the project, may include infrared inspection of new insulation, a blower door test to verify building air management and appropriate ventilation when air sealing has been done, and duct blaster/flowhood tests to assure that a revised HVAC system is performing efficiently and providing proper airflow and comfort to all rooms. None of these tests is done routinely, if ever, by most remodeling and HVAC contractors. This deficiency in common practice is an invitation to legal liability risks as well as customer dissatisfaction and even danger.

Providing homeowner with maintenance and operations instructions
Common practices vary widely in assuring knowledgeable job "handoff" to the customer. At the end of any remodeling or repair project, the contractor should provide the homeowner with all manuals, operating instructions, and warranty information for any equipment and materials used. In some states this is legally required. It is particularly important in energy-related improvements, where homeowner understanding of requirements is crucial in routine responsibilities such as air filter replacements, proper thermostat operation, and efficient use of lighting, pool pump timers, and similar features. Interviewees and team experience suggest that this is done effectively by some contractors but is too often incomplete or overlooked by both contractor and homeowner.

Scheduling maintenance and followup, including bill tracking
Opportunities for assuring continued quality and satisfaction are generally overlooked. Best practice for all remodeling and repair contractors is to recontact the homeowner several months after job completion to check on the home's performance after energy improvements and assure proper operation and maintenance. It is advisable to review utility bills at that stage as evidence of performance improvement. Interviews indicate that these useful steps are not taken in most cases.

3. FINDINGS – Whole House Retrofit and other Home Energy Efficiency Initiatives

This Section of the Report summarizes energy efficient remodeling initiatives in the U.S. and related programs. Both "whole house" (comprehensive) and trade-specific activities are included, as well as assisted-housing programs.

Examples of Whole House Energy Retrofits

Asdahl house, Henderson, NV. This 2002 demonstration, supported by HUD's Office of Research and Policy Programs and conducted by NAHB-RC with Nevada Power, involved a home diagnosis and many energy improvements ranging from new appliances and lighting to high-efficiency air conditioning, duct improvements, radiant barrier, and extensive insulation and air sealing. Energy savings were approximately 30%.

Nutting house, Fresno, CA. In addition to high air conditioning bills and poorly conditioned rooms, family members had breathing difficulties. Other contractors had proposed costly and ineffective remedies. Rare Service, a trained home performance contractor, tested and found that fiberglass insulation particles were being pulled in from the attic through unsealed recessed can lights due to shell depressurization, ducts were leaky and poorly designed, and closed interior doors were causing air distribution imbalances. Corrections removed the health and comfort problems, and overall energy bills were reduced by over 30%.

St. Laurent/Cranston house, Ithaca, NY. Even an old house can be energy efficient and comfortable in extreme weather. The new owners of this 1930-era Colonial style house found it cold and drafty in the winter despite unexpectedly high utility bills. A diagnosis by Performance Systems Contracting, a local home performance contractor, found extensive air leaks, very poor insulation, and an antique 53% efficient gravity furnace. After comprehensive improvements to the building shell and heating system, the heating bill dropped by two thirds, the cold drafts are gone, and the house also stays much cooler in the summer.

3.1. Whole House Retrofit Programs

Home Performance with ENERGY STAR®
The U.S. Environmental Protection Agency administers this program (HPwES), which seeks to promote local whole house retrofit sponsorship programs nationally. The program operates through a variety of Energy Star Partner organizations in specific regions and cities. Those local partners may include local nonprofit trade associations, advocacy groups, and governmental agencies, with sponsors such as utilities, home improvement manufacturers and public agencies.

The Home Performance with Energy Star program does not train, certify, or otherwise endorse individual contractors, allowing for variations among the local implementation efforts according to their needs and resources. The program allows use of the Energy Star logo for local programs and their trained home analysts and contractors who conduct comprehensive home diagnostics and do or arrange for proper repairs. Job quality assurance is provided by the requirement of either contractor accreditation by the Building Performance Institute or by a sample-based onsite inspection and testing program. No specific performance protocols or standards are imposed.

EPA is currently considering an expanded effort in existing home performance improvement through integrated marketing of its related activities in specific topics such as lighting, HVAC, water heating, windows, and insulation and air sealing. That effort includes encouragement of a “crawl, walk, run” approach to contractor education and authorization, exposing contractors to a gradually broader range of home assessment and improvement options to enable self-paced education rather than an all-or-nothing approach. This effort will be closely linked to the PATH 36 strategy through sharing of project plans and activities to assure consistency.

Current Home Performance with Energy Star implementation programs
There are at least twelve regional Home Performance with Energy Star programs now underway (see www.energystar.gov), with more emerging.

HP with Energy Star Program	***Sponsor/Operator***
Atlanta, GA	Southface Energy Institute
Atlantic City, NJ	Board of Public Utilities
Austin, TX	Austin Energy
Colorado	E-Star Colorado
Idaho	Idaho Energy Division
Kansas City, KS	Metropolitan Energy Center
Massachusetts	NSTAR Electric & Various Utilities
Minneapolis & St. Paul, MN	Neighborhood Energy Consortium
New York	New York State Energy Research and Development Authority
Northern California	California Building Performance Contractors Association
St. Louis, MO	Missouri Botanical Garden Earthways Center
Wisconsin	Focus on Energy

According to a presentation made by Mike Rogers of MSI Consulting under contract to the EPA Home Performance with Energy Star program (Boston; 6/16/05, “Home Performance With ENERGY STAR: Delivering Whole-House Performance”)**,** New York and Wisconsin were the Energy Star’s two initial Home Performance program markets, followed by California, Kansas City and Massachusetts in 2002 and 2003. It can take two or more years for these programs to gain significant traction. 2006 will be an important year for assessing the initial five regional programs, as documented energy savings, contractor participation and overall program progress will be measured, reported, shared and analyzed for the first time.

Protocols, Standards and Contractor Accreditation
The Energy Star retrofit programs in different states tend to use different standards and protocols for their contractor training and job verification, as well as different approaches to recognition of contractor capabilities. The examples in the following box indicate that there is as yet no formal agreement on a single set of best-practice protocols and building performance standards. There is a current Building Performance Institute effort to create such a common technical base, applying only to full whole-house contracting diagnostics and retrofits. However, there is still substantial controversy among programs as well as individual experts about the specifics of appropriate standards and best-practice protocols, and we are far from a single standard approach to these key functions.

Similarly, there is no agreement on appropriate approaches to contractor quality recognition, for a variety of reasons. Some sponsors have liability concerns regarding awarding of contractor accreditations, others are concerned about the possible inflexibility of any national branding of contractor accreditation, and the likely costs of any such process are also of concern despite the possible benefits of customer confidence in home performance contractors.

Examples of Program Standards, Protocols, and Contractor Accreditation Approaches

▪ **New York**	Follows Building Performance Institute (BPI) process for individual technician certification and contractor accreditation. Some performance standards per BPI (e.g., carbon monoxide testing), and soon to publish contractor ratings re compliance. Now developing best practices recommendations, starting with insulation, air sealing and duct sealing standards
▪ **Wisconsin**	Based technical training on home performance testing protocols by Performance Systems Development, Inc. Remediation practices not specified but follow conventional guidelines and codes. No formal technician certification or contractor accreditation.
▪ **California**	Uses expanded version of the Wisconsin diagnostic protocols, modified for climate and augmented by additional protocols for business and marketing practices. Uses existing national trade remediation protocols/standards. Does not formally certify technicians or accredit contractors, but uses field inspection and sanctions to assure quality and brand value.
▪ **Colorado**	Developed own training system, based protocols and standards on Saturn Resource Management and Building America guidelines. Using own contractor certification process to clearly distinguish participating contractors.
▪ **Atlanta area**	Developed their own training system, defined own protocols and standards plus QA/QC approach. No formal certification or accreditation of contractors at this early stage.
▪ **Massachusetts**	CSG is general contractor/administrator (BPI accredited), supervising subs. Now developing best practices recommendations, starting with insulation, air sealing and duct sealing standards (together with NY).
▪ **Oregon, New Jersey**	Use BPI certification; OR also allows a similar certification and now debating which protocols and standards to adopt.
▪ **Austin**	Training to BPI standards and moving toward BPI certification; no accreditation.
▪ **Kansas City area**	Uses BPI certification and standards; low funding & activity.
▪ **St. Louis area**	Uses BPI certification and standards; low funding & activity.

Examples of Home Performance with Energy Star Local Implementation Programs

Local Home Performance with ENERGY STAR® implementations vary widely in scale and approach. The **New York** program is the original and still by far the largest and most well-funded. It covers most of the state except New York City. NYSERDA uses a combination of extensive mass media advertising, a consumer choice of a cash rebate or project financing at low interest rates, and a variety of contractor incentives to create demand and a motivated set of contractors simultaneously. Contractors are required to be accredited by the Building Performance Institute (see below), and completed projects are sampled randomly for quality assurance inspections. Funding is committed for several years at a time, creating program stability.

