Barriers and Solutions to Achieving Potential Savings in Whole House Low-Income Weatherization Programs

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ABSTRACT

While low-income energy efficiency programs target many important goals, this paper focuses on how programs can achieve one important objective – maximizing energy savings. Challenges that can prevent programs from achieving their potential for energy savings include targeting and recruiting the highest usage homes, missed opportunities for installation of major measures, and failure to implement the proven best practices of building science.

An examination of energy savings by pre-treatment usage demonstrates how important it is to obtain participation among the highest usage customers. However, health and safety issues and other challenges can result in a low penetration rate for major measures in some of the homes with the greatest opportunities. Research on savings achieved by the number of major measures installed shows why it is critical to address problems that prevent important efficiency improvements.[1]

Even when services are delivered in high usage homes, expected savings will not be achieved if proper weatherization techniques are not applied. Clear program procedures, comprehensive contractor training, extensive quality control, re-training where needed, and assessment of energy saving results over time through the use of direct billing analysis are needed to ensure effectiveness.

Research shows that it is challenging to attain the average savings levels that are often claimed for weatherization programs, but it is achievable. Evaluation data on usage impacts, measure installation rates, and installation errors show why expected savings are not realized. The data and analysis also clarify the steps that can be taken to improve savings results.

Introduction

One goal of many low-income energy efficiency programs is to achieve maximum cost-effective energy savings. While there are many other important goals that these programs target, this paper focuses on how programs can achieve this one important objective. The paper does not claim that this one particular objective should be the only program focus and the only measure of success, but provides guidance on how this particular goal may be achieved based on extensive research in the field.[2]

Some recent evaluations have found that low-income programs (both utility and Weatherization Assistance Programs) did not achieve their expected potential for energy savings seen in previous impact study findings. Barriers to achieving high energy savings include the challenges associated with targeting and recruiting the highest usage homes, health and safety issues that prevent installation of cost-effective major measures, and inappropriate application of weatherization techniques, such as not prioritizing the most effective measures or air sealing in the most impactful areas of the home. Evaluation research clearly demonstrates that greater energy savings result from serving high usage households, installing more major measures, and delivering services in accordance with demonstrated best practices in the building science

[1] Research was conducted by APPRISE over the past ten years on weatherization and ratepayer-funded programs.

[2] Because the studies referenced here have not been made public, specific references cannot be provided. The referenced research is several studies conducted by APPRISE over the past ten years on weatherization and ratepayer-funded programs.

field. This paper brings together related research in these areas and provides recommendations for improving savings achieved through cost-effective low-income weatherization programs.

Recruiting High Usage Participants

Targeting and recruiting high usage program participants is critical to maximizing energy savings. Despite the availability of funding for extensive free weatherization services, customers may refuse participation due to any of the following issues.

- Skepticism about the program and the fact that services are provided at no cost to the participant.
- Confusion among potential participants due to many marketing calls received from alternative energy suppliers.
- Concerns about privacy and allowing strangers into the home.
- An inability to be home during the weekday due to work or other obligations.
- A refusal by the landlord to provide approval for service delivery.
- Fear that their natural gas will be shut off. Potential participants may have heard from others that their natural gas was shut off due to safety problems.

Programs need to conduct extensive outreach to ensure customers are aware the legitimate program exists and will be beneficial, and to market the free services to potential high usage participants. Referrals from friends and relatives is often a successful strategy for program outreach, and use of testimonials from program participants can be an effective means of creating trust and acceptance of a program.[3]

Strategies to encourage participation among high use customers include linkage with bill payment assistance programs. Bill payment programs provide subsidies to low-income customers to make their energy bills more affordable. Many of the bill payment assistance participants may have a problem with high energy usage that is causing their bills to be unaffordable. Programs can use existing relationships to encourage participation or can require these customers to accept weatherization services to continue receiving their utility bill discounts. Often customers will accept services once they have participated in the audit and understand how the program can improve their comfort, safety, and energy affordability. Treating these customers serves the additional goal of reducing the subsidy provided by other utility ratepayers.

