Developing a Market-Based Utility Duct Sealing Program

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ABSTRACT

In recent years, residential energy conservation research has focused attention on heating system distribution efficiency. Several field studies in the Pacific Northwest have found forced-air heating systems which have a majority of ducts located in unheated buffer spaces can lose as much as 30% of the equipment's heating output to duct air leakage and conduction loss. The magnitude of loss can be equivalent to the combined improvements in building shell insulation levels due to updated energy codes. Field review of forced-air heating systems often uncovers other problems with duct layout and equipment performance.

Several challenges face utilities planning to undertake a large-scale duct-sealing program. Most notable of these challenges are finding suitable homes; working with field protocols which encourage consistent, successful work; and measuring the effects of the work through field quality control and impact analysis.

This paper describes the response rate for duct sealing services based on one marketing approach and describes bill and field test screening criteria used to narrow the list of retrofit candidates. Results from the screening are presented, along with preliminary retrofit results and important operations and maintenance findings.

Introduction and Background

Research conducted in the Pacific Northwest during the past seven years has suggested forced air heating systems can add substantially to yearly heating costs because of duct air leakage and conductive losses. This research has found that annual heating load increases by an average of about 30% over predicted load for homes heated with non-ducted electric resistance units (Davis et al. 1998, Siegel et al. 1997, Olson et al. 1993). These losses typically occur from supply ducts into vented crawlspaces, because a significant portion of homes in the Pacific Northwest rely on counterflow (downflow) forced-air furnaces (including heat pumps) for heating and cooling.

These results are based on approximately 50 short-term coheat tests performed on site-built and manufactured homes sited in the Pacific Northwest and heated with electricity and natural gas. The short-term coheat method measures real-time energy consumption in a house while the house is heated to the same average temperature by ducted and non-ducted sources on two-hour alternating cycles.

On a house-by-house basis, the energy penalty from duct losses can be very large; the duct distribution efficiency in about 20% of the homes studied was 60% or less. This indicates great potential for energy savings if targeted air-sealing retrofits are performed. By "targeted," we mean that the retrofit crew focuses on sealing the highest priority leaks; i.e., those that are located closest to the furnace, where air temperature and static pressure are highest. These air sealing retrofits, which reduce duct air leakage by 50% to 75%, have been found to improve distribution efficiency substantially and result in a 10-30% savings in annual heating energy costs.

A well-trained crew can generally perform two of these retrofits per day, including leakage and furnace diagnostic tests. If the home is heated with fossil fuels, combustion safety tests can also be conducted within this time frame.

Program Outline

For the pilot program described in this report, the sponsoring utility, Puget Sound Energy (PSE), intended to retrofit 200 single family, site-built homes within a year. Puget Sound Energy is the largest utility in the state of Washington, serving a total of approximately 750,000 natural gas and electric customers in the major metropolitan and suburban areas west of the Cascades. Their program, designed with assistance from Ecotope, was designed to include 120 homes heated by natural gas and 80 heated by forced-air electric systems (including heat pumps). The utility had never undertaken a distribution efficiency improvement program but was willing to fund a pilot effort to investigate the feasibility of an ongoing program.

Administrative costs (including evaluation) were expected to be higher during the pilot program, but the utility anticipated that important lessons would be learned about recruiting, field evaluation, protocols, and health/safety issues. This information would be used to improve any follow-on program.

The pilot program was to run for about 8 months, with most of the recruiting expected to take about a month, retrofits expected to take about 5 months, and analysis and reporting to take an additional 2 months.

An experienced duct retrofit contractor was hired to do the retrofit work in homes heated by gas and electric forced-air furnaces and heat pumps. The program focused on sealing leaks in the supply system, as previous research on Pacific Northwest homes had shown return-side retrofits to be much less significant energy savers (Palmiter and Francisco 1997). The program intended the retrofit crew to perform return side repairs only to correct health or safety issues (for example, large return leaks in a well-sealed garage could pull carbon monoxide from automobile exhaust into the distribution system). Duct insulation was not installed as part of this program because of the relatively high material and installation costs.

The program's energy savings goals were based on the assumption that average savings of 10% of the annual heating load could be realized through the retrofit. This level of savings, applied to homes with annual heating loads on the order of roughly 800 therms or 10,000 kWh, would generate paybacks of 5 – 10 years (depending on fuel type and the absolute magnitude of savings). In most cases, this level of savings can be achieved with a reduction of about 10% in the heating system's supply leakage fraction (ratio of duct leakage at normal operating conditions to system airflow).

