Health and Safety Investments to Increase Energy-Saving Opportunities

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ABSTRACT

Many low-income usage reduction programs are facing increasing challenges serving customers due to the prevalence of health and safety problems that prevent major measures from being installed. As a result of serious issues in the home, customers must be deferred or are treated with only minor services, and high-usage customers with good potential for savings do not participate or only achieve low energy savings. We conducted research to assess the circumstances under which additional cost-effective health and safety spending can be made to achieve greater savings for low-income customers and the program as a whole.

The research conducted for a natural gas utility included an assessment of the extent of the problem and the types of health and safety issues encountered, a description of the current approach to health and safety issue remediation, an analysis of energy efficiency program savings results, and a decision framework to assess when and how much additional funds should be spent on health and safety issue remediation.

The research found that depending on the job characteristics, the natural gas utility may be able to spend a significant amount of funds on health and safety and still achieve cost-effective savings, given the high level of opportunities for savings found in the home. We recommended that the utility pilot additional health and safety spending on high-usage homes with significant health and safety barriers and assess the level of savings that are achieved.

Introduction

Many low-income usage reduction programs are facing increasing challenges serving customers due to the prevalence of health and safety problems that prevent major measures, such as air sealing and insulation, from being installed. Some of the most common health and safety problems are mold and moisture, asbestos, and structural issues such as roof leaks. As a result of such serious issues in the home, customers must be deferred or are treated with only minor services, and high-usage customers with good potential for savings do not participate or only achieve low energy savings. This reduces savings for the program as a whole and means that low-income customers will continue to struggle with high energy bills. This research provides an assessment of the circumstances under which additional cost-effective health and safety spending can be made to achieve greater savings for low-income customers and the program as a whole.

Deferred Jobs and Jobs without Major Measures

The first step in the research was to assess the extent of the issue. We analyzed the utility's 2015 program database, reviewed the cancelled jobs spreadsheet (a list of referred homes that were not served and the reasons that they were not served), and reviewed job[1]

[1] A job is defined as a home to be treated by the program.

paperwork including information recorded during the initial audit of the home, reasons why measures were not selected, and invoices for measure installations. We considered jobs in the following categories as the initial list of indicators that a health and safety issue prevented weatherization work:

- No measure invoice data.
- Job marked as incomplete.
- No blower door test data.
- Blower door indicator marked as not done.

Table 1 shows that these issues were encountered in a significant percentage of the 2015 jobs. Overall, 46 percent of the 997 jobs in the 2015 database had one or more of the issues.

Table 1. Assessment of 2015 Jobs with Potential Health and Safety Issues

Indicator of Potential Issue	Number	Percent
No Invoice Data	225	23%
Incomplete Job	391	39%
No Blower Door Test	398	40%
Blower Door Indicator Shows Test was not Done	382	38%
Any of Four Issues Listed	462	46%
All Jobs	997	100%

We next identified jobs that may be limited due to health and safety issues as those where total job costs were less than $750 or total job costs minus heating system replacement costs were less than $750. Table 2 shows that 35 percent of jobs had at least one of these issues.

Table 2. Assessment of 2015 Jobs that May Have Been Limited Due to Health and Safety Issues

Cost Issue	Number	Percent
Total Job Costs <$750	330	33%
Non-Heating Replacement Job Costs<$750	346	35%
Either Cost Issue	346	35%
All Jobs	997	100%

Table 3 shows that when considering all of the issues described above, 47 percent of the 997 jobs were flagged as having a potential health and safety issue.

Table 3. Assessment of 2015 Jobs with Potential Health and Safety Issues Based on All Analysis Factors

Indicator of Potential Issue	Number	Percent
No Invoice Data	225	23%
Incomplete Job	391	39%
No Blower Door Test	398	40%
Blower Door Indicator Shows Test was not Done	382	38%
Either Cost Issue	346	35%
Any of Five Issues Listed	467	47%

Indicator of Potential Issue	Number	Percent
All Jobs	997	100%

We next merged these jobs with the utility's cancelled/deferred jobs spreadsheet. Of the 467 jobs identified as having potential health and safety issues, 329 were in this cancelled/deferred jobs spreadsheet. When we assessed the reason for the cancelled job, we found that 91 of these jobs were cancelled or deferred due to health and safety issues, and the others were cancelled for other reasons including customer refusal and ineligibility.