The **California** program, operated by the California Building Performance Contractors Association and funded through the state's public goods charge on electricity bills, has focused on the Pacific Gas and Electric service territory covering most of the central and northern parts of the state. That

Northern California project is maturing and continuing for 2006-07 with further contractor training funded by PG&E and other CBPCA contractor support funded by membership dues and fees. CBPCA is also beginning a home performance contracting program in the Southern California Edison service area in 2006, employing cash incentives to contractors. CBPCA conducts its own contractor training and testing, but does not at this point employ formal contractor certification or accreditation. The California programs use the home performance best-practice protocols developed for the California Energy Commission by BKi and PSD, plus the State's Title 24 quality installation requirements. The CBPCA programs are primarily distinguished by their emphasis on contractor mentoring and support after training, as a way to help overcome both business and technical barriers faced by contractors moving toward whole house contracting.

The **Wisconsin** program is the main example of a focus on a "consultant" approach, separating the home diagnosis from the actual improvements. This statewide program is well advertised and provides incentives to trained and certified home energy raters, who diagnose home deficiencies and can either refer homeowners to qualified contractors for the improvements or coordinate the entire project. The program reports strong participation.

Most **other** HPwES programs are still relatively small and operate on very limited funding from a variety of startup grants and contributions from utilities and major materials suppliers. Typically those programs are in utility areas with relatively low emphasis on energy efficiency program funding, and have no incentives to offer either homeowners or contractors. For example, the **Atlanta, Missouri** and **Colorado** programs each operate limited whole house training programs but have not been able to attract sufficient funding to support expanded training, marketing or contractor support activities. Each has trained a few contractors and works to gain visibility and funding support.

Building Performance Institute

BPI seeks to build and provide a national standard for contractor accreditation and quality assurance. BPI was founded ten years ago to provide a reliable means of assuring homeowners of contractor capabilities in comprehensive home performance work. The organization has provided the home performance contracting industry with individual technician certifications and contractor accreditations based on a series of examinations. For those tests, individuals are trained by various providers and are given the examination by independent organizations affiliated with BPI. Only the testing and certification process is provided by BPI. Disciplinary tests include comprehensive diagnostics, heating, cooling, and shell specialties. Contracting firms seeking accreditation must have up-to-date certified professionals on staff or subcontracted in all specialties.

BPI works closely with the national Home Performance with Energy Star program, which awarded it a $1 million grant in 2004 to expand its activities to include the development of comprehensive home performance standards. A growing number of local and state performance programs are BPI affiliates, and BPI currently has 160 BPI-accredited contractors qualified to offer building performance services. Over 2500 specialists have been trained. BPI is introducing a new set of services and requirements in 2006 to reflect updated field practices and standards as well as to better meet the needs of future programs and contractors as the industry expands nationwide.

U.S. Department of Energy

DOE provides a variety of technical assistance products for energy efficient remodeling. The DOE's Building Technologies Program and Weatherization & Intergovernmental Program provide a broad range of information and tools for homeowners as well as contractors. DOE's most directly relevant recent activity for PATH 36 is its development and testing of training modules for comprehensive energy efficient remodeling. Eight modules are included:

- Introduction & Marketing
- Building Science Basics
- House as a System
- Room Additions
- Baths
- Kitchens
- Space Conversions
- Mechanical Systems

The modules have been field-tested and will soon be available for use by organizations involved in contractor training. The PATH 36 program will coordinate its guidelines for contractors with the DOE training modules.

Other regional whole-house contractor training programs

A growing range of organizations nationwide conduct training for home performance contractors. Examples include the Kansas Building Science Institute, the Pacific Gas & Electric Energy Training Center--Stockton, California Building Performance Contractors Association, Southface Institute, Saturn Resource Management, Performance Systems Development, and the Onondaga-Cortland-Madison BOCES (Board of Cooperative Educational Services) in New York.

As one of the earliest examples of such training providers, OCM-BOCES offers training in home performance/building science to prepare students for Building Performance Institute (BPI) certification in support of New York State's Home Performance with ENERGY STAR® program. Training focuses on whole-house diagnostics relating to energy efficiency, health, safety, comfort and durability, and includes both classroom and field studies. Trade-related math, computer and sales/marketing training are also offered in conjunction with the Building Science curricula.

Various emerging home performance contractor support programs around the country are either developing their own training curricula and activities or making use of a variety of expert private third-party training providers who have developed their own curricula and delivery systems. In addition to those already cited, examples include Saturn Resource Management, Performance Systems Development Inc., and several individual experts.

Residential Energy Services Network

RESNET provides home energy assessment training for energy raters and consultants. RESNET's activities are focused on:

- Adopting and maintaining the national standards for home energy ratings.
- Accrediting home energy rating providers, energy rating training providers, and home energy rating software programs.
- Working with the mortgage industry in developing innovative residential energy efficiency financing products
- Educating the public and the housing industry on the benefits of residential energy efficiency

The organization is primarily known for its national energy rater accreditation program. RESNET is important in the home performance movement because its accredited energy raters are required to master most of the same diagnostic skills that are required for the comprehensive diagnostic assessments of homes in whole-house contracting. This RESNET rater capability helps to increase the supply of capable home diagnostic specialists and encourage home performance business model options such as the use of independent raters who may associate with contractors capable of high-quality repair and installation work but who do not wish to be responsible for the diagnostic skills.

California Energy Commission
The CEC's Public Interest Energy Research (PIER) program has sponsored important basic research in building science and home performance best practices. PIER does not operate implementation activities, but its R&D activities have included a major study of the state of the art by Lawrence Berkeley National Laboratory and a follow-on project by Bevilacqua-Knight, Inc. (with subcontractor Performance Systems Development, Inc.) to translate the LBNL and other inputs into a set of home performance protocols. That project, now being completed, is delivering a comprehensive set of some 40 contractor protocols encompassing approximately 450 learning objectives. Those protocols are being used as basic inputs to the BPI standards project as well as to the PATH 36 structure for contractor education.

U.S. Department of Housing and Urban Development
HUD's Office of Policy Development and Research has sponsored a variety of field test projects to demonstrate home retrofit opportunities and solutions. Examples include the Asdal home retrofit in Henderson, Nevada (2002), in which a small tract home built in 1986 was extensively tested, remodeled, and reported on under the management of the National Association of Home Builders Research Center. Measures installed included high-efficiency HVAC, duct improvements and insulation, new low-E windows, attic joint-mounted radiant barrier, new major appliances, envelope sealing, additional attic and new wall insulation, and compact fluorescent and LED lighting, Electricity and gas savings were estimated at about 30%.

3.2. Trade-Specific Contractor Improvement Activities

North American Technical Excellence
The NATE program is an independent third-party national effort in certification for HVAC technicians. NATE only tests and certifies; it leaves training to the broad range of existing training programs around the country. It is supported by some 20 national and regional trade associations and professional societies in a unified effort to standardize certification of HVAC technicians.

Over the past few years, NATE has grown considerably. Over 20,000 technicians have been NATE-certified. NATE currently offers certification tests to both Installation and Service technicians. To earn certification contractors must take a core exam and one specialty exam of their choice. The five specialties available are: Air Conditioning, Air Distribution, Gas Heating, Heat Pumps, and Oil Heating. The Core Exam covers Safety, Tools, Soft Skills, Principles of Heat Transfer and Total Comfort, and Electrical questions.

The Specialty Exams cover Installation, Service, System Components, and Applied Knowledge: Regulations, Codes and Safety. Passing grade is 70 percent. Even if a contractor does not pass both exams and earn certification, they will receive credit for the exam they did pass and can register to re-take any exam not passed after a 30-day study and training period. Contractors have two years to take and pass the missing exam they need to complete certification. Some interviewees indicated that lack of skilled labor is a major factor limiting the quality of contractor work.

BPI has allied with NATE to make use of NATE certification in the BPI certification model. The PATH 36 project will assure that NATE standards for HVAC technicians are incorporated as appropriate into the project's products.

National Comfort Institute
NCI trains HVAC contractors in best system diagnostic and installation practices. Over the past 13 years, NCI has trained and certified over 6,000 heating, air conditioning and plumbing professionals in the tools and techniques to properly test, diagnose and provide complete solutions to heating and air conditioning system problems. Its approach focuses only on the HVAC system; in keeping with its disciplinary focus, NCI excludes the reduction of thermal loads through assessment and modification of the building envelope. NCI provides training in airflow diagnostics and air balancing, carbon monoxide analysis and combustion optimization, indoor air quality issues related to heating and air conditioning and more.

