Key Challenges with Cost-effectiveness Tests for Next Generation Residential Energy Retrofit Programs

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ABSTRACT

Over the past two years several states passed legislation for reducing statewide energy consumption by 15 - 20 percent of the state's annual consumption. These initiatives typically require utilities to file energy efficiency portfolios showing how they will attain consumption reduction goals. Lighting and appliances are mainstays in these portfolios but increases in the minimum efficiency standards and increased market penetration of efficient lighting and appliances are expected to reduce the energy savings achieved from these measures in years to come. Many utilities are now including comprehensive whole-house retrofit programs focused on achieving multiple energy efficiency improvements in their portfolios. These comprehensive programs have been slower to penetrate the marketplace than those focused on the retail market, due to the complexity of the transaction and the necessity of building an infrastructure of trained and knowledgeable contractors to deliver services using building diagnostics. The slow rate of market penetration and need for administrative and technical support can make these whole-house retrofit programs appear less cost-effective through traditional cost-effectiveness tests. This paper models the cost-effectiveness of prototypical whole-house retrofit programs in four climates, including the costs of a market-based approach for building infrastructure of whole-house contractors. The analysis demonstrates the need to include targeted sub-sectors that are less efficient, more likely to participate, and therefore most cost effective; to analyze individual measures tailored to the climate and building stock and select only the most efficient measures; to estimate performance goals. These strategies demonstrate how whole-house retrofit programs can pass traditional cost-effectiveness tests.

Introduction

Comprehensive retrofit programs are becoming more common in public utility commission filed demand-side management portfolios over the past two years but program cost-effectiveness results have been divergent across the country. One major reason for this is that there still very little data available on the performance and costs of comprehensive energy retrofit programs. One of the challenges that program designers face while considering or planning such a program is how to perform cost-effectiveness analysis.

The ability for whole-house programs like Home Performance with ENERGY STAR to pass cost-effectiveness tests depends on building appropriate measured assumptions for the major components of developing and designing the program. In many states the main cost-effectiveness test utilized is the Total Resource Cost Test (TRC), which has been used in the analysis for this paper. Although not the main focus of this analysis, the Rate Impact Measure, Participant Cost Test and Utility Cost Test were also evaluated. To research the performance of comprehensive retrofit programs on TRC tests an analysis was performed for a "typical" Home Performance with ENERGY STAR program in four climate regions (cold, hot/dry, hot/humid, and mixed). This paper analyzes the cost-effectiveness assumptions, and results, and identifies the key components that influence the results of the TRC test, and provides some guiding principles for performing cost-effectiveness evaluations on comprehensive energy retrofit programs.

Methodology

A similar analytical process was used to estimate the cost-effectiveness of a prototypical home performance program in each of four climates, which were represented by Las Vegas, Houston, Baltimore, and Chicago. The steps included the following:

- establishing baseline building configurations representative of typical conditions within today's housing stock;
- characterizing a series of energy efficiency measures for their life expectancy, incremental cost, incremental savings, and cost-effectiveness;
- estimating annual installations of each measure applied to each housing type over a five-year program implementation period;
- calculating the total program-level measure costs and savings across the program period; applying program-level implementation and administrative costs; and
- calculating the overall cost-effectiveness of the five-year program

Each of these steps is described in more detail below, with specific values included for the analysis completed for mixed-climate (Baltimore, MD).

Step 1: Establishing Baseline Building Configurations

To estimate the cost-effectiveness of energy savings, one must first estimate how much energy is presently being consumed. Building types in each location were configured with architectural characteristics (e.g., number of stories, foundation type, house size), energy efficiency features (e.g., insulation levels, infiltration rates, equipment efficiencies), and operating assumptions (e.g., hot water use per day, thermostat set-points) that are representative of their respective markets..

Our methodology was designed to address a common challenge that occurs when estimating the cost-effectiveness of home performance programs. Many building configurations exist within the marketplace, but analyzing many building types is time and cost prohibitive. As a result, a single representative building or small sets of buildings representing average conditions are often used. When this is done, key sub-sectors of the market that would be cost-effective within the home performance program can be overlooked. Consequently, the projected energy savings may be too conservative relative to the older and more inefficient mix of homes that typically are most likely to participate in such a program.