Some programs are required to serve all who apply, and are thus more limited in their ability to target high-usage households. However, in these cases, the level of services delivered should be calibrated to the opportunities that are available for energy savings. Some homes should not even receive an in-person visit unless a phone screening reveals a particular reason to do so, such as constrained usage by a household that cannot afford the energy bill. Homes that are already efficient should be limited to basic measures, perhaps provided through a business reply card mailing for an energy saving kit, or a neighborhood blitz where low cost opportunities are quickly identified and addressed in many homes that are clustered together. An abbreviated home assessment can determine whether some of those low-usage homes are in need of greater treatment, as they are low users due to broken heating equipment or affordability issues. In general, however, these low usage homes should not receive comprehensive audits and measure installation visits, as greater investments should be reserved for the higher usage homes that have more opportunities for energy savings. In this way, programs can appropriately invest even more where the potential for savings warrants more intensive treatment.[4]

[3] For example, see McMichael M, Shipworth D. The value of social networks in the diffusion of energy-efficiency innovations in UK households. Energy Policy 2013;53:159–68. doi:10.1016/j.enpol.2012.10.039.

[4] The Colorado Energy Efficiency programs introduced in 2006 provided service delivery that was varied based on the customer's energy usage.

Research on the Relationship between Pre-Treatment Usage and Energy Savings

Evaluation research findings on savings by pre-treatment usage levels demonstrates how important it is to encourage participation among the highest usage customers. Figure 1 displays the relationship between pre-treatment electric usage and weather normalized savings across seven low-income program evaluations over the last eight years. Figure 1 clearly demonstrates that higher pre-treatment usage translates into greater energy savings.