We requested a total of 229 job files from the utility. These were comprised of the 91 cancelled/deferred jobs with health and safety issues and the additional 138 jobs that were identified as having potential health and safety issues, but were not in the cancelled/deferred jobs spreadsheet.

Table 4 shows the number and percent of jobs that were initially flagged as potentially having a health and safety issue (and one additional job that was not initially flagged but was included in the cancelled jobs spreadsheet). The total number of jobs was 468. The table also shows the number and percent that were identified as having a health and safety issue that prevented energy efficiency work based upon a detailed review of the customer's file (this includes any time there was a note that work was not done in the home because of a health and safety issue). The job file usually included the audit form, work scope, and measure invoice(s). All of the materials in the file were reviewed to assess whether there was a health and safety issue that prevented work from being completed.

The table shows that overall 26 percent of the flagged jobs and 120 jobs in total had a health and safety issue that prevented weatherization.

Table 4. 2015 Jobs with Health and Safety Issues

Indicator of Potential Issue	All Jobs		Health and Safety Issues	
	Number	Percent	Number	Percent
No Invoice Data	225	23%	6	3%
Incomplete Job	391	39%	70	18%
No Blower Door Test	399	40%	93	23%
Blower Door Indicator =0	382	38%	81	21%
Either Cost Issue	346	35%	48	14%
Cancelled Jobs	329	33%	30	9%
Any of Six Issues Listed	468	47%	120	26%
All Jobs	997	100%	--	--

The file review described above was also the source of information for the specific health and safety issue(s). Table 5 displays the prevalence of major health and safety issues. Note that jobs could have more than one issue identified, so percentages do not sum to 100 percent. The most common issue was mold and/or moisture which prevented eight percent of jobs from being completed and comprised 68 percent of the health and safety issues. The other most common issues were knob and tube wiring[2] and roof leaks[3].

[2] Knob and tube wiring prevents installation of attic insulation due to potential fire hazards.
[3] Roof leaks prevent air sealing and insulation due to the potential for moisture and mold.

Table 5. 2015 Jobs with Health and Safety Issues

Health and Safety Issue	Jobs with Health and Safety Issues that Prevented Work		
	Number	% of All Jobs	% of H&S Issues
Mold or Moisture	83	8%	68%
Knob and Tube Wiring	41	4%	34%
Roof Leak	38	4%	31%
Asbestos/Vermiculate	18	2%	15%
Sewage Leak	13	1%	11%
Infestation	12	1%	10%
Structural Issues	12	1%	10%
Holes in Attic Floor	10	1%	8%
Clutter	8	1%	7%
Other	21	2%	17%
Any Issue	122	12%	100%
All Jobs	997	100%	100%

Current Health and Safety Approach

The utility allows contractors to spend up to $650 on health and safety repairs for all participants, regardless of whether the customer owns or rents the home. For renters, this funding is usually related to HVAC repairs that will allow for weatherization work to be completed. If the customer owns the home, the $650 may be used for a roof patch repair, or for a small amount of mold remediation.

The utility will approve additional spending on a case-by-case basis when contractors call to request additional funding. One of the most consistent areas where contractors ask for additional funding is for knob & tube abatement which may cost from $1,000 to $3,000. If the utility believes that the customer will achieve significant savings as a result of allowing the remediation because there is no insulation in the attic, the utility would approve such a request. This would result in higher health and safety spending and higher total job spending above the initial total calculated spending target.

Contractors have various risk thresholds when undertaking weatherization work and remediation work. Some will perform any repairs that the utility permits so that they can proceed with the job, and some will not address the home if there is any water in the basement, for example. The utility leaves it up to the contractor to decide what issues to address because the contractor has the responsibility for the liability. The utility could potentially re-assign a job to another contractor who is willing to do the health and safety remediation work if the originally assigned contractor would not perform the work.