To address this concern, two buildings of different ages were initially configured – one for homes built prior to 1978 and one for homes built after 1978. Subsequently, a single vintage of characteristics consistent with pre-1978 was used in the analysis. The primary different between the two vintages was the assumptions for envelope performance including windows, insulation levels, and slightly lower infiltration rates. The better performing envelope characteristics were addressed by lowering the penetration for attic insulation. All major housing configurations utilized in this analysis are summarized in Table 1. In support of this approach, Austin Energy's comprehensive energy retrofit program, has documented that 75% of its participants represented housing stock built before 1979 and nearly half were built pre-1969.[1] Both detached and attached homes were configured, as well as multiple HVAC system types.

[1] John Trowbridge, Energy Impacts for Residential Conservation Programs Presentation, ACI Conference, May, 2006

Table 1. Major Housing Characteristics Modeled

Location		Baltimore, MD
Sub Sector		Single-Family Attached (66%) Single-Family Detached (34%)
Housing Characteristics		
Stories Above Grade		One-Story & Two-Story
Foundation Type		Basement
Square Feet		Detached - 2250 Attached - 1800
Window Area to Floor Area Ratio		Detached: 14% Attached: 13%
% Ducts Outside Cond Space		One-Story Basement: 100% Two-Story Basement: 75%
Aspect Ratio	**(Front to Side)**	2:1
Envelope Information		
Roof Solar Absorptivity		0.75
Attic Insulation	**R-Value**	R-19
Cathedral Ceiling Insulation	**R-Value**	R-19
% Cathedral Ceilings		10%
Ceiling Insulation Grade		3
Wall Construction		2x4
Wall Insulation	**R-Value**	R-11
Wall Sheathing		OSB
Wall Insulation Grade		3
Door Insulation	**R-Value**	2.1
Rim Joist		Insulated
Number of Panes		1
Window U-Value		1.1
Window SHGC		0.70
Frame Type		Metal
Infiltration Value	**Natural ACH**	0.80
Mechanical Ventilation		None
Slab Insulation	**R-Value**	None
Below-Grade Bsmt Wall Height	**Feet**	6
Basement Space Type		Unconditioned
Basement Wall Insulation		None
Basement Wall Sheathing		None
Floor Insulation Over Bsmt		R-9
Systems Information		
System Type		Gas Furnace / Central AC Oil Furnace / Central AC Gas Furnace / Window AC Oil Furnace / Window AC Electric Res / Central AC Electric Res / Window AC Heat pump - Elec Backup
HVAC Motor Type		Non-ECM
Cooling Capacity	**Tons**	Detached: 3.5 Attached: 3.0
Cooling Efficiency	**SEER**	11, with 7% performance degradation
Heating Eff. (AFUE)	**AFUE**	76
Heating Eff. (HPSF)		7.2, with 7% performance degradation
Duct R	**R-Value**	2
Duct Leakage Value	**CFM/100 sq ft**	11
Thermostat		Manual
Domestic Hot Water		
DHW Fuel Type & Energy Factor	**EF**	Gas: 0.56 Electric: 0.88
DHW Capacity		40
DHW Insulation Wrap		None
DHW Temperature		135
DHW Pipe Insulation		None
Low Flow Shower Heads		No
Number of Bedrooms		3
Lighting and Appliances		
Dishwasher Efficiency		Standard Efficiency
Refrigerator Efficiency		Standard Efficiency
Freezer Efficiency		Standard Efficiency
Clotheswasher Efficiency		Standard Efficiency
Quantity of Flourescent Fixtures (beyond 10%)		0
Ceiling Fan Efficiency	**CFM/Watt**	70.4

Step 2: Characterizing Energy Efficiency Measures

With the baseline buildings configured, the energy efficiency measures could next be characterized. While multiple measures are often applied to a single home in a home performance program, the analysis began by characterizing the application of individual measures to each housing configuration. In this manner, each measure could be separately screened for cost-effectiveness and those with the highest potential could be bundled together and later reevaluated at the program level. Table 2 lists the measures that were evaluated in each location.