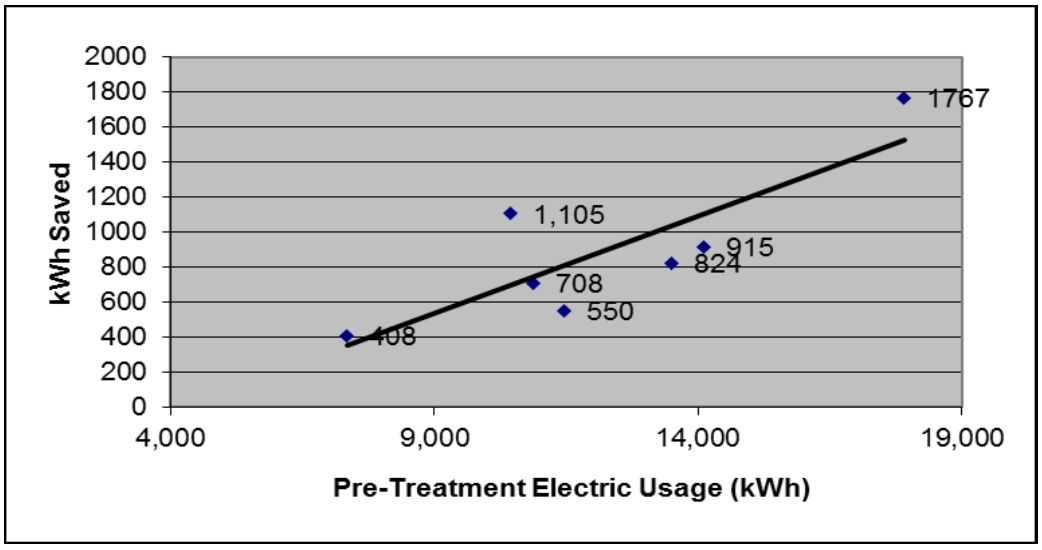

Figure 1. Electric Savings as a Function of Pre-Weatherization Electric Usage

Additional research on savings (estimated through weather-normalized billing data for the pre- and post-treatment year) by pre-treatment usage within individual programs further supports this finding. Table 1 shows that electric savings increase within the programs as pre-treatment usage increases. This is seen consistently in all programs shown below as mean kilowatt-hour (kWh) savings increases with the pre-treatment usage tier. In most cases, the percentage of pre-treatment usage saved also increases with the higher usage. For example, in Program 3, savings were 354 kWh for participants with usage below 10,000 kWh, savings were 693 kWh for participants with usage between 10,000 kWh and 16,000 kWh, and savings were 1,559 for customers with usage over 16,000 kWh. The percentage saved increased from 4.2 percent, to 5.4 percent, to 8.1 percent as usage increased from the lowest to highest tier.[5]

Table 1. Pre-Treatment Electric Usage and Savings

Pre-Treatment Usage (kWh)	Program 1 - Electric Baseload		Program 2 - Electric Baseload	
	Mean kWh Savings	Mean % Savings	Mean kWh Savings	Mean % Savings
< 8,000	-79	-1.1%	193	2.8%
8,000-12,000	419	4.3%	522	5.3%
> 12,000	1,079	6.6%	1,984	12.2%

[5] Measure expenditures were generally a few hundred dollars for baseload electric programs and were approximately $2,000 for electric heating programs.

Program 3 - Electric Heating		
Pre-Treatment Usage (kWh)	**Mean kWh Savings**	**Mean % Savings**
≤10,000	354	4.2%
10001-16,000	693	5.4%
>16,000	1,559	8.1%

Program 4 - Electric Heating		
Pre-Treatment Usage (kWh)	**Mean kWh Savings**	**Mean % Savings**
< 16,000	753	5.7%
16,000-26,000	1,367	6.7%
> 26,000	4,614	13.5%

Figure 2 displays the relationship between pre-treatment natural gas usage and weather normalized savings across seven low-income program evaluations over the last four years. Figure 2 also demonstrates that programs with higher pre-treatment natural gas usage achieved greater energy savings.

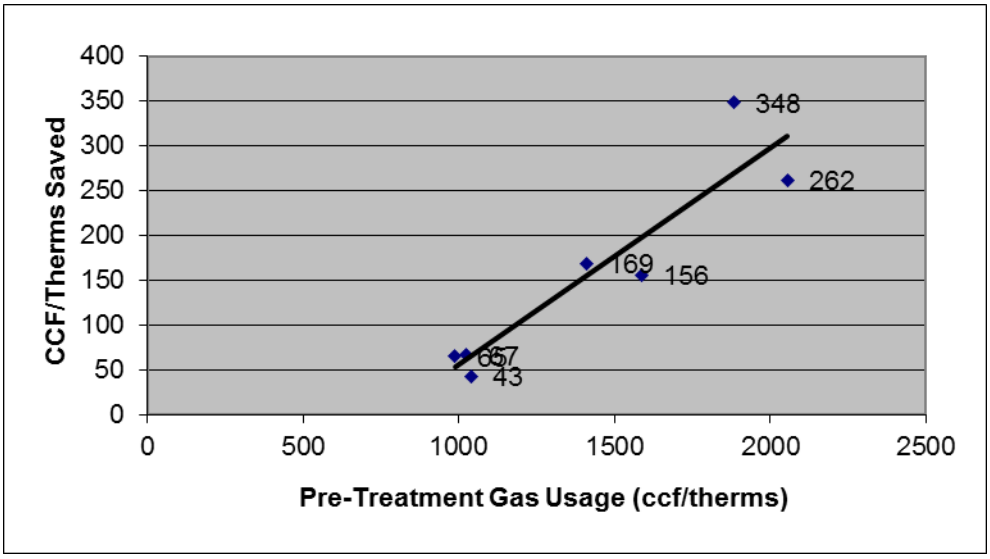

Figure 2. Natural Gas Savings as a Function of Pre-Weatherization Natural Gas Usage

Natural gas savings by pre-treatment usage within individual programs also supports this finding. Table 2 shows that natural gas savings increased within the programs as pre-treatment usage increased. One exception shown below is for Program 3 where customers with usage over 1,600 ccf had lower savings than those with lower pre-treatment usage.