Table 6 displays the percent of completed jobs included in the 2013-2015 evaluations with various health and safety repairs and the cost distribution for those repairs. Overall, 74 percent of the jobs had at least one of these repairs and the average cost of all repairs in the home was $453. Ten percent of jobs had total repair costs of more than $1,025. The most common issue was dryer venting, which was included in half of the 2013-2015 jobs. Miscellaneous repairs include chimney, windows, and electrical repairs. These miscellaneous repairs had the greatest costs. Interior repairs include floor, wall, ceiling, the floor under the bath, wall plaster, ceiling plaster, and other pre-air sealing repairs.

Table 6. 2013-2015 Health and Safety Repairs and Spending Distribution

Repair Issue	Had Issue		Repair Cost (For those with Repair)							
	#	%	Mean	Min	Percentile					Max
					10	25	50	75	90	
Dryer Venting	693	50%	$91	$10	$57	$75	$90	$91	$119	$635
Miscellaneous	528	38%	$392	$0	$31	$48	$102	$239	$1,388	$6,464
Interior	485	35%	$304	$8	$75	$112	$153	$345	$684	$2,654
Kitchen/Bath Exhaust	158	11%	$236	$28	$82	$125	$202	$350	$420	$1,016
Roof	68	5%	$167	$20	$70	$85	$85	$170	$370	$850
Total – Any Repair	1,028	74%	$453	$0	$80	$105	$230	$440	$1,025	$6,625

Energy Savings Results

We analyzed the utility's 2013, 2014, and 2015 evaluation data to understand the level of savings achieved based on weather normalized pre-treatment usage, contractor, measures, job costs, and other characteristics.

Table 7 displays the mean energy savings for 2015 jobs alone and the jobs completed in 2013 through 2015. We focus on the three-year analysis in this study to provide more jobs for analysis and a better prediction of energy savings based on job characteristics. While mean savings in 2015 were 258 ccf or 17.8 percent of pre-treatment usage, mean savings over the 3-year period were 304 ccf or 20.1 percent of pre-treatment usage. This shows the declines in savings that are being achieved, at least partially due to increased health and safety challenges.

Table 7. Weather-Normalized Gas Heating Savings Analysis

Analysis Group	Obs.	Usage (ccf)		Savings	
		Pre	Post	ccf	%
2015	533	1,449	1,191	258**	17.8%
2013-2015	1,398	1,515	1,211	304**	20.1%

**Denotes significance at the 99 percent level. *Denotes significance at the 95 percent level. #Denotes significance at the 90 percent level.

Table 8 displays the mean energy savings for 2013-2015 jobs by pre-treatment usage. We use the 3-year period to provide a greater number of jobs in each usage bin. The table provides the following information.

- Job Cost: As expected, there is a trend toward higher costs for jobs with greater pre-treatment usage, as there are more opportunities in these homes. However, the mean job cost do not increase linearly with the pre-treatment usage, indicating that the number and depth of measures does not increase at the same rate as pre-treatment usage. There is likely to be variance caused by differences in contractors' practices and costs, and by home conditions that impact energy-saving opportunities.
- CCF savings: The amount of natural gas saved does increase linearly with pre-treatment weather-normalized usage. While jobs with pre-treatment usage of less than 1,000 ccf save an average of 159 ccf, jobs with pre-treatment usage of 1,201 to 1,300 ccf save an average of 245 ccf, jobs with 1,701 to 1,800 ccf save an average of 345 ccf, and jobs with

pre-treatment usage over 2,200 save an average of 629 ccf. This shows the importance of continuing to target and provide comprehensive service delivery to high-usage homes.

- Percent savings: The percent of pre-treatment usage saved generally increases with pre-treatment usage, but not as consistently as the amount saved.

Table 8. Weather-Normalized Savings by Pre-Treatment Usage, 2013-2015 Participants

Weather-Normalized	Obs.	Mean Cost	Usage (ccf)		Savings	
Pre-Treatment Usage			Pre	Post	ccf	%
<1,000	104	$5,514	927	767	159**	17.2%
1,001-1,100	122	$4,935	1,049	877	172**	16.4%
1,101-1,200	118	$5,672	1,151	929	222**	19.3%
1,201-1,300	136	$5,307	1,249	1,004	245**	19.6%
1,301-1,400	159	$5,288	1,349	1,097	252**	18.7%
1,401-1,500	125	$5,574	1,448	1,147	301**	20.8%
1,501-1,600	151	$5,135	1,547	1,234	313**	20.2%
1,601-1,700	112	$5,217	1,648	1,340	308**	18.7%
1,701-1,800	89	$5,130	1,746	1,402	345**	19.8%
1,801-1,900	67	$5,648	1,847	1,436	410**	22.2%
1,901-2,000	54	$6,169	1,947	1,535	412**	21.2%
2,001-2,200	60	$6,408	2,082	1,663	419**	20.1%
2,201+	101	$7,601	2,627	1,999	629**	23.9%

**Denotes significance at the 99 percent level. *Denotes significance at the 95 percent level. #Denotes significance at the 90 percent level.