Table 2. Energy Efficiency Measures Evaluated

Energy Efficiency Measures		
ENERGY STAR Central AC w/ commissioning	Water Heater Temp Setpoint Reduction	Duct Sealing
ENERGY STAR Central Heatpump w/ commissioning	Low-Flow Showerheads	Ceiling Insulation
ENERGY STAR Qualified Gas Furnace	CFL	AC/HP Tune-Up
ENERGY STAR Qualified Oil Furnace	ENERGY STAR Qualified Clotheswasher	Radiant Barriers
High Efficiency Electric Water Heater	ENERGY STAR Qualified Refrigerator	Solar Screens
Water Heater Insulation Wrap	Envelope Sealing	

Each measure was characterized for its lifetime, incremental cost, and savings. Lifetime for each measure was estimated using public sources or estimated using professional judgment. Incremental costs were determined in a similar fashion. In the case of equipment measures, it was assumed that these would be applied near the end of useful life for existing equipment and, therefore, incremental costs and savings were determined from minimum efficiencies allowed by law today. To estimate the incremental savings, hourly simulations were completed using the DOE-2.1e simulation software for each of the baseline building configurations alone and then with each of the measures applied. By taking the difference in consumption between the baseline and measure upgrade, incremental kWh savings, kW savings, and therm savings were calculated.

With these parameters characterized for each measure, an initial assessment of TRC could be completed. TRC is a standard cost-benefit ratio that is used by public utility commissions as a basis for evaluating the cost-effectiveness of utility-sponsored efficiency programs. The benefits in such a test are comprised of the costs that are avoided by not needing to generate the energy that was saved through the efficiency measure. The costs for the test are increased costs required to generate any energy that may be needed as a result of the measure (e.g., low-e windows may decrease cooling energy but increase heating energy), plus any incremental costs to install the measure and to administer a program responsible for installing such measures.

Utility commissions are generally concerned with the cost-effectiveness of an overall program. However, evaluating the cost-effectiveness of each measure, prior to the application of any administrative costs, can provide valuable information about which measures can improve the overall portfolio cost-effectiveness and which measures might decrease the effectiveness of the overall portfolio.

Step 3: Estimating Annual Installations for Measures

Using the parameters characterized for each measure in the prior step, installations could next be projected for each year of a five year program. Installations were estimated with these parameters in mind in combination with intuition gained from the real world implementation of home performance programs, all of which promote comprehensive installations involving multiple products. Some of the measures were assumed to have high penetration across all locations. For example, installations of compact-fluorescent lamps are assumed to occur in all locations due to that measure's high cost-effectiveness, ease of installation, and potential for multiple installations in each home. Other measures implemented frequently included air-sealing, duct sealing, and the addition of ceiling insulation, which are all cost-effective across all four locations and provide the opportunity for significant savings. These shell measures are intrinsic to any Home Performance with ENERGY STAR program as are the installation of multiple measures. Austin Energy's Home Performance with ENERGY STAR Program has historically shown that a typical home performance project will include 3 or more measures about 80% of the time.[2] Other measures had climate-specific applications, such as air conditioners in hot climates and furnaces in cold climates. Table 3 lists the total installations for each measure in each location over the five-year program period.

Table 3. Estimated Installations by Energy Efficiency Measure

Upgrade Measure	Houston	Las Vegas	Baltimore	Chicago
ENERGY STAR Central AC w/ commissioning	5,580	4,650	2,180	1,946
ENERGY STAR Central Heatpump w/ commissioning	620	1,550	969	26
ENERGY STAR Qualified Gas Furnace	0	0	2,153	4,599
ENERGY STAR Qualified Oil Furnace	0	0	391	0
High Efficiency Electric Water Heater	415	10	367	22
Water Heater Insulation Wrap	415	194	582	53
Water Heater Temp Setpoint Reduction	1,550	1,356	515	1,555
Low-Flow Showerheads	1,550	1,356	2,053	1,563
CFL	62,000	62,000	62,000	62,520
ENERGY STAR Qualified Clotheswasher	0	698	798	700
ENERGY STAR Qualified Refrigerator	0	698	798	700
Envelope Sealing	6,588	6,394	5,414	6,635
Duct Sealing	6,588	5,425	4,397	5,468
Ceiling Insulation (R-19 to R-38)	1,556	1,356	5,692	4,702
AC/HP Tune-Up	775	775	1,570	3,093
Radiant Barriers	0	0	0	0
Solar Screens	5,425	3,875	0	0