Other trade-specific standards, training, and accreditation
Many trade associations offer specialized trade-specific training and various forms of accreditation to contractor personnel. These include national organizations such as ACCA, NARI, NAHB, and SMACNA as well as active regional or local groups such as Southern California's Institute of Heating and Air Conditioning Industries Inc. (IHACI). These groups focus on offering their members educational opportunities in best technical practices. All are discipline-focused, most often on HVAC topics. They rely on others to provide standards, and either import or provide their own curricula.

Standards relevant to home energy performance are provided by a variety of organizations. In addition to the current BPI initiative in home performance standards, which is the only activity with a comprehensive residential scope, the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) is the dominant industry standards provider for HVAC topics. Other trade groups and professional societies establish standards as part of their services in other specific trades, from insulation to heating and cooling equipment and including both material specifications and installation practices. Many of the most relevant providers are indicated in Appendix C's listing of standards references for each aspect of home energy performance contracting.

3.3. Practices in Assisted Housing Programs

This study focuses on the private home repair and remodeling market, which constitutes most of the nation's individual housing stock and activity in energy efficiency-relevant modifications. This chapter supplements that private-market focus by providing a brief review of relevant activities in the assisted-housing market. We define that market to include improvements to subsidized low-rise housing as well as low income weatherization assistance to private homeowners across the country. In general, assisted housing repair and improvement practices vary widely but include some valuable opportunities for broader application in the unassisted private homeowner market.

Improvement programs in subsidized housing
Most subsidized housing is in large multifamily buildings, typically rental tenanted. Significant energy-saving improvements to such buildings are usually difficult to fund. When projects are done, energy services companies (ESCOs) are sometimes asked to conduct audits and propose shared-savings improvements, but it is more common for the sponsor agency to simply select most urgently needed improvements and contract directly for them. The quality and effectiveness of the work, which is susceptible to abuse due to cost pressures, depends largely on the sponsoring agency's ability to supervise and exert quality control.

Low-rise assisted housing, including townhouses and some condominium conversions of former small apartment complexes, is often similar to single family homes in construction, mechanical systems, and operation. Such assisted housing can sometimes make use of trained home performance diagnostic and repair specialists, although we find little evidence of any such connection. There is good potential for a stronger link between home performance specialists and housing agencies with such projects and needs.

Low income weatherization programs

Energy saving practices vary widely among weatherization programs nationally. These programs provide financial support and trained personnel to remedy energy-wasting conditions in homes with low income owners. Most states offer such programs, using a combination of state and federal funding. Weatherization program delivery is inconsistent. Based on interviews and personal experience, Team IBTS estimates that the top 25% of agencies—those in the best states—are good, while others often do sub-par work and fewer improvements per house.

Weatherization project work is done typically either by local agency field personnel or private contractors who tend to specialize in such programs. These field personnel are often relatively well trained in diagnostics in contrast to typical remodeler staff, and would appear to be prime candidates for expansion into the private market as home performance specialists. However, most of these contractors continue to work exclusively in the public weatherization programs rather than adding private market work.

Other low income assistance programs to improve home energy use are offered by many electric and gas utilities. Most of these are limited to subsidies for the purchase and installation of a limited set of specific energy saving appliances or home improvements. A significant exception is the NYSERDA Home Performance with Energy Star program, which offers grants of up to $5,000 to qualified low income homeowners to help finance whole-house inspections and comprehensive improvements. Another exception is the Federal tax credit available to low income homeowners for cost-effective home improvements, in the form of affordable 30-year mortgages.

4: CONCLUSIONS

The Study's Principal Conclusion

Apart from the participation of relatively few contractors in regional Home Performance with Energy Star or utility incentive-backed programs, most conventional remodeling-related contractors are missing vast opportunities in their daily work for energy savings nationwide. Other lost benefits include improvements in comfort, safety, health, home maintenance cost, and value. These missed opportunities generally persist for many years. The comprehensive home diagnostic testing, best practice solutions and quality installations that could capture those benefits are extremely rare among existing home projects from HVAC replacements to complete home renovations and expansions. Further comments follow on selected aspects.

General Business Practices

- Few contractors incorporate knowledgeable best-practice energy efficiency improvements into their remodeling or repair work.
- The home remodeling and repair industries are dominated by small firms for whom such changes tend to be difficult without more direct assistance than currently available.
- There is a major need for providing large numbers of contractors with a manageable stepwise path to selling and making home energy improvements of increasing scope and scale.

Home Inspection and Testing

- Energy-focused home inspection and testing occurs almost exclusively in work by energy raters to qualify new Energy Star homes (and other premium home performance specifications) rather than to improve the energy performance of existing homes.
- There is a small group of contractors—perhaps several hundred to one thousand nationally, or less than one percent—who are trained in comprehensive inspection and testing as well as effective implementation of solutions for existing homes, but the barriers to entry to that level of expertise tend to be very high for most other contractors.

Finding/Selling Solutions

- Once a trained home inspection and testing step is done, determining the most appropriate solutions to energy-related deficiencies tends to be straightforward…but in common practice very few contractors are trained to do this testing and solution specification.
- Selling energy-related home improvements, either as stand-alone projects or as additions to broader remodels, requires significant effort and support in consumer education. This requires a substantial upgrade in the sales skills and techniques of most contractors.

Installation Practices

- Inadequate remodeling and equipment installation practices that impair home energy performance, comfort, safety, and home durability are widespread.

- The vast majority of home improvement contractors have no easy access to the rationale and knowledge needed to offer home energy improvements effectively

Quality Assurance

- Internal test-based job quality assurance by contractors is an important way to reduce liability risk, callback costs, and customer disputes, but most contractors do no testing to assure quality of work such as duct and envelope air sealing, insulation, and combustion safety.
- Providing homeowner operations instructions and following up to assure performance and satisfaction after energy-saving improvements are completed are important steps in effective home energy performance improvement. In common practice, these steps are often not taken, but are particularly important to assure that the expected energy savings and other benefits actually occurred and are being supported by the owner's operation of the home.
- Post-installation annual service contracts are a significant part of the mechanical contracting business model. Scheduled annual visits for seasonal system maintenance and repair are quite common, although such visits rarely include safety testing or energy efficiency-focused inspection of the complete HVAC system or building shell.

Home Energy Efficiency Improvement Programs for Contractors

- There are many industry associations, utilities, and government agencies offering training and resource materials to contractors for home energy efficiency programs, but virtually all are focused on a single discipline such as air conditioning equipment installation and do not consider the whole house as an integrated system.
- Comprehensive home energy efficiency testing and repair training and materials for contractors are few in number and not widely known among remodeling contractors. The comprehensive programs that do exist are not extensively used by contractors, due to many intrinsic barriers to change in routine practices.
- Utilities and state-sponsored contractor training programs typically require high amounts of immediate quantified energy savings (within year one). Programs like HPwES can often take as long as three years to gain significant traction in a new marketplace, making it difficult for sponsors with short-term goals to support.
- The principal comprehensive program to encourage improved contractor practices in home energy use reduction is the Home Performance with ENERGY STAR® promotional effort operated by the US Environmental Protection Agency, supported by the certification and standards-setting activities of the Building Performance Institute. However, individual implementation efforts around the country vary in their choices of standards, best-practice protocols, and certification of technicians or accreditation of participating contractors.

APPENDIX A: Participating Interviewees

Approximately 60 industry representatives were contacted for their assessments of major common practices deficiencies in energy-related home repair and remodeling.

Interviewee	*Organization*	*Location*
Dan Taddie	National Association of the Remodeling Industry (NARI)	National
Mike Kwart	Insulation Contractors Association of America (ICAA)	National
Glenn Hourahan	Air Conditioning Contractors of America (ACCA)	National
Pat Murphy	North American Technical Excellence (NATE)	National
Tim Locke	CA Building Performance Contractors Ass'n	San Francisco
John Zink	Plumbing Heating Cooling Contractors Ass'n	National
Mike Gorman	TechKnowledge (contractor business consultant)	Lakeland, FL
Eric Howarth	Electric and Gas Industries Association	Sacramento
Doug Garrett	Home Performance Consultant	Austin, TX
Tom Hacksaw	Dynatemp Incorporated (HVAC contr)	Maryland
Marilou Cheple	University of Minnesota (housing researcher)	Minneapolis
Giles Griffiths	Staats Developers	Virginia
Chad Garner	Wise Choice Construction, LLC (remodeler)	Maryland
Russ Irvine	Town & Country Home Crafters (windows, etc.)	Baltimore, MD
Tom Conlon	GeoPraxis	Sonoma, CA
George Sullivan	Eco Smart Building (Remodeler)	Chicago
n/a	EEBA List serve	National
George K. Swatzbaugh III	GK Construction (Remodeler)	Maryland
Chandler Von Schrader	EPA – Home Improvement Team	Washington, D.C.
Dick Kornbluth	Entherm (home performance cont'r)	Syracuse, NY
Michael Strong	Brothers Strong Construction	Houston
Michael Lotesto	Performance Exteriors	Illinois