In-field quality control is performed by an independent contractor, and focuses on duct leakage measurement and heating system performance measurements which are processed by a detailed mathematical duct model (Palmiter and Francisco 1997), yielding an estimate of the efficiency improvement. A billing analysis will also be performed following collection of one year of post-retrofit data.

Market Assessment

An important goal of this pilot program was to assess the size of the potential market for duct-sealing services within the Pacific Northwest single-family housing stock. Anecdotal evidence from throughout the US suggests duct leakage is a significant problem; however, residential duct leakage testing is a nascent field with very few comprehensive studies now published.

Earlier estimates of duct leakage were based on small samples, which are almost certainly subject to regional differences and self-selection bias. Mark Modera's review of overall duct leakage levels in residences is one of the most comprehensive works (Modera 1989); however, these data are not directly applicable to the construction types most commonly found in the Pacific Northwest. Regional studies (e. g. Davis & Roberson 1993; Parker 1989) have found great potential for energy savings from treating ducts, but have relied on a limited numbers of homes. This pilot program provided an opportunity to conduct a market assessment of a large sample of housing types commonly found in the maritime Pacific Northwest.

One reason for the paucity of studies is that no residential-sized equipment was available for determining duct leakage levels until 1992. In fall of that year, a well-known manufacturer of residential energy-efficiency testing equipment began shipping prototype duct pressurization fans (a smaller version of the blower door). Protocols to properly use this fan were new to the testing community and still are not used widely. The quality of many of the early duct leakage tests is questionable, just as with the early commercial blower door tests conducted a decade earlier.

Washington Natural Gas (which merged with Puget Power in 1997 to form Puget Sound Energy) had funded a field study in 1993 which gathered house and duct leakage data on a random sample of 300 gas-heated homes in the PSE service territory. About half of the homes in the random sample had a majority of ducts located in unheated buffer spaces and were thus of most interest to us in planning the program.

The results of this study were provocative but inconclusive. About 167 of these homes were found to have substantial portions of the duct system located in unheated spaces. Of these, 50 were tested with a duct pressurization fan. The average leakage for these homes was 523 CFM @ 50 Pa (the most commonly used testing reference pressure differential, equivalent to 0.2" water column). However, the test did not isolate the supply and return sides of the duct system, so the results were not useful in predicting the effects of supply-side sealing measures. More importantly, the utility was unable to recall whether the tests measured total leakage – which includes leaks from the duct system back into the heated space – or whether the reported result was for leakage to the outside (that is, to buffer spaces such as the crawlspace). This meant that the efficiency impact of the duct leakage was difficult to predict for these homes, and extrapolation to the population of homes with the majority of supply ducts in unheated buffer spaces was also problematic.

The short-term coheat projects had used a target supply leakage to outside of 300 CFM_{50} for inclusion in research. About 50% of the homes recruited for the coheat tests had leakage equal to or greater than this amount. The recruiting pool was relatively limited. For planning purposes, we expected 50-60% of the homes with ducts in unheated buffer spaces would yield a cost-effective retrofit.

Homeowner Recruitment

Despite uncertainty regarding the potential number of homes with leaky ducts, the program forged ahead. A variety of avenues were utilized in the first few weeks of the program (starting in early September, 1997) to notify potential candidates that this service was available and generate interest in the program. Some of the options explored were:

- Paid advertisements in a major local newspaper
- Bulletin boards (targeted at the sponsoring utility's employees) posted at utility facilities
- Article in the utility's Employee Newsletter
- Press releases to large and small local newspapers.

Our initial attempts to disseminate information to the public were not very successful. Advertisements run in a major local paper generated only five calls, despite the fact that the sponsoring utility's name was prominent and the ads stressed the fact that there was no cost to the consumer involved. Utility employees were more successfully targeted through bulletin board notices posted in some of the utility's facilities and an article that was printed in the utility newsletter. Eventually, about 35 employees were recruited into the sample pool. Utility bill inserts were also considered because of the superior access to potential retrofit candidates. However, the lead-time required for working a description of the program into the bill insert (2-3 months) proved prohibitive.

The most successful recruitment method by far was the issuance of press releases to the local newspapers. About one month after the program began, the state's largest newspaper ran a small article on page 6 of the Sunday "Home" section. We were initially somewhat disappointed with the location of the article; however, the response proved overwhelming. More than 1,000 calls were recorded by the third day, (with about 1300 by the end of the week) and return calls were made over the course of the next three weeks to solicit telephone interviews.