Table 9 displays 2013-2015 savings by contractor for all contractors who had at least 50 jobs included in the 2013-2015 evaluations. Average savings vary significantly by contractor. Contractors with the lowest savings had mean savings of about 200 ccf or 15 percent of pre-treatment usage, and one contractor with the highest savings who had 306 jobs included in the evaluations saved an average of 433 ccf or 27.5 percent of pre-treatment usage. While some of these differences are due to the types of homes served and the opportunities for savings in the contractors' service territories, others are related to work comprehensiveness and quality.

Table 9. Weather-Normalized Savings by Contractor, 2013-2015 Participants

Contractor Code	Obs.	Mean Cost	Usage (ccf)		Savings	
			Pre	Post	ccf	%
28	306	$8,184	1,573	1,140	433**	27.5%
83	169	$4,968	1,528	1,270	257**	16.8%
101	121	$8,322	1,478	1,168	310**	21.0%
74	108	$7,836	1,458	1,121	336**	23.1%
96	98	$5,160	1,436	1,141	294**	20.5%
90	96	$7,046	1,420	1,187	233**	16.4%
102	81	$5,105	1,619	1,374	245**	15.1%
77	78	$5,979	1,467	1,171	296**	20.2%
108	76	$8,052	1,317	1,116	201**	15.3%

Contractor Code	Obs.	Mean Cost	Usage (ccf)		Savings	
			Pre	Post	ccf	%
75	66	$5,445	1,526	1,299	226**	14.8%
103	57	$7,677	1,716	1,441	275**	16.0%
Other Contractors	142	$7,852	1,558	1,306	253**	16.2%

**Denotes significance at the 99 percent level. *Denotes significance at the 95 percent level. #Denotes significance at the 90 percent level.

Table 10 displays the savings by the total job cost. The table shows that jobs with higher costs have greater savings, due to the greater number of measures installed. While jobs with total costs under $4,000 saved an average of 180 ccf, jobs with total costs of more than 10,000 saved an average of 458 ccf. This also demonstrates the importance of addressing health and safety problems so that all effective major measures can be installed.

Table 10. Weather-Normalized Savings by Total Cost, 2013-2015 Participants

Total Cost	Obs.	Mean Cost	Usage (ccf)		Savings	
			Pre	Post	ccf	%
<=$4,000	264	$2,806	1,492	1,312	180**	12.1%
$4,001-$6,000	336	$5,112	1,505	1,272	233**	15.5%
$6,001-$8,000	320	$6,970	1,511	1,192	318**	21.1%
$8,000-$10,000	230	$8,898	1,504	1,137	367**	24.4%
>$10,000	248	$12,288	1,571	1,113	458**	29.2%

**Denotes significance at the 99 percent level. *Denotes significance at the 95 percent level. #Denotes significance at the 90 percent level.

Table 11 displays the savings by the job cost excluding the cost of heating system replacements. Savings also increase with these costs.

Table 11. Weather-Normalized Savings by Cost Excluding Heating System Replacements, 2013-2015 Participants

Cost	Obs.	Mean Cost	Usage (ccf)		Savings	
			Pre	Post	ccf	%
<=$4,000	451	$2,434	1,505	1,271	234**	15.5%
$4,001-$6,000	374	$5,101	1,497	1,218	278**	18.6%
$6,001-$8,000	353	$6,966	1,488	1,131	357**	24.0%
>$8,000	220	$11,341	1,612	1,202	410**	25.4%

**Denotes significance at the 99 percent level. *Denotes significance at the 95 percent level. #Denotes significance at the 90 percent level.