The above installations associated with each of the four locations used for analysis were based on the home performance project completions represented in Table 4, which are shown with the actual program performance for NYSERDA's Home Performance with ENERGY STAR Program[3]. NYSERDA's program was used as a source for these project completion assumptions.

Table 4. Modeled Project Completions vs. NYSERDA Program Completions

	6-Month Pilot	Year 1	Year 2	Year 3	Year 4	Year 5	Totals
Modeled	0	250	750	1500	2250	3000	**7750**
NYSERDA	n/a	315	1025	2504	2565	3165	**9574**

[2] John Trowbridge, Austin Energy, Energy Impacts of Residential Conservation Programs Presentation, ACI Conference, May 2006

[3] Andrew Fisk, NYSERDA, NYSERDA Program Update Presentation, ACI Conference, May, 2006.

Step 4: Calculating Program-Level Measure Costs and Savings

With the annual installations estimated for each measure, the incremental costs could be multiplied by the total installations across the five-year program period to determine total measure costs. By summing the costs across all measures, the full measure cost for the program was determined. A similar process was then used to calculate the total energy and demand savings across all measure installations for the five year period. Calculating the TRC at this point would provide a best-case scenario for cost-effectiveness, because no implementation costs have been added yet. In other words, this cost-effectiveness would be accurate if such measures were voluntarily adopted by the marketplace in the absence of incentives, program administration or marketing.

Table 5. – Program-Level Savings (kWh, kW, Therms) by Energy Efficiency Measure & Location

	kWh				kW				Therms			
Upgrade Measure	Houston	Las Vegas	Baltimore	Chicago	Houston	Las Vegas	Baltimore	Chicago	Houston	Las Vegas	Baltimore	Chicago
ENERGY STAR Central AC w/ commissioning	6,238,847	6,180,471	1,243,917	756,813	3,065	2,939	478	731	-6,543	-3,394	-11,846	-17,356
ENERGY STAR Central Heatpump w/ commissioning	890,399	2,495,474	1,953,398	54,510	346	981	230	11	0	0	0	0
ENERGY STAR Qualified Gas Furnace	0	0	0	0	0	0	0	0	0	0	234,355	647,393
ENERGY STAR Qualified Oil Furnace	0	0	-57,179	0	0	0	-7	0	0	0	28,370	0
High Efficiency Electric Water Heater	38,247	922	33,855	2,028	4	0	4	0	0	0	0	0
Water Heater Insulation Wrap	171,925	62,994	189,361	17,232	20	7	22	2	0	0	0	0
Water Heater Temp Setpoint Reduction	282,991	237,815	156,958	15,002	32	27	18	2	34,757	30,853	8,719	46,945
Low-Flow Showerheads	194,450	200,911	568,981	18,665	22	23	65	2	23,882	26,065	31,799	42,833
CFL	2,833,839	2,623,288	2,367,718	2,388,855	528	447	545	446	-776	-27,553	-19,549	-68,478
ENERGY STAR Qualified Clotheswasher	0	49,243	76,506	8,112	0	6	10	1	0	3,552	3,575	5,774
ENERGY STAR Qualified Refrigerator	0	57,767	58,085	52,151	0	9	13	10	0	-331	-715	-1,512
Envelope Sealing	5,180,995	2,487,234	5,381,551	1,958,154	2,007	3,419	600	1,572	247,424	236,181	645,766	1,465,494
Duct Sealing	2,814,890	1,937,278	646,816	127,342	1,393	855	128	184	19,442	19,160	49,937	91,665
Ceiling Insulation (R-19 to R-38)	609,499	467,049	2,096,909	586,166	171	15	238	290	0	16,546	218,154	290,354
AC/HP Tune-Up	349,141	355,280	500,782	263,858	172	159	123	421	0	0	0	0
Radiant Barriers	0	0	0	0	0	0	0	0	0	0	0	0
Solar Screens	5,990,191	3,460,888	0	0	2,206	1,320	0	0	-66,191	-129,961	0	0