A caveat to the relationship demonstrated by Program 3 is that sometimes homes with the highest usage cannot receive complete treatments because the same issues that cause the very high usage create barriers to cost-effective service delivery. These issues include severe structural issues or heating systems on the brink of being nonfunctional. Implementation contractors have occasionally reported that they pulled back from targeting the very highest usage customers because they were finding many of those homes had serious problems that could not be cost-effectively addressed and were larger than the scope of the program. As a result, one contractor moved to targeting the top 60 to 90 percent of users (instead of those over the top 90 percent of usage), and found this approach to be more productive.[6]

[6] Therefore, we sometimes find exceptions to the expected relationship as shown for Program 3 in Table 2 below. However, most of the programs show the expected and usual relationship between pre-treatment usage and savings. Measure-level expenditures were approximately $2,000 for the gas heating programs.

Table 2. Pre-Treatment Natural Gas Usage and Savings

Program 1		
Pre-Treatment Usage (ccf)	**Mean ccf Savings**	**Mean % Savings**
≤800	10	1.5%
801-1,200	46	4.7%
>1,200	79	4.9%

Program 2		
Pre-Treatment Usage (ccf)	**Mean ccf Savings**	**Mean % Savings**
< 800	23	3.5%
800 – 1,400	76	7.3%
> 1,400	144	8.3%

	Program 3		Program 4	
Pre-Treatment Usage (ccf)	**Mean ccf Savings**	**Mean % Savings**	**Mean ccf Savings**	**Mean % Savings**
<1,400	146	11.7%	133	10.7%
1,400-1,600	184	12.3%	130	8.8%
>1,600	129	6.5%	228	12.0%

Program 5		
Pre-Treatment Usage (ccf)	**Mean ccf Savings**	**Mean % Savings**
<750	71	11.0%
750-1,000	123	14.0%
1,000-1,250	182	16.4%
1,250-1,500	217	15.9%
>1,500	365	20.0%

It is important to note that the relationship between pre-treatment usage and energy savings may be somewhat overstated because of a regression to the mean. In any home, there is variation in the amount of energy used over time. Usage may be greater in one year than in another because there were more people in the home, a baby was born, or there was an illness in the family. These homes may be more likely to have higher usage in the pre-treatment year and have reduced their usage in the post-treatment year as they return to more typical usage patterns for the household. Therefore, these homes with higher pre-treatment usage are likely to see a greater reduction in usage not only because of greater opportunities, but because of their non-typical usage in the pre-weatherization period. This factor may cause an overstatement of the relationship between pre-treatment usage and energy savings, but the relationship is still present and strong.

However, this measurement issue can be addressed by stratifying the comparison group by usage in the same way the treatment group is stratified by usage tier. Table 3 shows (for Program 4) that within the comparison group, the highest usage homes also had relatively larger savings as compared to the lower usage groups (that increased their usage). However, the net savings shows that the savings for the highest usage group was greater than for the other groups.

Table 3. Pre-Treatment Natural Gas Usage and Savings, Treatment and Comparison Groups

	Treatment Group (Weatherization in 2010)					Comparison Group (Weatherization in 2011)					Net Savings	
		Usage (ccf)		Savings			Usage (ccf)		Savings			
Utility	**Obs**	**Pre**	**Post**	**ccf**	**%**	**Obs**	**Pre**	**Post**	**ccf**	**%**	**ccf**	**%**
<1,400 ccf	108	1,238	1,173	64	5.2%	160	1,216	1,284	-69	-5.6%	133	10.7%
1,400-1,600 ccf	62	1,483	1,368	115	7.8%	112	1,502	1,518	-15	-1.0%	130	8.8%
>1,600 ccf	89	1,898	1,659	239	12.6%	135	2,017	2,006	11	0.6%	228	12.0%

Penetration of Major Measures

Once customers are recruited, it can be difficult to provide comprehensive services. Health and safety (or structural) issues may prevent the critical air sealing and insulation work that is needed to achieve targeted savings levels. Common issues that prevent comprehensive implementation include the following.