Guy Lundsten	Installation Masters	Minnesota
Warren Lupson	ACCA	National
Stan Johnson	Stan's Heating and Air	Austin
Breck Powers	LBJ Construction	Houston
Jeff Hunt	Heritage Construction	Houston
Bob Briner	Amazing Siding	Houston
Randal Riedel	CEC	California
Dave Johnson	What's Working	Boulder, CO
Dale Gustavson	ACCA California	Orange, CA
Gary Richardson	Rare Service HVAC	Clovis, CA
Dave Robinson	Renaissance	Fresno, CA
n/a	Energy Conservatory	Minneapolis
Bob Bell	Bell's Remodeling	Duluth, MN
Chris Strand	Strand's Remodeling	Austin, TX
Dan Foley	Foley Mechanical	Alexandria, VA
David Tyson	Tyson Remodeling	Charlotte, NC
Brian Harvey	Heating & Cooling, Inc.	
Chris Perry	J&P Heating	Washington, D.C.
Bob Wendt	Oak Ridge National Laboratory	Tennessee
Frank Malpere	Consultant	
Jim Heivelin	Old Dominion Remodeling	Round Hill, Virginia
Lenox Bowman	P&B Finishers	Shelby Township, MI
Paul Harris	The Linc Group	Irvine, CA
Ron Kazmierczak	Kaz Brothers Remodeling	Buffalo, NY
Rick Chitwood	Chitwood Energy	Mt. Shasta, CA
Russ Rudy	KBSI/Balance Home Energy	Kansas City
Therese Ford Crahan	NAHB Remodelers' Council	National

APPENDIX B: Best Practice Sources

Overview

In a related prior project for the California Energy Commission, IBTS subcontractors produced a bibliography of authoritative standards and best practices sources related to each of a set of home performance protocols. That bibliography is included here for its potential use in the PATH 36 project's development of guidance for national and local energy efficiency programs, professional educators, and contractors seeking to improve field performance in energy related common practices.

Building Performance Protocol Resources

(by Performance Systems Development, Inc. for BKi and the California Energy Commission)

A. Resource Categories

Inspection Process
Home Inspection Process
Conducting "Testout" and Documentation Tests

Customer Involvement
Customer Interview Process
Common Customer Concerns/Motivations

Structural Inspections
Inspection of Thermal Boundary Performance (insulation, windows)
Inspection of Building Envelope Performance (air infiltration)

Indoor Air Quality Inspections
Evaluating Moisture Issues
Evaluating Health, Durability, IAQ and Safety

Mechanical Inspections
Evaluating Combustion Appliance Performance and Ventilation Systems
Inspection of Air Distribution System Performance (ducts)
Inspection of Major Appliance and Lighting Performance

Structure Installation
Common Practices for Installation of Windows
Common Practices for Installation of Insulation

Mechanical Systems Installation
Common Practices for Installation of Combustion/HVAC/DHW
Common Practices for Installation of Duct Systems/Remediation

B. Home Inspection Activities and References

Home Inspection Process

Best Practices:
1. Perform a "whole house" investigation.
2. Maintain a logical sequence to the order of systems testing.
3. Determine probable causes and resolutions for issues and problems.
4. Record results and make recommendations.
5. Maintain and utilize diagnostic equipment in accordance with manufacturers specifications.

Reference information:
MSDS National Repository Hendersonville, TN: MSDSSEARCH, Inc. (#http://msdssearch.com/#)
The Energy Conservatory's web site Minneapolis, MN: The Energy Conservatory. (#http://www.energyconservatory.com/#)
Tools to Know for Home Diagnostics By Stewart Selman. Home Energy Magazine. (#http://www.homeenergy.org/archive/hem.dis.anl.gov/eehem/00/000313.htm l#)

Conducting "Testout" and Documentation Tests

Best Practices: (incomplete)

Customer Interview Process

Best Practices:
1. Involve the occupant at the beginning of the investigation.
2. Identify the number of occupants and appliance utilization habits for ventilation.
3. Ask about the structural integrity of the building.
4. Ask about historical or seasonal moisture issues.
5. Ask about systems performance.
6. Ask about health concerns or complaints.
7. Ask about occupant influence on distribution systems.
8. Ask about building configurations, auxiliary fuels and thermostat settings.
9. Collect energy use information from fuel vendors or fuel use records.

Common Customer Concerns/Motivations

(no references)

Inspection of Thermal Boundary Performance (insulation, windows)

Background information:
ASHRAE Fundamentals By John T. Krigger, Chris Dorsi (2004). ASHRAE. Chapter 3 Heat Transfer.
Builder's Guide: Hot Dry and Mixed Dry Climates Westford, MA: Building Science Corp. Chapter 12 Insulation. (#http://www.energy.ca.gov/efficiency/qualityhomes/INSULATION_CHECKLIS T.PDF#)
A guide to the design and remodeling of wall systems Partnership for Advancing Technology in Housing. (#http://www.pathnet.org/si.asp?id=399#)

Partitions, Ceilings, Floors and Stairs By Steven Winter. Partnership for Advancing Technology in Housing. (#http://www.pathnet.org/si.asp?id=446#)
Radiant Barrier Bibliography Building Environmental Science and Technology. (http://www.nrg builder.com/pdf/radiantbarriers.pdf)
Radiant Barrier Fact Sheet Oak Ridge National Lab Building Thermal Envelope Program. (http://www.ornl.gov/sci/roofs+walls/whole_wall/wallsys.html#http://www.ornl.go v/sci/roofs+walls/whole_wall/wallsys.html#)

Best Practices:
1. List the values of a well defined thermal boundary.

Reference information:
Energy & Environmental Building Association (EEBA) Builder's Guide Westford, MA: Building Science Corp. Chapter 12, pp. 149-155.
25 Checkpoints for Inspecting Insulation Jobs Insulation Contractors Association of America. (#http://www.insulate.org/frameset.php?thePage=builders.html#)
California Energy Commission, Procedures for Proper Installation of Insulation Contractors Association of America. (#http://www.insulate.org/frameset.php?thePage=builders.html#)
Handling Framing Details in High Performance Homes By Larry Hasterok. Home Energy Magazine. (#http://www.homeenergy.org//archive/hem.dis.anl.gov/eehem/96/960908.ht ml#)
High Performance House, What Does it Take? California Energy Commission. (#http://www.energy.ca.gov/efficiency/qualityhomes/insulation.html#)

2. Define the conditioned and unconditioned areas of the building.

Reference information:
No Regrets Remodeling Home Energy Magazine. pp. 42, 43, Glossary.
Beauty and the Beast Upstairs Home Energy Magazine. (#http://www.homeenergy.org//archive/hem.dis.anl.gov/eehem/95/950910.ht ml#)
First Step in Cellulose Sealing: Spot the Style Home Energy Magazine. (#http://www.homeenergy.org//archive/hem.dis.anl.gov/eehem/95/950309.ht ml#)

3. Evaluate the placement of thermal boundaries.

Reference information:
Energy & Environmental Building Association (EEBA) Builder's Guide Westford, MA: Building Science Corp. Chapter 12, pp. 223-236.
25 Checkpoints for Inspecting Insulation Jobs Insulation Contractors Association of America. (#http://www.insulate.org/frameset.php?thePage=builders.html#)
Air Sealing in Low Rise Buildings Home Energy Magazine. (http://www.homeenergy.org//archive/hem.dis.anl.gov/eehem/95/950910.html #Protocol Preparation\Inspections3Structure\Inspecting the Thermal Boundary Preparation CA 080604_CM.doc 1,6956,7116,0, HYPERLINK "http://www.homeener)
Air Sealing in Occupied Homes Home Energy Magazine. (#http://www.homeenergy.org//archive/hem.dis.anl.gov/eehem/95/951111.ht ml#)

4. Measure accurately the components of the thermal boundary.

Reference information:
Instrumented Home Energy Commissioning Lawrence Berkeley National Laboratory. pp. 37-41.
Residential Loads Calculation Air Conditioning Contractors of America.