Step 5: Applying Program-Level Implementation and Administrative Costs

In reality, the marketplace invests in energy-efficient improvements for existing homes much less frequently than is optimal from a societal perspective. Reasons for this lack of adoption include a lack of awareness that improvements can be made, the first costs associated with the improvements, or a lack of infrastructure to market and sell such improvements effectively. This last reason is especially prevalent for home performance programs. Unlike simple sell-through programs such as CFL buy-down programs, which can rely upon an existing sales and marketing infrastructure, developing a network of qualified contractors that can adequately advise homeowners and implement improvements in existing homes is both time intensive and expensive.

As a result of these barriers, utility programs often need to provide financial incentives, marketing support, and infrastructure development in order to achieve a high rate of adoption. Because the development of an infrastructure is a prerequisite for success, the upfront costs for running a home performance program are generally high and can make the early years of the program unattractive from a cost-effectiveness standpoint. In terms of success rate with contractor recruiting the 80-20 rule applies, with only about 2 out of 10 contractors recruited into the program becoming truly active and adopting the whole-house diagnostic driven contracting model. The New York State Energy Research and Development Authority's Home Performance with ENERGY STAR Program is one of the longest running whole-house retrofit programs in the country and in 2007 about 5% of their participating contractors completing 100 projects or more, another 7% of contractors completed 50-99 projects, and

30% of their participants completed 0-1 projects[4]. In a market-based delivery model, the ability to find the highly active contractors is a key to early program success.

Within this context, the next step in the analysis was to develop a realistic annual budget for the implementation of the program. To help inform the budget development process an analysis of existing Home Performance with ENERGY STAR budgets was performed based on the budgets of the Wisconsin Focus on Energy[5], NYSERDA[6], New Jersey Board of Public Utilities[7], and National Grid's programs[8]. Budget expenditures were distributed to management and administration, incentives and financing, marketing and communications, or evaluation for the purpose of comparison. The following Table shows the average percent of budget attributed to each of the four categories for existing Home Performance with ENERGY STAR Programs and Table 7 shows the budget allocations for the program cost-effectiveness analysis for the Baltimore, MD market.

Table 6. Average Budget Allocations for Home Performance with ENERGY STAR Programs

Budget Expenditures	Percent of Total Budget
Administration and Program Development	23.0%
Sales, call center, marketing and Web site	22.0%
Rebates, grants, and incentives	52.0%
Evaluation Costs	3.0%

Table 7. Five Year Program Budget Allocations for Baltimore, MD Home Performance with ENERGY STAR Cost-effectiveness Analysis

5 Year Budget Expenditures	Cost	Percent of Total Budget
Mgmt & Admin	$ 3,059,967	20.3%
Marketing	$ 2,515,573	16.7%
Training	$ 383,203	2.5%
Incentives	$ 8,604,698	57.0%
QA Inspect	$ 305,000	2.0%
Evaluation	$ 225,000	1.5%
Total	$ 15,093,441	100%

The next table lists the budget developed for Baltimore, MD, the city used for the mixed climate analysis.

Table 8. Implementation Budget Developed for Mixed/Humid Climate

4 New York Energy Smart[SM] Program 2007 Annual Evaluation and Status Report, March 2008
5 Residential Home Performance Programs National Summary, Consortium for Energy Efficiency, August, 2005.
6 Residential Home Performance Programs National Summary, Consortium for Energy Efficiency, August, 2005.
7 Honeywell, 2008 New Jersey Clean Energy Program Plan 120707 Final
8 National Grid, 2006 Energy Efficiency Annual Report submitted to MA DOER, MA DPU, August, 2007.