- Roof leaks.
- Sewer leaks.
- Moisture and mold.
- Asbestos.
- Gas leaks.
- Knob and tube wiring.[7]
- Structural issues.
- Extreme clutter or unsanitary conditions.

These issues are often seen in low-income homes and result in a low penetration rate for major measures. Many contractors have avoided the mitigation work, even when it is funded by the program, because of a corporate liability policy to walk away from homes that have mold or asbestos, and many programs have a policy to walk away from these homes or to only install minor measures. Contractors have not been productive in returning to homes where customers have addressed these issues and energy-saving opportunities become available. In some areas, walk-way procedures have resulted in low penetration of major measures, where major measures are installed in less than half of the homes treated. These low penetration rates have detrimental impacts on the energy savings achieved by the program.

However, there are ways to address low major measure penetration rates that are caused by health and safety issues. When one program manager became aware of the magnitude of this problem, the manager worked with existing contractors and procured additional contractors who were willing to perform the necessary pre-weatherization health and safety work. Another potential solution is the use of Low-Income Home Energy Assistance Program (LIHEAP) Weatherization funds to address these issues. Such funds are available to address health and safety issues in low-income homes with important health and safety issues or inadequate heating and/or cooling. These programs vary by state, but are often an untapped source for addressing these problems. Programs generally may be able to improve outcomes by working to coordinate services for customers with important health and safety issues.

In other cases, major measures are missed because of contractor oversight, incomplete diagnostic testing, or installation visits that are limited to one day. These problems may be more readily addressed, but also require data review, assessment, and contractor oversight.

Research on the Relationship between Number of Major Measures and Energy Savings

Table 4 compares two low-income energy efficiency programs that targeted reduction of natural gas usage. Table 4 shows that Program 1 homes were likely to have had much greater energy saving opportunities than those in Program 2, as the mean usage for participants in Program 1 was 35 percent higher. Program 1 should have higher savings, as mean total costs were about 50 percent greater than for Program 2. However, mean savings for Program 1 was 72 percent higher than those achieved in Program 2 (greater than the differential opportunity seen due to usage and expenditures.) Table 4 shows that while blower door testing was done in 89 percent of Program 1 homes, it was only done in 68 percent of Program 2 homes, air sealing was done in 77 percent of Program 1 homes compared to 60 percent of Program 2 homes,

[7] There is disagreement over whether knob and tube wiring should prevent attic insulation.

and attic insulation was performed in 51 percent of Program 1 homes, compared to only 27 percent of program 2 homes. While 35 percent of Program 1 homes had zero or only one major measure installed, 51 percent of Program 2 homes had one or fewer major measures installed.

Table 4. Major Measures Installed and Natural Gas Savings

	Program 1	**Program 2**
Observations	471	3,161
Blower Door Test	89%	68%
Air Sealing	77%	60%
Air Leakage Reduction	82%	36%
Attic Insulation	51%	27%
Wall Insulation	23%	10%
Door Work	81%	52%
0-1 Major Measures	35%	51%
3+ Major Measures	30%	22%
Total Cost	$4,176	$2,164
Pre-Treatment Usage	1,588 ccf	1,039 ccf
Average Savings	156 ccf	43 ccf
	9.8%	4.1%

Table 5 displays the relationship between the number of major measures and electric savings in electrically heated homes from one program evaluation. Major measures in Table 5 are defined as air sealing, attic insulation, other insulation, HVAC replacement, duct sealing, and refrigerator replacement. Table 5 shows that homes with one major measure had average savings of 427 kWh, home with two had average savings of 1,172 kWh, homes with three had average savings of 1,429 kWh, and homes with four to five major measures had average savings of 2,293 kWh. While many of the homes may not have had opportunities for all of the major measures, it is important to ensure that contractors are not walking away from major energy saving opportunities. Findings from inspection research, presented later in this paper, shows that there are often many missed opportunities that could be addressed within available program funding levels.