Press releases were also sent to a number of small, weekly publications. However, it took several weeks for these sources to print the information, and the program closed to new recruits for some fuel types by the time these articles were printed.

While no specific records were kept, it is clear from anecdotal evidence heard during the telephone interviews that the legitimacy afforded the program by the publication of an article in a well-respected newspaper was substantial. We estimate that 95% of all inquiries about the program were a result of this article. Each interviewer reported that several respondents mentioned seeing the paid advertisement, but expressed skepticism of anything advertised as a free service.

Although the recruiting effort was phenomenally successful in attracting gas-heated homes, only about 15% of the respondents to the newspaper story used forced-air electric heat (including heat pumps). In a further attempt to recruit homes with forced-air electric heat and ducts in unheated spaces, Ecotope received a database of about 600 cases for which the homeowner had completed a survey on physical characteristics and energy-using features in the home. The utility processed this information, along with the customer's electricity usage, and produced a "Personal Energy Profile" (PEP) of the house, while simultaneously recommending conservation strategies. This database yielded about 360 homes with ducts located in unheated buffer spaces. This group of homes became the primary source from which to draw electric heat candidates.

Screening Methodology

A large pool of candidates was available for retrofits. It was not known how representative these homes were of any particular sector of the housing stock. The primary requirement for inclusion in the program was that the homes have forced-air heat (supplied by a natural gas furnace, electric forced-air furnace, or heat pump) and that the majority of the ducts are located in unheated buffer spaces. Other information, such as size of home, number of stories, etc. would be collected during the telephone screening and could be used later on to characterize the homes visited by the retrofit crew.

Initial Screening: Characteristics Questionnaire

A telephone interview was conducted for each of the interested homeowners. The interview focused on determining the home's heating system, heating fuel, location of ducts, and information about home occupancy, major appliances, and supplemental heat. Questions about insulation levels and thermostat setpoint were asked to a subset of homeowners, once it became apparent this information would improve the quality of the screening.

Of the initial group of about 1,300 contacts found through the newspaper and other early efforts, approximately 300 were rejected because the home's ducts were inside the heated shell (primarily in multi-story homes, where the ducts were between floors). Others were rejected because the home was not sited within the sponsoring utility's service territory, was a manufactured home, used an unducted heating system (such as electric baseboard), or a similar reason. After the initial round of screening was completed, about 700 (primarily gas-heated) homes remained. Billing data were requested for these 700 homes for further processing, as well as for electrically heated homes gleaned from the PEP database.

Second Screening: Billing Analysis

The next stage in recruiting was to evaluate the energy usage of potential retrofit candidates. A year of billing data was obtained from the utility for those respondents who met the initial screening criteria. The data were analyzed using a median low-bill procedure (described in Baylon et al. 1995 and Kennedy 1994), which estimated the normalized annual heating load for the home (energy use intensity, or EUI).

The approach used to prioritize retrofit candidates was to compare the EUI generated from the utility bill by use of the median low bill method with the EUI generated by using age of construction, house occupancy, insulation levels, and auxiliary appliance information gathered during the telephone interview. The primary problem with this approach was that it relied heavily on an estimation of heating load which was base largely on homeowner reports. This made difficult to identify the likelihood that a high EUI was due to leaky ducts rather than a combination of estimation errors or some other factor.

Results of the Two-Step Screening

The shortcomings of the paper-based screening became apparent in the first weeks of fieldwork, which began in early October, 1997. We anticipated that approximately 20-30% of the homes that appeared to be viable candidates on paper would turn out to have safety problems, inaccessible ducts, or other unforeseen problems that make them unfit for retrofit at the time the crew arrived for work and would thus be labeled "dry holes". Of the approximately 30 homes visited during the first five weeks of the program, 7 were labeled dry holes (all due to low duct leakage, rather than safety problems). An additional 10-12 retrofitted homes had relatively low pre-existing leakage levels, making expected energy savings from the retrofit difficult to clearly identify with current billing analysis techniques. Overall, about 2/3 of homes were either unsuitable for retrofit or expected to deliver only modest savings because of the retrofit.

This finding dealt a serious blow to the program, both from an energy savings standpoint and from the point of the view of the retrofit contractor. Not only were a sizable number of the homes not producing significant retrofits, the contractor was concerned about the impact of dry holes on the overall cost-effectiveness of the program. A further complication was that these were site-built homes spread over a large geographic area, making it difficult to schedule a fill-in candidate on short notice. Rather than accept a high percentage of dry holes, the course of the program was changed.