Cost Description	6 Month Pilot	Year 1	Year 2	Year 3	Year 4	Year 5	Program Total
Management/Admin	156,000	160,277	225,110	242,219	259,329	276,439	1,319,374
Program Development	52,000	53,426	-	-	-	-	105,426
IT / Database Solutions	50,000	25,000	10,000	10,000	10,000	10,000	115,000
Recruitment / Partners	65,000	258,333	258,333	258,333	258,333	258,333	1,356,667
Mentoring	12,500	25,000	37,500	37,500	37,500	13,500	163,500
Quality Assurance - For Returning Contractors	-	5,000	15,000	30,000	45,000	60,000	155,000
Quality Assurance - For New Contractors	-	12,500	25,000	37,500	37,500	37,500	150,000
Total Administration Costs							**3,364,967**
Equipment	-	-	-	-	-	-	-
Training	29,297	58,594	87,891	87,891	87,891	31,641	383,203
Certification	-	-	-	-	-	-	-
Accreditation	-	-	-	-	-	-	-
Job Incentives		33,309	99,926	199,851	299,777	399,702	1,032,564
Coop Advertising	-	-	-	-	-	-	-
Contractor Incentives							1,415,767
Homeowner Incentives		244,262	732,787	1,465,574	2,198,361	2,931,149	7,572,134
Total Incentive Costs							**8,987,901**
Evaluation	25,000	40,000	40,000	40,000	40,000	40,000	**225,000**
Sub-Total	389,797	915,701	1,531,546	2,408,869	3,273,691	4,058,263	**12,577,867**
Marketing/Call Center	77,959	183,140	306,309	481,774	654,738	811,653	2,515,573
Grand Total	**467,756**	**1,098,841**	**1,837,856**	**2,890,642**	**3,928,429**	**4,869,916**	**15,093,441**

The program implementation budget each of the cost categories were derived based on projected program goals and based on budget breakdowns available from existing Home Performance with ENERGY STAR Programs.

When developing the program administrative budget there are a number of categories that are location dependent. Each market is different and different levels of effort are needed to start a program. Common program challenges that must be overcome include:

Lack of Contractor Infrastructure

Home performance contracting - taking a whole-house approach to home improvement that includes a strong health and safety ethic as well as a commitment to energy efficiency - is still emerging in the residential contracting industry. While there may be some areas of the country that have knowledgeable contractors trained in building science; it is more likely that they will be essentially non-existent at the outset of a home performance program. This lack of infrastructure is a major challenge that requires dedicated program funds for recruiting, managing, and providing technical assistance to new building-science trained contractors. These infrastructure development costs make it extremely difficult to have success with project goals in the initial one to two years of the program. For some programs the contractor infrastructure building efforts have included substantial contractor incentives for diagnostic equipment, technical training and building science certification. In pilots of Home Performance with ENERGY STAR in Colorado and Missouri among other places it was not necessary to provide incentives for diagnostic equipment to build their contractor infrastructures. However, limited funds available for customer incentives and program marketing resulted in limited success. For the purposes of this analysis, equipment and training incentives were not included and marketing of the program was prioritized to support the contractor's investment in participation.

Lack of Building Science (Whole House) Training

There is very little developed infrastructure for training home performance contractors across the United States. In many areas the closest offerings are from local weatherization training organizations, which are typically not capable of taking on the additional training capacity needed to service a new comprehensive retrofit program, are often not located close enough to the contractor participants, or may have a training curriculum that would require substantial development to be appropriate for a market-based home performance contracting model. There is a lack of qualified personnel to perform needed training and mentoring of new home performance contractors in most markets; this necessitates that training development and support be a component of the program. In both New York and Oregon programs, for instance, there have been significant efforts to engage the local community college system to service the training needs of their Home Performance with ENERGY STAR programs.

Market and Consumer Awareness

A significant area of program spending will be focused on building consumer awareness about and demand for the benefits of home performance contracting. Lessons learned from existing programs indicated a need for marketing that generates consumer interest and encourages contractor participation and investment.