5. Identify construction materials associated with the thermal boundary.

Reference information:
Residential Energy Saturn Resource Management. pp. 240-244.
Home Energy Consumer Guide to Insulation Home Energy Magazine.
(http://www.homeenergy.org//archive/hem.dis.anl.gov/eehem/96/960908.html #Protocol Preparation\Inspections3Structure\Inspecting the Thermal Boundary Preparation CA 080604_CM.doc 1,9111,9271,0, HYPERLINK "http://www.homeener)
Wall R Values That Tell it Like It is Home Energy Magazine.
(#http://www.homeenergy.org//archive/hem.dis.anl.gov/eehem/97/970308.ht ml#)

6. Inspect thermal boundary for integrity and proper placement.

Reference information:
Inspecting for the Residential Provisions of the IECC US Department of Energy. Chapter 5 Insulation Inspection.
Whole Wall Thermal Performance Calculator Oak Ridge National Lab Building Thermal Envelope Program. (#http://www.ornl.gov/sci/roofs+walls/whole_wall/wallsys.html#)

7. Identify ineffective or damaged insulation materials.

Reference information:
Attic Bypasses Minnesota Department of Commerce.
(#http://www.commerce.state.mn.us/pages/Energy/InfoCenter/pdfs/atticby.pdf #)
Insulation Checklist California Energy Commission.
(#http://www.energy.ca.gov/efficiency/qualityhomes/INSULATION_CHECKLI ST.PDF#)
Wall Insulation Fact Sheet Southface Energy Institute.
(#http://www.southface.org/home/sfpubs/techshts/wallinsulation.pdf#)

8. Apply thermal imaging to inspection protocol.

Reference information:
ASHRAE Fundamentals By John T. Krigger, Chris Dorsi (2004). ASHRAE. Chapter 3 Heat Transfer.
Residential Energy, Saturn Resource Management. pp. 223-236, 240-244.

Standards:
Standard Practice in Determining Thermal Resistance for Building Envelopes, American Society for Testing and Materials (ASTM).

9. Evaluate the importance of radiant temperatures upon occupant comfort and provide recommendations for improvements.

Reference information:
ASHRAE Fundamentals By John T. Krigger, Chris Dorsi (2004). ASHRAE. Chapter 8 Physiological Principles for Comfort and Health.

10. Determine options to improve thermal boundaries.

Reference information:

Energy & Environmental Building Association (EEBA) Builder's Guide Westford, MA: Building Science Corp. Chapter 12, pp. 149-155.
No Regrets Remodeling Home Energy Magazine. pp. 42, 43, Glossary.
Advanced Air Sealing Iris Communications. (#http://oikos.com/library/airsealing/index.html##)
Builder's Guide: Recessed Lights City of Fort Collins.
(#http://www.ci.fortcollins.co.us/lightandpower/buildersguide/09_ceilings/99.htm#)

Inspection of Building Envelope Performance (air infiltration)

Background information:
Builder’s Guide: Hot Dry and Mixed Dry Climates Westford, MA: Building Science Corp. Chapter 7 Foundations & Wood Frame Construction.
(#http://www.energy.ca.gov/efficiency/qualityhomes/INSULATION_CHECKLIS T.PDF#)
Builder’s Guide: Hot Dry and Mixed Dry Climates Westford, MA: Building Science Corp. Chapter 8.
(#http://www.energy.ca.gov/efficiency/qualityhomes/INSULATION_CHECKLIS T.PDF#)
Graphic Guide to Frame Construction Taunton Press.
Residential Energy Saturn Resource Management. Chapter 2 Energy and the Building Shell.

Best Practices:
1. Identify framing style used in construction.

Reference information:
The Standards of Practice and Code of Ethics American Society of Home Inspectors.
(#http://www.ashi.com/inspectors/standards/standards.asp#)

Standards:
Standards of Practice California Real Estate Inspection Association.
(#http://www.creia.org/lawsstandards/index.htm#)

2. Determine framing techniques and characteristics incorporated into a structure.

Reference information:
25 Checkpoints for Inspecting Insulation Jobs Insulation Contractors Association of America.
(#http://www.insulate.org/frameset.php?thePage=builders.html#)
Moisture Dynamics Whole Building Design Guide.
(#http://www.wbdg.org/design/resource.php?cn=0&cx=0&rp=20#)
Path Rehab Inspection Guide Foundations Partnership for Advancing Technology in Housing.
(#http://www.pathnet.org/si.asp?id=481#)
Path Rehab Inspection Guide Walls Partnership for Advancing Technology in Housing.
(#http://www.pathnet.org/si.asp?id=399#)

Standards:
The Standards of Practice and Code of Ethics American Society of Home Inspectors.
(#http://www.ashi.com/inspectors/standards/standards.asp#)

3. Inspect the building envelope for continuity.

4. Identify the building materials utilized in establishing the building envelope.

5. Identify degradation of envelope materials.

6. Evaluate ventilation systems that penetrate the building envelope.

Standards:
NFPA 54, National Fuel Gas Code National Fire Protection Association. Appendix L Examples of Opening Design for Combustion and Ventilation.

7. Determine if attic ventilation has an impact on the conditioned areas of the building.

Reference information:
Attic Ventilation Advanced Energy.
(#http://www.advancedenergy.org/buildings/knowledge_library/ventilation/atti c_ventilation.html#)
Attic Ventilation and Moisture Control Strategies By Don Fugler. Vancouver, BC: The Sheltair Group. (#http://www.sheltair.com/library/Attic%20Moisture%20Control.pdf#)
Research Exposes Attic Ventilation Myth Oikos. (#http://oikos.com/esb/30/atticvent.html#)

Evaluating Moisture Issue

Background information:
ASHRAE Fundamentals By John T. Krigger, Chris Dorsi (2004). ASHRAE. Chapter 20 Thermal Insulation and Vapor Retarders.
Builder's Guide: Hot Dry and Mixed Dry Climates Westford, MA: Building Science Corp.
(#http://www.energy.ca.gov/efficiency/qualityhomes/INSULATION_CHECKLIS T.PDF#)
Environmental Health Watch Environmental Health Watch. (#http://www.ehw.org#)
Indoor Air Quality Environmental Protection Agency. (www.epa.gov/iaq)

Best Practices:
1. Conduct a visual inspection of the building for indications of excess moisture.

Reference information:
Environmental Health Watch Environmental Health Watch. (www.ehw.org#http://www.ehw.org#)

2. Conduct a relative humidity test.

Reference information:
ASHRAE Fundamentals By John T. Krigger, Chris Dorsi (2004). ASHRAE. Chapter 6 Psychrometrics.

3. Utilize a psychometric chart to interpret potential for moisture problems.

Reference information:
Air Properties Temperature and Relative Humidity Institute of Agricultural and Natural Resources.
(#http://ianrpubs.unl.edu/generalag/g626.htm#)

4. Evaluate the causes of mold and mildew growth in closets, corners and remote areas of the living area.

Reference information:
EPA Guide to Mild Causes and Mold Cleanup Strategies for the Home Environmental Protection Agency. (#http://www.epa.gov/iaq/molds/moldguide.html#)
Home Moisture Audit Environmental Health Watch.
(#http://www.ehw.org/Healthy_House/HH_Moist_Audit.htm#)

5. Evaluate the impact of humidifiers and dehumidifiers upon the indoor air quality and upon the integrity of heating/cooling appliances. .

Reference information:
Biological Pollutants Environmental Protection Agency. (#http://www.epa.gov/iaq/pubs/bio_1.html#)
EPA Fact Sheet: Use and Care of Home Humidifiers Environmental Protection Agency.
Tips on using a dehumidifier in the home American Lung Association.
(#http://www.healthhouse.org/tipsheets/dehumidifier.asp#)

6. Evaluate and control moisture sources that produce condensation on interior building surfaces.

Evaluating Health, Durability, IAQ and Safety

Background information:
Investigating, Diagnosing and Treating Your Damp Basement Canadian Mortgage and Housing Corporation.
Residential Indoor Air Quality and Energy Efficiency American Council for an Energy Efficient Economy.
The Clean Air Guide: How to Identify and Correct Indoor Air Problems in Your Home

Best Practices:
1. Provide a short term radon test.
2. Identify other home conditions contributing to poor air quality.
3. Compare home pollutant levels with acceptable and unsafe levels.

Reference information:
Residential Energy Saturn Resource Management. Appendix A21 Indoor Air Pollutants.