Revisions to the Screening Methodology

In mid-November, the utility decided to introduce a screening audit to the methodology, to be conducted by the retrofit field crew. This was intended to add a duct pressurization test to the pressure pan diagnostics to improve the predictive ability of the field crew in determining the suitability of a house for the duct retrofit.

The pressure pan is widely used in assessing duct leakiness, as it is fast and can give crews a good idea of the location of the worst leaks. The pressure pan determines the ratio of outside leaks to all leaks from the supply ducts. (Some of the leaks from the supply ducts under normal operating conditions are "interior" leaks; they find their way from the ducts back into the house and thus do not count as heat waste). Unfortunately, the pressure pan does not quantify duct leakage. A relationship between pressure pans and leakage has been proposed and tenuously verified for some datasets, but much more study is needed. The pressure pan should be used primarily as a coarse screening tool to eliminate homes for which a duct pressurization test would not be useful. For energy savings determination, a direct measurement of leakage is essential.

The majority of homes visited in the first five weeks of the program had an average pressure pan reading of less than 2 Pa. Average readings of this magnitude generally indicate a relatively tight system. Spot checks of duct leakage through duct pressurization showed some of these homes had less than 200 CFM_{50} of exterior supply leakage before retrofit and are thus expected to deliver savings of perhaps only 5% of their pre-retrofit heating load.

The field crew was given a revised protocol to be used in addition to the pressure pan test. Table 1 describes the prioritization developed to process the field screening results.

Table 1. Field Screening Priority Criteria

Retrofit Priority Class	Ext. Supply Duct Leakage @ Pa_{50}	More Than ½ Ducts Accessible?	Safety/Furnace Problems	Duct Insulation*	Floor Insulation**
Very high	>400 CFM	Yes	No	Yes	Yes
High	200-400 CFM	Yes	None/resolvable	Yes or no	Yes
Low	<200	Yes or no	None/resolvable	Yes or no	Yes or no

* Defined to mean there is at least 1" of insulation on the ducts, especially plenum and trunk ducts.
** Generally there will be at least R-11 if any floor insulation is installed, so merely indicate if any insulation is found between the joists.

Duct leakage and duct accessibility remained the main determinants in prioritizing cases. Safety issues were also given a high priority, since the crew was expected to find systems which needed corrective maintenance or repairs. If a furnace was deemed unsafe or a serious safety problem was identified, the retrofit was postponed until the problem had been corrected. Floor insulation levels had to be carefully considered in borderline cases, since a significant portion of duct losses will be recovered inside a home without floor insulation, diminishing the effect of the air sealing.

Results of the Revised Screening Methodology

It was expected the combination of higher EUI homes and screening audits would generate a large backlog of good retrofit homes relatively quickly. However, the rate of candidate identification did not increase nearly as much as expected. The retrofit success rate (defined as total retrofits over total screenings, with adjustments made for 8 dry holes and 8 early retrofits which would not have met the adjusted criteria) average approximately 35%. Broken down by fuel type, the success rates are approximately 30% for gas-heated homes, 45% for homes with electric central furnaces, and 55% for homes heated with heat pumps.

These success rates mean three homes have to be screened to identify one cost-effective retrofit (one expected to reduce the home's supply leakage fraction by at least 10%). The field cost per home to find a good candidate is about $450, which is then added to the $425 to perform the retrofit, approximately doubling the overall cost per program home. This finding impacts natural gas homes especially hard – due to the low cost of the fuel, the simple payback estimate has been extended from about 8 years to almost 20 years. One of the original stated benefits of duct air sealing was the relatively favorable cost/benefit ratio for these activities. The results achieved by this pilot program to date cast doubt on whether a stand-alone follow on program would be cost-effective.

Operations and Maintenance Review

One unexpected result of the screenings to date is the identification of a large number of homes which have operations and maintenance (O&M) issues, some of which can lead to serious health and safety problems. About 35% of the gas-heated homes we visited had at least one O&M issue needing attention; about 15% had multiple problems (see Table 2).

The most common problem identified in gas-heated homes involves high levels of carbon monoxide in the flue gas from the furnace or the water heater (and occasionally another gas appliance). More serious problems, such as cracked heat exchangers or ambient carbon monoxide levels above 3 ppm, have also been encountered in a few cases. It should be noted that, even in cases where a significant health or safety problem was not identified, the homeowner was very interested in the results of the safety checks and relieved when no problems were identified.