An option for addressing these challenges that was not utilized in this paper would be to use a "Resource Acquisition" program delivery model instead of a "Market-Based" approach. This would help address the lack of a contractor infrastructure and to that extent reduce the quantity of building science training needed by focusing the program delivery on the selection of one or multiple contractors. This program model is often utilized in other programs like low-income weatherization and the installation of demand response controls for air conditioning units. Taking this approach could significantly reduce near-term program costs related to building and managing a network of specially trained contractors, but it would most assuredly also reduce the potentially large downstream economic benefits that come with such an investment in permanent market infrastructure.

A market creation approach can deliver non-energy benefits that some have argued should be accounted for in the cost-effectiveness test or a percentage of the cost associated with the benefit should not be counted. These non-energy benefits include job creation; spillover of energy efficiency services outside of the target market; lasting changes in the way home improvement work is completed; development of a competitive market that can reduce costs associated with energy efficient improvements; and development of small businesses.

Results

By combining the measure costs, the measure savings, and the cost of implementation, an overall cost-effectiveness value can be calculated for the program. It is at this point that program designers can visualize how program administration and incentive strategies have a tangible impact on the overall potential for program adoption. For example, establishing a low-cost pilot phase that minimizes marketing costs until implementation partners are brought up to speed can be one successful strategy.

Table 9. Cost-effectiveness Test Results from Analysis

Mixed/Humid - Baltimore, MD			Hot/Humid - Houston, TX		
Cost Effectiveness Test	**w/ Gas**	**w/o Gas**	**Cost Effectiveness Test**	**w/ Gas**	**w/o Gas**
Total Resource Cost	1.09	0.66	Total Resource Cost	1.34	1.21
Rate Impact Measure	n/a	0.49	Rate Impact Measure	n/a	0.49
Participant Cost Test	2.20	1.48	Participant Cost Test	3.36	3.10
Utility Cost Test	1.73	1.05	Utility Cost Test	2.14	1.93
Hot/Dry - Las Vegas, NV			**Cold - Chicago, IL**		
Cost Effectiveness Test	**w/ Gas**	**w/o Gas**	**Cost Effectiveness Test**	**w/ Gas**	**w/o Gas**
Total Resource Cost	1.07	1.00	Total Resource Cost	1.01	0.22
Rate Impact Measure	n/a	0.60	Rate Impact Measure	n/a	0.26
Participant Cost Test	2.11	1.95	Participant Cost Test	2.91	0.78
Utility Cost Test	1.7	1.59	Utility Cost Test	1.69	0.36

Additional research into Home Performance with ENERGY STAR Programs that are passing TRC would be a next step to evolve this whole-house retrofit program cost-effectiveness analysis. For example, National Grid's Home Performance with ENERGY STAR Program in Massachusetts has achieved a 1.73 TRC Ratio in cost-effectiveness testing based on their 2006 program year.[9] Additional research into the success of programs in Austin, Wisconsin, New York, and Massachusetts was not completed in time for inclusion in this analysis.

Conclusions

The methodology of this analysis was generally conservative in its approach to energy efficiency measures, program annual goals, and the measures installed on a typical job. This approach made the analysis of cost-effectiveness slightly more difficult when analyzing how the program performs on a TRC test. Specifically, the slower ramp up period leads to evaluating the program over a five year period. There are significant early program costs associated with building market infrastructure of home performance contractors, developing program delivery, and building consumer awareness results in the lowest TRC's during the first two years of the program. However, as a whole-house retrofit program matures the cost-effectiveness results will improve as participating home performance contractors adopt the whole-house model, feature it in their businesses, and rely less on the program for generating consumer demand.

The major focus of the cost-effectiveness analysis was on the objective of a whole-house retrofit program passing the Total Resource Cost (TRC) test in various climates. To answer the question of "Can a whole-house retrofit program pass Total Resource Cost tests in various climates? We believe that this analysis shows that the answer is yes. However, for a program like Home Performance with ENERGY STAR it could be argued that the societal test may be a more appropriate evaluator of program cost-effectiveness because of the additional side benefits of building jobs in the marketplace and significant non-energy benefits of whole-house home improvements like better indoor air quality, increased comfort, even temperatures, better humidity control, and reduced allergens.