4. Evaluate the need for additional or seasonal fresh air supply.

Reference information:
California Indoor Air Quality Program #http://www.caliaq.org/#)
Diagnostics and Balancing, January 2000 Case study on balancing ventilation
for building needs (#http://www.toolbase.org/Docs/ToolBaseHome/PATHFieldResults/1912_al2
_00.htm#)
Regulating Ventless Heaters Home Energy Magazine.
(#http://www.homeenergy.org//archive/hem.dis.anl.gov/eehem/98/980108.ht ml#98010811#)

5. Identify improper storage of volatile organic compounds and household chemicals.

Reference information:
Household Products Database National Institute of Health.
(#http://householdproducts.nlm.nih.gov/index.htm#)
The Inside Story – A Guide to Indoor Air Quality Environmental Protection Agency.
Water temperatures and stored chemicals are burn and fire hazards in the home

6. Determine response options to any identified fuel leaks.
Reference information:

Natural Gas Hazards Frank Montagna.
(#http://www.chiefmontagna.com/Articles/Gas%20Hazards.htm#)

7. Evaluate any lead associated with building materials that may require handling in the course of proposed work.

Reference information:
Identification of Dangerous Levels of Lead Environmental Protection Agency.
(#http://www.epa.gov/EPA TOX/2001/January/Day05/t84.htm#)
Lead Control Regulation HUD US Dept. of Housing and Urban Development.
(#http://www.hudclips.org/sub_nonhud/cgi/nphbrs.cgi?d=FR00&s1=%40docn&l=100&SECT1=TXTHLB&SECT5=FR00&u=./
nphbrs.cgi%3Fd=FR00&s1=%40docn&l=100&SECT1=TXTHLB&SECT5=FR00&
u=./hudclips.cgi&p=5&r=419&f=G#)

8. Inspect building for material storage that poses potential fire hazard.

Reference information:
Home Fire Hazards City of Phoenix. (#http://www.ci.phoenix.az.us/FIRE/homefire.html#)
Home Inspection Checklist City of Phoenix.
(#http://www.ci.phoenix.az.us/FIRE/homefire.html#INSPECT#)
The fire hazard posed by halogen lamps Home Energy Magazine.
(#http://www.homeenergy.org//archive/hem.dis.anl.gov/eehem/99/990310.ht ml#99031006#)

9. Conduct egress evaluation.

Reference information:
Conducting a fire safety exit drill in the home Albany, NY: New York State Department of State.
(#http://www.dos.state.ny.us/fire/pdfs/brochures/EDITH.pdf#)
Fire extinguisher selection use and maintenance Albany, NY: New York State Department of State.
(#http://www.dos.state.ny.us/fire/pdfs/brochures/FireXT.pdf#)

Evaluating Combustion Appliance Performance and Ventilation

Best Practices:
1. Identify all ventilating appliances to be tested.

Reference information:
NFPA 31 (fuel oil) National Fire Protection Association.
NFPA 58 (LP Gas) National Fire Protection Association.

Standards:
NFPA 54 (natural gas) National Fire Protection Association.

2. Inspect venting system for design, maintenance and safety.

Standards:
NFPA 54 (natural gas) National Fire Protection Association.
NFPA 54, National Fuel Gas Code National Fire Protection Association. Chapter 7 Design of venting systems for category 1 appliance.

3. Identify all unvented and undervented combustion appliances.

Reference information:
Regulating Ventless Heaters Home Energy Magazine.
(#http://www.homeenergy.org//archive/hem.dis.anl.gov/eehem/98/980108.ht ml#98010811#)
Unvented Gas Space Heaters: Drainless Sinks? Home Energy Magazine.
(#http://homeenergy.org/archive/hem.dis.anl.gov/eehem/96/960905.html#)

Standards:
NFPA 54, National Fuel Gas Code National Fire Protection Association. Chapter 10 Sizing of Category 1 Venting Systems for Single….
NFPA 54, National Fuel Gas Code National Fire Protection Association. Chapter 7 Design of venting systems for category 1 appliance.
Technical Standards for Technician 1 Building Performance Institute. pp. 14 Appliance Ventilation Requirements.

4. Inspect appliance vent for obstructions and design.

Reference information:
Condensing Furnaces Lessons From a Utility Home Energy Magazine.
(#http://homeenergy.org/archive/hem.dis.anl.gov/eehem/94/941108.html#)

Standards:
NFPA 211 Standards for Chimneys, Fireplaces, Vents and Solid Fuel Burning Appliances
NFPA 54, National Fuel Gas Code National Fire Protection Association. Chapter 7, Section 754 Inspection of Chimneys.

5. Inspect combustion appliance vent systems for required clearance to combustible materials.

Standards:
NFPA 54, National Fuel Gas Code National Fire Protection Association. Chapter 7, Section 744 Clearances for Vent Connectors.

6. Conduct vent spillage tests.

Reference information:
Backdrafting Causes and Cures Home Energy Magazine.
(#http://homeenergy.org/archive/hem.dis.anl.gov/eehem/91/910500.html#)

Standards:
California Conventional Home Weatherization Installation Standards Pacific Gas and Electric. Chapter 19, Section 21 Draft and Spillage Tests.
Method to Determine the Potential for Pressure Induced Spillage from Vented Appliances
NFPA 54, National Fuel Gas Code National Fire Protection Association. Chapter 7 Design of venting systems for category 1 appliance.
NFPA 54, National Fuel Gas Code National Fire Protection Association. Chapter 7, Appendix H Safety inspection to verify vent performance.
PG&E Central Inspection Program Combustion Appliance Safety Test Procedure Gas Furnaces/Heaters and Water Heaters.

Technical Standards for Building Analyst 1 Building Performance Institute. pp. 10 Spillage and Draft Test.

7. Provide a vent pressure test.

Standards:
NFPA 54, National Fuel Gas Code National Fire Protection Association. Chapter 7, Appendix H Safety inspection to verify vent performance.
PG&E Central Inspection Program Combustion Appliance Safety Test Procedure Gas Furnaces/Heaters and Water Heaters.
Practical diagnostics for Evaluating Residential Commissioning Metrics Lawrence Berkeley National Laboratory. pp. 32-34.
Technical Standards for Building Analyst 1 Building Performance Institute. pp. 10 Spillage and Draft Test.

Inspection of Mechanical Equipment Performance

Background information:
ASHRAE Fundamentals By John T. Krigger, Chris Dorsi (2004). ASHRAE. Chapter 22 Ventilation and Infiltration.
Builder's Guide: Hot Dry and Mixed Dry Climates Westford, MA: Building Science Corp. Chapter 9 HVAC. (#http://www.energy.ca.gov/efficiency/qualityhomes/INSULATION_CHECKLIS T.PDF#)
Title 24 Residential Manual For Compliance with California's 2001 Energy Efficiency Standards
Diagnostics and Balancing, January 2000 Case study on balancing ventilation
for building needs (#http://www.toolbase.org/Docs/ToolBaseHome/PATHFieldResults/1912_al2_0 0.htm#)
Preliminary Assessment of Ventilation Requirements for New Single Family
Homes (#http://www.toolbase.org/Docs/MainNav/Energy/2505_assess_ventilation_req _SF_homes.pdf#)
Understanding ventilation: How to Design Select and Install Residential Ventilation Systems (www.hhinst.com#http://www.hhinst.com#)

Best Practices:
1. Identify any pollutant source requiring ventilation as a control method.

Reference information:
EPA fact Sheet on "Sick Building Syndrome" Environmental Protection Agency. (#http://www.epa.gov/iaq/pubs/sbs.html#)
Sources, Standards and Control Strategies for Volatile Organic compounds in the Home

Standards:
Home ventilation and Indoor Air Quality Environmental Protection Agency. (#http://www.hvi.org/guide/HVI%20Guide_0903.pdf#)

2. Measure capacity of mechanical ventilation systems.

Reference information:
Directory of ventilation Manufacturers and specifications of various products Home Ventilation Institute. (#http://www.hvi.org/directory/#)

Standards:
Flow Meter User's Manual Minneapolis, MN: The Energy Conservatory.
(#http://www.energyconservatory.com/download/boxman.pdf#)

3. Determine ventilation requirements based on building use, size, and occupants.

Reference information:
A Homeowner's Guide to Ventilation NYSERDA. (#http://www.nyserda.org/guide.pdf#)
Standards:
ASHRAE 62.99 Ventilation Requirements for Residential Buildings ASHRAE.
ASHRAE Fundamentals By John T. Krigger, Chris Dorsi (2004). ASHRAE. Chapter 22 Ventilation and Infiltration.
EPA recommendations for bathroom mechanical ventilation Environmental Protection Agency.
(#http://www.epa.gov/iaq/homes/hipbathroom.html#)
EPA Recommendations for Kitchen mechanical ventilation Environmental Protection Agency.
(#http://http://www.epa.gov/iaq/homes/hipkitchen.html#)
Home ventilation and Indoor Air Quality Home Ventilation Institute. pp. 21 Determining Ventilation Capacity. (#http://www.hvi.org/guide/HVI%20Guide_0903.pdf#)

4. Determine type of ventilation system that is most appropriate.

Reference information:
Description of the various designs for ventilation systems Home Ventilation Institute.
(#http://www.hvi.org/#)

5. Determine controller best suited for mechanical ventilation.

Reference information:
Energy Federation Incorporated Energy Federation Incorporated. (www.efi.org#http://www.efi.org#)
Ventilation controllers Home Ventilation Institute.
(#http://www.hvi.org/purpose/articles/VentContArticle_0204.pdf#)

6. Determine proper placement of the air supply and air exhaust components of a ventilation system.

Reference information:
Residential Mechanical ventilation Skill Tech Academy.
Home ventilation and Indoor Air Quality Home Ventilation Institute. pp. 21-24.
(#http://www.hvi.org/guide/HVI%20Guide_0903.pdf#)

Inspection of Air Distribution System Performance (ducts)

Background information:
Practical diagnostics for Evaluating Residential Commissioning Metrics Lawrence Berkeley National Laboratory. pp. 3234.
Residential Loads Calculation Air Conditioning Contractors of America. Manual D.
Residential Loads Calculation Air Conditioning Contractors of America. Manual J.
Duct System Design, Installation, Sealing and Diagnostics, Pacific Gas and Electric

Best Practices:

1. Identify the components of the distribution system and provide a visual inspection.

Reference information:
Duct Installation and Sealing Standards Pacific Gas and Electric. Chapter 3, Section 14 Supports.
Duct Installation and Sealing Standards Pacific Gas and Electric. Chapter 3, Section 16 Duct Sealing Materials.
Duct Installation and Sealing Standards Pacific Gas and Electric. Chapter 3, Section 18 General Installation Criteria.
Duct Installation and Sealing Standards Pacific Gas and Electric. Chapter 3, Section 20 Flex duct precautions.
Duct Installation and Sealing Standards Pacific Gas and Electric. Chapter 3, Section 7 Drawbands.