Ecotope has attempted to contact all of the homes with serious O&M problems. In about a dozen cases, we provided extensive follow up including referrals to private contractors, provision of technical information, sketches, and other advice to help the homeowner resolve the issue. In our experience, this information and intervention has been very well received and has provided great relief to the homeowners, some of whom had relatively serious problems.

We also noted some problems with heat pumps and electric forced air furnaces which were unknown to the homeowner (such as bad elements, burned out sequencers, high heat pump reset thermostat settings, and burned out compressors). Based on our detailed audits (in which we found several cases where the coefficient of performance (COP) of the heat pump was considerably less than 2), we expect that we would find a fairly high incidence of this problem if services were expanded to include a check of the heat pump's refrigerant charge. The impacts of these heating system reviews could be as great as the duct retrofits. These reviews would not necessarily involve extensive amounts of training, but would have to be performed by a field technician familiar with refrigeration pressure gauges.

Table 2. Operations and Maintenace Problems Identified In Field
(268 total contacts, 165 have natural gas furnace and/or water heater)

Problem	n
High CO reading(>50 ppm) in at least 1 heat exhanger exhaust port or in combined furnace exhaust	36
Furnace venting problem (low draft pressure, soot/corrosion on vents, undersized vent)	15
Furnace or DHWH flue gas spillage	6
Inadequate furnace combustion air	4
Furnace short-cycling	6
High CO reading (>100 ppm) in DHWH flue	4
DHWH venting problem	4
Serious return duct problem (undersized, pulling in furnace exhaust or other unhealthy air, etc.)	5
Cracked furnace heat exchanger	3
[CO] > 100 ppm in gas log	2
[CO] > 100 ppm in gas range after 5 minutes	2
[CO] > 3 ppm in supply air	4
Heat pump compressor burned out (homeowner unaware of problem)	3
At least one electric furnace element burned out	5
Electric furnace sequencer burned out	1
Heat pump outdoor thermostat disconnected or set wrong	2
Condensate from clogged line rusting supply plenum	2

- Number of houses with at least one problem: 65
- Number of gas-heated houses with at least one problem: 57

The most cost-effective method of conducting a heating system and duct system screening program may be to change the marketing focus. A program which stresses the benefits of a general heating system maintenance and safety review, including an optional duct efficiency audit, may be more well received by the public. The results of the duct efficiency tests could be reported directly to the owner, allowing them to seek a retrofit if desired.

Quality Control and Savings Estimation

From the start, the project team was extremely interested in making sure there would be adequate data to support a reliable estimate of savings. To estimate program impacts, a billing analysis will be performed following the collection of one year of post-retrofit data. However, such analysis is prone to many pitfalls and must await the collection of data from another heating season. For this reason, a second evaluation approach was developed, which combined field data with a detailed mathematical model of duct efficiency developed by Palmiter and Francisco of Ecotope in 1997.

The model accounts for the complex interaction between leakage and conduction losses, supply-side and return-side losses, and unbalanced duct leakage to outside with natural infiltration. It also addresses the recovery of a portion of the losses back to the conditioned space as useful heat.

The three most important inputs to the model are exterior duct leakage, air handler flow, and system operating pressure. Two types of quality control audits were to be performed to gather this information. The basic audit, designed to be complete in about two hours, measured supply register flows and delivery temperatures, as well as direct duct leakage and system operating static pressures.

major determinant in energy savings from a duct air-sealing retrofit. The second audit is more in depth, and includes a duct map, detailing of duct and floor insulation levels, and measurement of equipment energy usage and temperatures at various points in the duct system. Enough information is collected in this audit to fully inform the model.

The detailed audit takes longer and is more costly, so only about 35% of all of the retrofit cases were subjected to the more rigorous approach. The air handler flow will be determined for about 50% of all homes which receive retrofits, in order to improve the accuracy of the savings estimates. This will allow the change in supply leakage fraction to be determined, which will be applied to the home's annual heating load (from bills) to estimate annual energy savings.

Preliminary Retrofit Results

The bulk of the field data have been processed at the time of this paper's publication. However, a detailed description of the savings estimation is not yet available. Instead, data on duct leakage reduction are presented in Table 3, with both indirect data (blower door subtraction, pressure pan) and direct measurements (duct pressurization tests) summarized.