Table 5. Electric Savings by Number of Major Measures Installed in Electric Heating Jobs

Number of Major Measures	**Air Sealing, Attic Insulation, Other Insulation, HVAC Replacement, Duct Sealing, Refrigerator Replacement**		
		Savings	
	Obs	**kWh**	**%**
None	72	3	<0.1%
1	90	427	3.3%
2	87	1,172	8.8%
3	63	1,429	9.4%
4-5	22	2,293	14.1%

Table 6 displays the relationship between the number of major measures and natural gas savings in gas heated homes from two program evaluations. Table 6 shows how natural gas savings and the percent of pre-treatment usage saved increases with the number of major measures installed. The highest savers from one program with five to six major measures installed had average savings of 237 ccf or 17.3 percent of pre-treatment usage, and the highest savers from the other with four or more major measures installed had average savings of 271 ccf or 16.8 percent of pre-treatment usage.

Table 6. Natural Gas Savings by Number of Major Measures Installed

Number of Major Measures	Air Sealing, Attic Insulation, Floor Insulation, Sidewall Insulation, Wall/Perimeter Insulation, HVAC Replacement, Duct Sealing		
		Savings	
	Obs.	ccf	%
0	938	8	0.8%
1	678	15	1.6%
2	838	25	2.5%
3	506	111	9.9%
4	168	170	13.5%
5-6	32	237	17.3%

Number of Major Measures	Air leakage reduction and/or air sealing (one measure), Attic insulation, Wall insulation, Header insulation, Insulation		
		Savings	
	Obs	ccf	%
0	58	167	10.6%
1	198	80	5.1%
2	254	162	10.5%
3	167	226	14.2%
4 or more	53	271	16.8%

Quality Service Delivery

On-site observation of service delivery and inspections of completed work in low-income programs around the country have found that installations often do not follow best practices identified and demonstrated in the building science field (through prominent weatherization experts and organizations such as the Building Performance Institute (BPI). Key problems that have been identified include the following.

- Insufficient use of diagnostic testing results to inform measure selection and installation specifications.
- Lack of focus on the highest priority areas before moving on to other measures. One of the highest priority areas that is often not comprehensively completed is air sealing at the top of the envelope.
- Failure to use the blower door to guide air sealing work and not using zonal pressure testing to affirm the appropriate pressure boundary.
- Duct sealing that does not focus on ducts outside of conditioned spaces. Incomplete duct sealing and not using pressure pan testing to ensure that the work was effective.
- Missed opportunities for insulation.
- Failure to meter or otherwise assess all refrigerators and freezers. Missed opportunities for two-for-one swaps (replacing two old inefficient refrigerators with one new more efficient refrigerator.)
- Unclear work orders that do not provide appropriate guidance from the audit to installation contractors.
- Inadequate customer education that results in a misunderstanding of how to use energy and maintain measures, and lost opportunities for proactive customer actions to reduce energy usage.

One common area for improvement in all of the programs where we conducted on-site inspections was air sealing. Many observed and inspected homes were left with important missed air sealing opportunities because of the following key issues.