Table 12 displays savings by whether or not certain measures were installed. The table shows that for all measures except heating system repair, jobs with the measure saved more than those without. For example, while jobs with blower door guided air sealing saved an average of 323 ccf, jobs without that measure saved an average of 290 ccf. While jobs with a heating

system replacement saved an average of 392 ccf, jobs without a heating system replacement saved an average of 239 ccf.

Table 12. Weather-Normalized Savings by Measures Installed, 2013-2015 Participants

Cost	Obs.	Mean Cost	Usage (ccf)		Savings	
			Pre	Post	ccf	%
Blower Door Test						
Yes	1,282	$7,188	1,513	1,204	310**	20.5%
No	116	$4,902	1,537	1,291	247**	16.0%
Blower Door Guided Air Sealing						
Yes	618	$7,110	1,517	1,195	323**	21.3%
No	780	$6,909	1,514	1,224	290**	19.2%
Insulation						
Yes	1,116	$7,581	1,509	1,185	323**	21.4%
No	282	$4,692	1,542	1,312	231**	15.0%
Blower Door Air Seal & Insulation						
Yes	563	$7,403	1,513	1,173	339**	22.4%
No	835	$6,724	1,517	1,236	281**	18.5%
Heating System Repair						
Yes	390	$7,394	1,467	1,191	275**	18.8%
No	1,008	$6,845	1,534	1,218	316**	20.6%
Heating System Replacement						
Yes	599	$8,762	1,526	1,133	392**	25.7%
No	799	$5,676	1,508	1,269	239**	15.8%
Duct Work						
Yes	546	$7,097	1,458	1,115	343**	23.5%
No	852	$6,935	1,552	1,272	280**	18.0%
Health & Safety Repairs						
Yes	1,028	$7,433	1,508	1,190	317**	21.0%
No	370	$5,789	1,537	1,267	270**	17.5%

**Denotes significance at the 99 percent level. *Denotes significance at the 95 percent level. #Denotes significance at the 90 percent level.

Table 13 displays savings for 2015 jobs by the blower door measured leakage reduction (for jobs with pre- and post-treatment testing values). This table is only shown for 2015 because the additional database that contains this information was not analyzed for the other program years. The table shows that savings increase as the CFM50 reduction increases. With a greater reduction in air leakage, there is less heat that escapes from the home and a greater reduction in energy usage.

Table 13. Weather-Normalized Savings by Blower Door Leakage Reduction, 2015 Participants

CFM50 Reduction	Obs.	Mean Cost	Usage (ccf)		Savings	
			Pre	Post	ccf	%
<=500	140	$7,183	1,437	1,224	213**	14.8%
500-1,000	80	$6,771	1,430	1,174	257**	17.9%
1,001-2,000	111	$7,373	1,408	1,107	300**	21.3%
>2,000	96	$8,880	1,585	1,242	343**	21.6%
All	427	$7,537	1,461	1,188	273**	18.7%

**Denotes significance at the 99 percent level. *Denotes significance at the 95 percent level. #Denotes significance at the 90 percent level.

Potential Savings for Homes with Health and Safety Problems

We conducted regression analysis to assess the job-related factors that best predict energy savings. After running several models, the following model kept the variables that were statistically significant, as shown in Table 14. This model shows the factors that are important in explaining energy savings, and the coefficients are used to predict potential energy savings. Given the potential energy savings, we can determine how much can cost-effectively be spent on energy-savings measures and health and safety measures combined.

Table 14. Energy Savings Regression Analysis, 2013-2015 Participants

Variable	2013-2015 Participants (1,372 Observations)		
	Coefficient	95% Confidence Interval	
Pre-Treatment Usage (ccf)	0.30	0.27	0.32
Home Age	-1.06	-1.51	-0.61
Square Feet	-0.09	-0.11	-0.07
Blower Door and Air Sealing Cost	0.05	0.04	0.05
Heating System Replaced (yes/no)	154.56	131.84	177.28
Duct Sealing (yes/no)	55.80	32.41	79.19
Contractor #74	79.58	36.48	122.67
Contractor #77	73.69	23.52	123.86
Contractor # 102	-72.10	-119.97	-24.22
Contractor # 103	-106.37	-162.50	-50.24
Constant	-73.01	-135.24	-10.79

Previous iterations of the regression included the following variables, but these were not found to be significant.