Standards:
ASHRAE Fundamentals By John T. Krigger, Chris Dorsi (2004). ASHRAE. Chapter 33 Duct Design.
Specification of Energy Efficient Installation and Maintenance Practices Boston, MA: Consortium for Energy Efficiency. (#http://www.cee1.org/resid/rsac/reshvacspec.pdf#)

2. Evaluate the heat transfer characteristics of the heating/cooling distribution, with relationship to occupant comfort.

Reference information:
ASHRAE Fundamentals By John T. Krigger, Chris Dorsi (2004). ASHRAE. Chapter 8 Physiological Principles for Comfort and Health.

Standards:
Californian Energy Efficiency Standards for Residential Buildings California Energy Commission. Chapter 6.

3. Identify the basic principles of proper duct design.

Standards:
ASHRAE Fundamentals By John T. Krigger, Chris Dorsi (2004). ASHRAE. Chapter 33 Duct Design.
Duct Installation and Sealing Standards Pacific Gas and Electric. Section 14 & 21 Duct Supports.
Duct Installation and Sealing Standards Pacific Gas and Electric. Section 17 Duct Sealing Materials and Techniques.
Duct Installation and Sealing Standards Pacific Gas and Electric. Section 20.
Duct Installation and Sealing Standards Pacific Gas and Electric. Section 913 Duct Materials.
Residential Duct Systems, Manual D Air Conditioning Contractors of America. Section 1 Residential Air Distribution.
Residential Duct Systems, Manual D Air Conditioning Contractors of America. Section 3 Basic principles and duct sizing calculations.

14. Measure air flow across the cooling coil.

Reference information:
Practical diagnostics for Evaluating Residential Commissioning Metrics Lawrence Berkeley National Laboratory. pp. 26-29.

Standards:
Californian Energy Efficiency Standards for Residential Buildings California Energy Commission. Section 4.1.2 Fan Flow Accuracies.

Californian Energy Efficiency Standards for Residential Buildings California Energy Commission. Section 4.3.7 Measuring Fan Flow.
Residential Contractor Program 2000R Southern California Gas Co, Southern California Edison Co.. Chapter 4, Section 9 Ductblaster Testing.

5. Evaluate air flow volumes with relation to recommendations.

Reference information:
Practical diagnostics for Evaluating Residential Commissioning Metrics Lawrence Berkeley National Laboratory. pp. 54-57 Evaluation of Air Handler Airflow Tests for Cooling Systems.

Standards:
Californian Energy Efficiency Standards for Residential Buildings California Energy Commission. Section 4.3 Procedures for determining duct efficiencies.
Californian Energy Efficiency Standards for Residential Buildings California Energy Commission. Section 4.5 Delivering Seasonal efficiencies.

6. Identify factors affecting air flow requirements.
7. Evaluate cooling load reduction options.

Reference information:
Residential Energy Saturn Resource Management. Chapter 8 Cooling.
Kicking the Air Conditioner Habit By David Springer (July/August). Home Energy Magazine, 0.
Will Duct Repairs Reduce Cooling Loads Home Energy Magazine.
(#http://homeenergy.org/archive/hem.dis.anl.gov/eehem/93/930919.html#)

Standards:
Residential Duct Systems, Manual D Air Conditioning Contractors of America. Section 12 Duct system efficiency.

8. Identify distribution components requiring insulation.

Standards:
Californian Energy Efficiency Standards for Residential Buildings California Energy Commission. Section 4.3.6 Duct surfaces and insulation.

Inspection of Major Appliance and Lighting Performance

Background information:
Bright Prospects for Lighting Retrofits By Larry Hasterok. Home Energy Magazine.
(#http://homeenergy.org/archive/hem.dis.anl.gov/eehem/95/950911.html#)
Leaking Electricity By Alan Meier. Home Energy Magazine. (
http://homeenergy.org/archive/hem.dis.anl.gov/eehem/93/931112.html#http://
http://homeenergy.org/archive/hem.dis.anl.gov/eehem/93/931112.html#)
National Residential Home Appliance Market Transformation Plan Boston, MA: Consortium for Energy Efficiency. (#http://www.cee1.org/resid/seha/seha_str_plan.pdf#)
What Stays On When You Go Out By Alan Meier. Home Energy Magazine.
(#http://homeenergy.org/archive/hem.dis.anl.gov/eehem/93/930711.html#)

Best Practices:

1. Seek information from occupants related to baseload appliance usage and performance.

Reference information:
Appliances California Energy Commission.
(#http://www.consumerenergycenter.org/homeandwork/homes/inside/applian ces/index.htm#)

2. Conduct a lighting survey for efficiency considerations.

Reference information:
Lighting Makeovers: The Best Is Not Always the Brightest By Kathryn Conway. Home Energy Magazine. (#http://homeenergy.org/archive/hem.dis.anl.gov/eehem/95/950509.html#)

3. Identify and repair/replace recessed lighting fixtures that contribute to building air leakage and compromise thermal boundaries.

4. Conduct a refrigeration appliance evaluation.

5. Evaluate the use of flow restrictors and low flow showerheads

Reference information:
Hot Water Improvements Top Warm Climate Weatherization Measures Home Energy Magazine.
(#http://homeenergy.org/archive/hem.dis.anl.gov/eehem/98/980907.html#)

Standards:
California Conventional Home Weatherization Installation Standards Pacific Gas and Electric.
Section 8 Energy Saver Showerhead and Faucet Aerator….

6. Maintain and utilize diagnostic equipment in the evaluation of baseload systems .

Reference information:
The value of a Good Light Meter Electrical Construction and Maintenance.
(#http://www.keepmedia.com/ShowItemDetails.do?itemID=149864&extID=10 032&oliID=213#)
Watt Hour Meter Maintenance and Testing US Bureau of Reclamation.
(#http://www.usbr.gov/power/data/fist/fist3_10/3_10_3.htm#)

C. Installation and Repair Practices

Practices for Installation of Windows

Best Practices:
1. *Select replacement windows.*
2. *Install replacement windows.*
3. *Air seal windows and window casements*.

Practices for Installation of Insulation

Background information:
Title 24 Residential Manual For Compliance with California's 2001 Energy Efficiency Standards

Foundation Systems Partnership for Advancing Technology in Housing. (#http://www.pathnet.org/si.asp?id=481#)
Insulation Materials standards, installation techniques and tools ToolBase Services. (#http://www.toolbase.org/secondaryT.asp?CategoryID=1025#)
Path Rehab Inspection Guide Walls Partnership for Advancing Technology in Housing. (#http://www.pathnet.org/si.asp?id=399#)
Roof Systems Partnership for Advancing Technology in Housing. (#http://www.pathnet.org/si.asp?id=482#)

Best Practices:
1. Insulate sidewalls with high density cellulose .

Reference information:
Builder's Guide: Hot Dry and Mixed Dry Climates Westford, MA: Building Science Corp. Chapter 12 Insulation. (#http://www.energy.ca.gov/efficiency/qualityhomes/INSULATION_CHECKLI ST.PDF#)

Standards:
Residential Contractor Program 2000R Southern California Gas Co, Southern California Edison Co.. Chapter 10 Walls.
Reducing Lead Hazards When Remodeling Your Home Environmental Protection Agency. (#http://www.epa.gov/lead/rrpamph.pdf#)

2. Insulate attics and roof systems.

Reference information:
Builder's Guide: Hot Dry and Mixed Dry Climates Westford, MA: Building Science Corp. Chapter 12 Insulation. (#http://www.energy.ca.gov/efficiency/qualityhomes/INSULATION_CHECKLI ST.PDF#)
Partitions, Ceilings, Floors and Stairs By Steven Winter. Partnership for Advancing Technology in Housing. (#http://www.pathnet.org/si.asp?id=446#)
Roof Systems Partnership for Advancing Technology in Housing. (#http://www.pathnet.org/si.asp?id=482#)

Standards:
California Conventional Home Weatherization Installation Standards Pacific Gas and Electric. Appendix B Attic Ventilation Net Free Venting charts.
California Conventional Home Weatherization Installation Standards Pacific Gas and Electric. Section 3 Ceiling Installation Standards.
California Conventional Home Weatherization Installation Standards Pacific Gas and Electric. Section 4 Attic Ventilation Standards.
Residential Contractor Program 2000R Southern California Gas Co, Southern California Edison Co.. Chapter 9 Attics.