- Attic inspection – in some cases auditors did not climb into the attic during the inspection (The auditors carried small (2' or 4') ladders in their vehicles and used them to photograph the attic through the hatch. Only a small portion of the attic is visible using this method) and in many cases they did not create access to inaccessible attics.
- Blower door use during the audit/inspection – many of the observed auditors did not use the blower door while inspecting the home for leaks.
- Zonal pressure diagnostics – this testing is often not completed during the audit. This testing is necessary to define the thermal boundary.
- Blower door use during sealing – many contractors did not use the blower door to guide air sealing during the implementation of the work.
- Zonal pressure testing at installation visit – zonal testing was not used to verify that significant improvement has been attained after air sealing and confirm a continuous thermal boundary.
- Attic air sealing – leaks under existing attic insulation were often not sealed.
- Incorrect prioritization – contractors were often seen insulating the basement ceiling although it is often not effective and there were greater opportunities in the attic.

Table 7 provides data from audit observations. Table 7 shows that in both programs observed, the auditors were unlikely to create access to inaccessible attics, sometimes did not inspect for all typical bypasses, and did not use the blower door while inspecting for leaks in about one third of the observations.

Table 7. Audit Observation Findings, Air Leakage and Insulation Diagnostics

	Program 1			**Program 2**		
	Applicable Observations	**Action Taken**		**Applicable Observations**	**Action Taken**	
		#	**%**		**#**	**%**
Measured surfaces	100	94	94%	75	57	76%
Inspected all accessible attics	78	69	88%	62	61	98%
Created access to inaccessible attics	33	3	10%	23	0	0%
Inspected for all typical bypasses	100	62	62%	75	67	89%
Visual inspection for air sealing opportunities	100	83	83%	76	71	93%
Used blower door while inspecting for leaks	96	64	67%	51	32	63%

Table 8 provides findings on observation of the air sealing work. Table 8 shows that the blower door was rarely used to guide the air sealing, zonal pressure was often not completed, sealing at the top and bottom of the envelope was not appropriate prioritized, and there were many cases where all major opportunities were not sealed.

Table 8. Measure Installation Findings – Air Sealing Work

	Program 1			Program 2			Program 3		
	Applicable Obs	Action Taken		Applicable Obs	Action Taken		Applicable Obs	Action Taken	
		#	%		#	%		#	%
Blower door used to guide air sealing	83	18	22%	26	2	8%	4	2	50%
Zone pressure testing done	80	9	11%	23	12	52%	4	0	0%
Sealing at top and bottom prioritized	82	63	77%	21	13	62%	4	2	50%
All major opportunities sealed	83	47	57%	25	12	48%	4	1	25%

Table 9 displays information on leaks that were found in the attics during inspections of completed homes. Table 9 shows that in both programs, it was rare that all leaks were addressed by the program when they should have been addressed. For example, in Program 1, there were only minor leaks found during the inspections in 28 percent of the cases and no leaks that should have been sealed by the program in 15 percent of the cases. However, the program should have addressed all remaining leaks in 14 percent of the cases and most remaining leaks in 26 percent of the inspected homes. These are prevalent missed opportunities that result in lower than expected energy savings.

Table 9. Inspection Findings – Attic Air Sealing Work

	Leaks found During Post Inspection Part that Program Should Have Addressed				Only Minor Leaks Remain	Total
	All	Most	Some	None		
Program 1 (N=227)						
Program Should Have Addressed Leaks	14%	26%	17%	15%	28%	100%
Program 2 (N=20)						
Program Should Have Addressed Leaks	0%	30%	40%	20%	10%	100%

The research has shown that there are improvements to be made in the way that the program is implemented in the field. Experts who consulted on these studies agreed that the following program improvements could have a large impact on program implementation.