Pressure pan data are often used by the field crews to determine when to stop sealing and are now commonly reported in duct sealing research. Pressure pan data reported in this study are for the supply-side only; the supply and return sides are isolated from one another at the furnace before the test is conducted. Blower door subtraction results are unreliable on a case-by-case basis since they may not put the ducts under the same pressure differential as the rest of the house, etc., but these results are often the only "hard" data available to utility personnel evaluating duct sealing efforts.

Duct pressurization results are of most interest to the authors of this report, as they can be combined with other information (air handler flow, operating pressures, buffer space temperatures) to estimate improvements in distribution efficiency. The reduction in leakage to outside at 50 Pa is about 60%, which is about 15% less than the leakage reduction percentages noted in recent retrofit fieldwork (Siegel et al 1997, Davis et al. 1998). However, the reduction is encouraging, given the retrofits in this program have taken an average of 4 crew hours to complete, including travel. Earlier retrofits, done in a pure research setting, often took longer than a half-day to complete and included treatment of lower priority leaks such as those at supply register boots.

Complete data analysis and modeling are expected to provide an estimate of program savings within one month of the completion of the field work (mid-June 1998) and will be available in future publications.

Table 3. Summary of Preliminary Retrofit Effects (averages)

	n*	Pre-Retrofit	Post-Retrofit	Absolute Change	% Change
Whole House Leakage @ 50 Pa [CFM]	76	3408	3140	-275	N/A
Supply Leakage to Out @ 50 Pa [CFM]	52	432	177	-256	-58%
Supply Leakage to Out at 25 Pa [CFM]	51	286	116	-171	-58%
Average Supply-Side Pressure Pan [Pa]	90	5.4	1.3	N/A	N/A

* Results based on 95 homes. Project will include about 125 homes by its completion. Averages for each row based on complete pairs of data. Depending on testing conditions and configuration of house, all tests not conducted on all homes. Pressure pan data corrected (where necessary) to reflect a testing pressure differential of 50 Pa. Because of study design, pre/post-retrofit duct pressurization tests conducted on about 50% of homes.

Conclusions

The program is nearly complete at time of publication and savings are still being calculated. Several findings can be reported, based on 230 total field contacts and 95 retrofits.

1. Recruiting efforts using a small article placed in a large circulation newspaper were very successful in attracting consumer interest. Despite speaking with and reviewing utility billing records of over 1000 homeowners with the majority of their heating ducts in exterior zones, the program performed retrofits on only about ½ the homes expected by the six-month mark. There is sufficient market "pull" from consumers who believe they are paying too much for heating their homes (even with relatively cheap natural gas), but this has not been found to be due to leaky ducts in many cases.

2. Utility bill screening combined with an occupant survey is not sufficient to determine duct leakiness. Utility bills can indicate general levels of consumption, and can point the field crew in the direction of homes which do appear to have high consumption (based also on review of house characteristics as reported by the homeowner).

3. A second stage of screening, field review, is necessary to screen homes, and this means per-house costs rise substantially in order to find good candidates. This has serious implications for a follow on program which is based solely on duct air sealing retrofits, as it doubles the cost of the retrofit. The field screening protocol combines an indirect assessment of leakage (the pressure pan test) with a direct measurement of duct leakage (duct pressurization test). Special training and tools are needed to perform these tests.

4. Preliminary results, based on the first 95 retrofits, indicate duct air leakage reductions have been substantial -- on the order of 60% of pre-retrofit leakage or about 256 CFM at 50 Pa. The two-person retrofit crew has been able to deliver a high level of service on a two-a-day schedule.

5. Because the rate of success in performing retrofits is only half that expected at the outset of the program, overall this program will not meet retrofit production targets. However, introduction of the screening audits means the overall number of contacts will be 30% greater than the program target of 200.

6. Benefits from these added contacts – beyond identifying suitable retrofit sites -- will be difficult to quantify, but they are valuable to utility customers, especially in cases where significant health and safety problems exist. Roughly half of the 175 homes visited so far have one or more operational problem(s) which have health and safety implications. These problems include high readings in exhaust gases, combustion and venting air problems, and various equipment failures (such as inoperative elements or malfunctioning heat pump compressors).

7. A relatively low cost-per-house program, recoverable through utility rates, could be a cost-effective means of addressing customer needs while simultaneously gathering information on duct leakiness. By shifting the focus to O&M tasks which appear needed in a majority of homes, the utility could mitigate health and safety problems and build a list of homes which could also benefit from duct sealing services through a shared-expense mechanism.

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