3. Insulate floor and foundation areas.

Reference information:
Builder's Guide: Hot Dry and Mixed Dry Climates Westford, MA: Building Science Corp. Chapter 7 Foundations & Wood Frame Construction. (#http://www.energy.ca.gov/efficiency/qualityhomes/INSULATION_CHECKLI ST.PDF#)

Path Rehab Inspection Guide Foundations Partnership for Advancing Technology in Housing. (#http://www.pathnet.org/si.asp?id=481#)

4. Determine the requirements and location for vapor barrier placement, with installed insulation.

Reference information:
ASHRAE Fundamentals By John T. Krigger, Chris Dorsi (2004). ASHRAE. Chapter 20 Thermal Insulation and Vapor Retarders.
Builder’s Guide: Hot Dry and Mixed Dry Climates Westford, MA: Building Science Corp. Chapter 12 Insulation. (#http://www.energy.ca.gov/efficiency/qualityhomes/INSULATION_CHECKLIST.PDF#)
Moisture and moisture control Partnership for Advancing Technology in Housing. (#http://www.pathnet.org/si.asp?id=441#)

Standards:
Title 24 Residential Manual For Compliance with California's 2001 Energy Efficiency Standards

Common Practices for Installation of Combustion/HVAC/DHW

Background information:
California Conventional Home Weatherization Installation Standards Pacific Gas and Electric. Chapter 19, Section 21 Draft and Spillage Tests.
No Regrets Remodeling Energy Auditor and Retrofitter, Inc.. Chapter 8 Heating.
Residential Energy Saturn Resource Management. Chapter 6 Heating.
Bacharach Training Bacharach Training. (#http://www.bacharach training.com/combustionzone/efficiencytypes1.htm#)
Buyer’s Guide: Natural Gas Heating Systems American Gas Association. (#http://www.aga.org/Content/NavigationMenu/About_Natural_Gas/Using_Natural_Gas/Default257.htm#)
Energy Efficiency and Renewable Energy US Department of Energy. (http://www.eere.energy.gov/consumerinfo/factsheets/thermo.html#http:// http://www.eere.energy.gov/consumerinfo/factsheets/thermo.html#)
Top Rated Energy Efficient Appliances American Council for an Energy Efficient Economy. (#http://www.aceee.org/consumerguide/topfurn.htm#)

Best Practices:
1. Clean burner assemblies and perform adjustments

Reference information:
Servicing Gas Burners AllAboutHome.com. (#http://www.allabouthome.com/tips/mechanical/gas_burners.html#AnchorCleaning595#)
Specification of Energy Efficient Installation and Maintenance Practices Boston, MA: Consortium for Energy Efficiency. Chapter 4. (#http://www.cee1.org/resid/rsac/reshvacspec.pdf#)

2. Clean or replace furnace air filters.

Reference information:
Residential Duct Systems, Manual D Air Conditioning Contractors of America. Section 2 Equipment and Air Side Devices.

Is It worth Putting In a Better Furnace Filter? By Don Fugler. Home Energy Magazine. (#http://homeenergy.org/archive/hem.dis.anl.gov/eehem/00/000516.html#)
Tips About Your Furnace Filter American Lung Association. (#http://www.healthhouse.org/new/press/fall2001/filterfactsheet.htm#)

Standards:
ASHRAE 52.2 and its impact on indoor air quality ASHRAE. (#http://www.mc2link.com/52point2.htm#)
Understanding MERV Ratings ASHRAE. (#http://www.aerochem.com/technical/mervratings.html#)

3. Clean and lubricate distribution fan motor, fan vanes, and visually inspect fan belt.

Reference information:
Specification of Energy Efficient Installation and Maintenance Practices Boston, MA: Consortium for Energy Efficiency. Chapter 4. (#http://www.cee1.org/resid/rsac/reshvacspec.pdf#)

4. Clean and tune gas oven and range tops burners, to reduce carbon monoxide outputs.

Reference information:
California Conventional Home Weatherization Installation Standards Pacific Gas and Electric. Chapter 29 Natural Gas Appliance Testing.
Design and installation of the properly sized range hood Home Energy Magazine. (#http://homeenergy.org/archive/hem.dis.anl.gov/eehem/97/971104.html#971 10413#)
Stove and Oven Cleaning and Care Pioneer Thinking. (#http://www.pioneerthinking.com/stove1.html#)

Common Practices for Installation of Duct Systems/Remediation

Background information:
Improving the Efficiency of your Duct System US Department of Energy.
Residential Duct Diagnostics and Repair Air Conditioning Contractors of America.
Ducts Lawrence Berkeley National Laboratory. (#http://ducts.lbl.gov/#)
Specification of Energy Efficient Installation and Maintenance Practices Boston, MA: Consortium for Energy Efficiency. (#http://www.cee1.org/resid/rsac/reshvacspec.pdf#)
Those Wild ducts In Your Walls Home Energy Magazine. (#http://homeenergy.org/consumerinfo/ducts/index.html#)

Best Practices:
1. Distribution system repair redesign criteria.

Reference information:
Residential Duct Diagnostics and Repair Air Conditioning Contractors of America. Chapter 2 Installation and Repair of Duct Systems.
Residential Duct Diagnostics and Repair Air Conditioning Contractors of America. Chapter 3 Duct Design Strategies.

Standards:
Specification of Energy Efficient Installation and Maintenance Practices Boston, MA: Consortium for Energy Efficiency. Chapter 5, Section 2 Design. (#http://www.cee1.org/resid/rsac/reshvacspec.pdf#)

2. Identify and correct duct leakage and conditioned air leakage into unheated attic areas.

Standards:
Residential Contractor Program 2000R Southern California Gas Co, Southern California Edison Co.. Chapter 2 Duct Sealing.
Title 24 Residential Manual For Compliance with California's 2001 Energy Efficiency Standards
Specification of Energy Efficient Installation and Maintenance Practices Boston, MA: Consortium for Energy Efficiency. Chapter 5, Section 3 Duct Leakage Standard.
(#http://www.cee1.org/resid/rsac/reshvacspec.pdf#)
Specification of Energy Efficient Installation and Maintenance Practices Boston, MA: Consortium for Energy Efficiency. Chapter 5, Section 4 Sealing Materials.
(#http://www.cee1.org/resid/rsac/reshvacspec.pdf#)

3. Identify and install various duct and pipe insulations.

Standards:
ASHRAE Standard 90A Duct Insulation Requirements ASHRAE.
Title 24 Residential Manual For Compliance with California's 2001 Energy Efficiency Standards
Specification of Energy Efficient Installation and Maintenance Practices Boston, MA: Consortium for Energy Efficiency. (#http://www.cee1.org/resid/rsac/reshvacspec.pdf#)

4. Cooling distribution system design considerations including convective loop impacts.

Standards:
ASHRAE Fundamentals By John T. Krigger, Chris Dorsi (2004). ASHRAE. Section V Duct and Pipe Size.
ASHRAE Fundamentals By John T. Krigger, Chris Dorsi (2004). ASHRAE. Chapter 32 Space Air Diffusion.
ASHRAE Fundamentals By John T. Krigger, Chris Dorsi (2004). ASHRAE. Chapter 33 Duct Design.
Manual D Equipment selection and system design procedures Air Conditioning Contractors of America.
Manual E Room Air Distribution Considerations Air Conditioning Contractors of America.

5. Maintaining humidifiers and condensate pans in central conditioning appliances.

Standards:
ARI 63082 Selection installation and servicing humidifiers Air Conditioning and Refrigeration Institute.

ADDITIONAL REFERENCES

Belsky, Eric, Mark A. Calabria, and Alfred R. Nucci, 2001. *Survivorship and Growth in the Residential Remodeling Industry: Evidence from the Census of Construction 1997*, WO1-5, Harvard Joint Center for Housing Studies

California Energy Commission, forthcoming in 2006. *Final Report on Whole House Energy Efficiency Improvement Protocols, by Bevilacqua-Knight, Inc. in association with Performance Systems Development, Inc.*, Public Interest Energy Research Program.

Harvard Joint Center for Housing Studies, 2004. *The Changing Structure of the Home Remodeling Industry: Improving America's Housing 2005*