1. Program Manual – Many programs do not have manuals that define the specific methods for implementing weatherization procedures. Even in cases where detailed program manuals do exist, there is room for improvement in clarifying measure selection and installation procedures. Program managers should ensure that the manuals clearly describe the parameters of program implementation and that such practices conform to best practices in the home performance industry.
2. Spending Guidelines – When provided, they need to relate directly to opportunities for saving. Sufficient flexibility needs to be provided to accommodate variations in opportunities and special circumstances.
3. Work Orders – Clear and specific work orders are rarely seen. Improving the documentation and transfer of information can improve program outcomes.
4. Training – Review of program implementation showed that auditors and installers have a need for more training. Key areas for such training are as follows.

a. Review of basic building science, the "house as a system", why the work is being done, and how the measures work.
b. Using testing results to guide the work and affirm a continuous thermal boundary.
c. Use of duct testing to guide duct sealing. Focusing work on ducts outside the conditioned space and those with the greatest potential for saving.
d. Writing a clear and comprehensive work order that effectively passes information from the auditor to the installation team.
e. Customer education, including partnership development, creating the participant's action plan, and assessing thermostat and lighting opportunities. Working with the customer to obtain and use information to improve service delivery and ensure effective measure installation.
f. Diagnosing and addressing high electric baseload usage.

5. Quality Control – More time needs to be spent by observers and inspectors in the field to directly observe service delivery, review completed jobs and conduct diagnostic tests, and ensure that best practices are followed. Crews should be required to return to jobs to correct or complete their work.
6. Performance Measurement – The program needs to review performance over time and assess changes in performance to ensure that program refinements are having the intended effects. With respect to the specific issue of proper implementation of weatherization techniques, managers need to define specific targets based on observations and inspections, and review energy saving impacts over time through the use of direct billing analysis.

Summary and Recommendations

This paper discussed three key challenges in achieving savings from low-income energy efficiency programs, based on evaluations of such programs implemented across the country. Key lessons from the research are as follows.

1. Target services to high-usage customers.
2. Ensure that major measures are installed where opportunities exist and that missed opportunities are minimized.
3. Design and implement programs to maximize use of proven home performance techniques.

All of these recommendations require performance measurement to achieve and document improvement in implementation over time and to confirm that the program changes lead to greater energy savings. We recommend that programs take the following steps to measure baseline performance, improve design and implementation, conduct quality control, and assess results over time.

1. Develop baseline statistics – Document current statistics on pre-treatment usage, major measure installation rates, and energy savings measured through billing analysis.
2. Refine – Review and refine the program procedures. Train the contractors on areas of key weakness. Our research showed that program weaknesses resulted from both a lack of clear program guidance and a lack of understanding and follow through among implementation contractors.
3. Pilot program changes – Pilot test innovative strategies to achieve greater success if it appears that barriers cannot be fixed with incremental changes. For example, programs may test a new process for compensating contractors to achieve results, or pilot new procedures for treating different types of homes, including homes with low usage, high baseload usage, health and safety problems, and homes previously treated by the program.

4. Conduct quality control – Observe work in the field and conduct inspections of completed jobs on a frequent and intense (including diagnostic testing) enough basis to verify that procedures are correctly and comprehensively implemented. Review all aspects of the work, including audits, documentation of the work scope, and installation. Require contractors to return to any homes that do not meet the program standards, and ensure that all parties agree to program specifications and procedures.
5. Hold contractors accountable – Periodically review work at the contractor level. Remove contractors that do not meet standards or require remedial training and improved results for continued participation in the program.
6. Assess inputs and outputs – Conduct analysis of the program inputs and outputs on a regular basis. Review the pre-treatment usage of program participants and the measure penetration rates for major measures. Are these statistics improving enough to lead to better results?
7. Assess inspection results – Review rates of comprehensive and high quality installations. Review rates of missed opportunities and poor quality work. These statistics, in coordination with the input and output statistics, will provide an early indicator of what to expect in terms of program savings.
8. Assess results – Review savings results on an annual basis. One evaluation every several years is not sufficient to ensure that the program is achieving the expected results. If done on a regular basis, program managers can develop procedures to more easily extract usage data and the impact evaluation could be completed at much lower cost. Compare results over time, assess what is working, and refine the program again.

This rigorous and continuous program improvement process requires measurement, refined program design and implementation, quality control, and continued assessment.

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