Lessons Learned and Recommendations

[9] National Grid, 2006 Energy Efficiency Annual Report submitted to MA DOER, MA DPU, August, 2007.

- The start-up period is longer for Home Performance with ENERGY STAR programs. Therefore the program is best evaluated over a 5-year program life. Program cost-effectiveness improves with each additional year and growth in number of completed projects annually.

- Take the proper time to evaluate the housing stock within the markets served by the program and use the characteristics of homes most likely to participate in the program (e.g. homes built pre-1978). This analysis was still conservative in its approach for some housing characteristics such as using a pre-improvement insulation value of R-19 in the attic which represents the “average” home. This assumption makes cost-effectiveness of attic insulation appear worse than it would actually perform in the program because most homes receiving the measure would have existing insulation below an R-19. This could be addressed through adding more housing configurations and bundled packages of measures, but running them all through the analysis is time consuming and costly. Alternatively, the program design should feature strategies for targeting older homes and high energy users as a major focus of program delivery to harmonize with the lower efficiency of base housing characteristics.

- Eliminate incentives for diagnostic equipment and training to reduce program costs. These needs may be addressed through outside sources of funding that focus on workforce training and economic development instead of relying on program funds.

- Evaluating a bundle of measures results in lower savings for each measure than if each measure in the bundle were evaluated individually. The development of multiple bundles of measures that effectively capture what would typically be installed in homes is the best way to mitigate the underestimating energy savings.

- Evaluating TRC for each measure individually will help screen out measures with lower cost-effectiveness and avoid using them within bundled packages. For specific measures like wall insulation the development of a specific base case house without existing wall insulation will be the best method of evaluating the cost effectiveness of this improvement and other improvements that may be installed in conjunction with it for a comprehensive job. This can help ensure measures are evaluated for cost-effectiveness exactly as they would be through actual program implementation.

- Cost effectiveness tests assume the full cost (labor and materials) for measures like air sealing, duct sealing, and insulation because there is no incremental cost basis. In large part, these improvements accomplish not only energy efficiency but also increase the comfort and durability of the home. Ideally, non-energy benefits associated with these improvements should be evaluated as part of cost-effectiveness on whole-house retrofit programs.

- Administrative costs are driven by expenses and incentives needed to stimulate the growth of home performance contracting businesses as a permanent market infrastructure through the “Market-based Delivery Model.” Alternatively, structuring a whole-house program as a “Resource Acquisition Delivery Model” or using a competitive selection process to select a small number of contractors to deliver all measure installations can significantly reduce administrative costs. However, there are significant economic benefits associated with taking a market-based approach to delivery of whole-house programs. Unfortunately, the TRC test does not include these economic benefits in the cost-effectiveness calculation but does include the increased administrative costs of the Market-based Model.

The TRC Test is not effectively capturing the benefits associated with whole-house retrofit programs; it penalizes the whole-house approach by reducing the energy savings of overlapping measures without consideration of the additional benefits. Nor does it reward market transformation efforts to build permanent markets for the technologies that the programs promote. Conversely, when analyzing single measures, it does not take into account the opportunity cost of installing them without addressing other problems (e.g., installing a new HVAC system without addressing deficiencies in the building insulation, house air tightness, or deficiencies in the HVAC distribution system). It can therefore reward measures that leave significant energy savings on the table.

We're entering a new age of energy efficiency programs where cost-effectiveness tests may need to evolve beyond the TRC Test to capture deeper energy savings reduction goals, like the 15% reduction in energy demand and consumption by 2015 targeted in Maryland's Empower Maryland Act of 2008. To accomplish the deeper energy savings goals we must start to broaden the definition of cost-effective and make changes to established cost-effectiveness tests and thereby open the door to additional qualifying energy efficiency measures that the public is ready to purchase. Until that time, taking some of the steps recommended in this paper will help ensure whole-house retrofit programs pass the traditional cost-effectiveness tests now in use throughout the country.

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