- Home Ownership
- Row Home (as opposed to single-family)
- Contractors not included above
- Blower-door reduction (2015 regression only)
- Health and Safety Repairs (yes/no)
- Health and Safety Repair Costs

Decision Framework for Additional Health and Safety Investments

Based on this research, we developed a decision framework for how much to spend on health and safety work. Table 15 displays some examples of model inputs and outputs. The table shows a range of pre-treatment usage, home age, home size, and measure investments. Based on the inputted fields, the model calculates the predicted annual savings and percent savings, the present discounted value of savings assuming a five percent discount rate, and the maximum spending on health and safety given the projected savings and the measure-level spending. The maximum spending was based upon the then current price of $1.04723 per therm of natural gas.

In addition to showing the discounted present value of savings, the table shows twelve years of savings without discounting, which leads to higher total savings and a greater amount allocated for health and safety spending. Under Scenario 5, a large old home with high pre-treatment usage, and a large investment in air sealing and other measures, the model shows that there can be up to $8,805 spent on health and safety (with no discounting) and the job will still be cost-effective.

Table 15. Model Scenarios

Variable		Scenario				
		1	2	3	4	5
User-Entered Fields	Pre-Treatment Therms	1500	1600	2500	3800	5000
	Home Age	50	30	100	100	100
	Square Feet	1500	1250	2000	3200	3200
	Air seal + Insulation Cost	$800	$1,400	$1,000	$2,700	$5,000
	Heat Sys Replace (yes=1)	0	0	1	1	1
	Duct Sealing (yes=1)	0	1	0	1	1
	Contractor 74	0	0	0	1	0
	Contractor 102	0	1	0	0	0
	Contractor 77	0	0	0	0	1
	Contractor 103	0	0	0	0	0
	Heat Sys Cost	0	$0	$3,500	$3,500	$3,500
	Other Non H&S Costs	$800	$800	$1,000	$1,000	$2,000
Calculated Fields 5% Discount	Ann Save (Therms)	214	301	578	1075	1536
	Calculated % Saved	14%	19%	23%	28%	31%
	PDV (Therms)	1,897	2,672	5,126	9,527	13,615
	Max Spending	$1,986	$2,798	$5,368	$9,977	$14,258
	Non H&S Costs	$1,600	$2,200	$5,500	$7,200	$10,500
	H&S Allowance	$386	$598	-$132	$2,777	$3,758
Calc. Fields No Discount	12-Year Savings (Therms)	2,568	3618	6940	12898	18434
	Max Spending	$2,689	$3,789	$7,267	$13,507	$19,305
	H&S Allowance	$1,089	$1,589	$1,767	$6,307	$8,805

The model provided above is an alternative to the utility's method of projecting job savings and an initial spending allocation. The utility's current method applies a specific savings factor to pre-treatment usage for each contractor based on their historical savings. A regression that only controls for pre-treatment usage and the installation contractor accounts for 25 percent of the variation in savings. However, the model shown in Table 14 and used in the analysis above, explains 43 percent of the variation of savings. Therefore, this model that takes account of additional factors does a better job of predicting savings. This model only includes the contractors who have statistically significant differences in savings after controlling for the other factors. Some contractors may have higher or lower savings than average, but those differences are better explained by differences in factors included in the model, and given those factors, those contractors do not have savings that are statistically different than the other contractors.

Under the utility's current method of determining the initial amount of spending, they allow for an adjustment if the contractor feels that he will be able to obtain greater savings than his usual percentage given the opportunities in the home. For example, if the contractor has historical savings of 20 percent, but feels that he or she can achieve 25 percent on the home, the utility may raise the spending ceiling. Under this revised approach, the utility could also provide that same flexibility if desired. However, they would use this alternative model estimate as the starting point for the spending cap, rather than the simple percentage savings based on the contractor's historical savings level.

Summary

The research presented in this paper showed that when there are good opportunities for energy saving, a significant amount can be spent on health and safety remediation. Because the high savings can be achieved, the job will still be cost-effective. Given the increasing prevalence of health and safety barriers in low-income weatherization jobs, it is important for program managers to assess where such additional spending is warranted and make these investments when significant cost-effective savings can be realized.

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