Maintaining Cost-Effective ENERGY STAR Homes Programs in a Shifting Environment

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ABSTRACT

In many states across the country, the 2009 and 2012 International Energy Conservation Codes are the new effective minimum for residential energy efficiency. ENERGY STAR Version 3 and aggressive HERS targets have become the new standard for efficient, above code residential new construction. The combination of a significantly more efficient baseline and the added incremental costs for Version 3 present serious cost-effectiveness challenges for utility demand-side management (DSM) programs. This paper reviews options for designing a cost-effective and successful program given the challenges facing residential new construction program managers.

The authors examined the cost-effectiveness of an ENERGY STAR New Homes program as implemented by a major Midwestern utility during state adoption of the IECC 2009 in 2013. The program was modeled using a transparent, Excel-based benefit-cost model incorporating actual implementation and evaluation results, including ex-post savings, incremental costs, participation rates and program costs. To identify those aspects of the program that have the greatest impact on its cost-effectiveness, the team conducted a sensitivity analysis on key inputs and program elements. The team used the results of this sensitivity analysis to assess revisions to model inputs to develop the most cost-effective, successful design scenarios for future program years.

The paper presents the model results and sensitivity analysis, discussing the rationale behind the selection of each program element in response to ongoing changes in codes and standards, regulatory objectives and market trends. Findings from this paper will assist utilities across the country as they consider the challenges and solutions to maintaining cost-effective Residential New Construction (RNC) programs.

Introduction

Cost-effectiveness pressures can present an existential threat to Residential New Construction (RNC) programs. In addition to general pressures facing cost-effectiveness for all types of energy efficiency (EE) programs, such as decreasing avoided supply costs (AVCOS) related to relatively low natural gas prices, RNC programs face the added challenge of achieving savings above and beyond increasingly stringent building codes. Cost-effectiveness modeling serves as a major resource for developing and testing program design recommendations to maintain cost-effective programs in light of these pressures.

The Total Resource Cost (TRC) test is often used as the key perspective for judging the cost-effectiveness of energy efficiency programs and will be the focus of this analysis. However, the authors would like to acknowledge that the TRC and the other major cost-effectiveness tests do not fully reflect all the benefits delivered through Residential New Construction programs. For this reason, the authors believe that current cost-effectiveness testing is not a fair and accurate basis for judging the success of energy efficiency programs. However, the goal of this paper is to determine the most effective "levers" that program administrators have to influence the cost-effectiveness of their programs, within the current constraints of cost-effectiveness testing.

This paper draws on a cost-effectiveness analysis of an ENERGY STAR New Homes program as-implemented in 2013 by a major Midwestern utility (Climate Zone 5) during state adoption of the IECC 2009 energy code. The program is jointly delivered through a partnership between an electric and gas utility, with each utility challenged to meet cost effectiveness goals for its specific fuel. This paper only evaluates the position of the electric company, as each utility analyzes the program's cost-effectiveness separately from the perspective of their own fuel type. Implementation is carried out by a single third-party implementation contractor responsible for day-to-day operations of the program.

Program builders are provided with financial incentives to meet and exceed the ENERGY STAR Version 3 ("ESv3+") standards, and to go beyond those levels by applying additional prescriptive requirements and incentives linked to HERS score achievement. A less stringent performance level based on the prior Version 2 ("ESv2+") is also offered and is designed to retain contractor participation while supporting a transition to the more rigorous ENERGY STAR Version 3 standard.

The first step in the analysis involved modeling the cost-effectiveness of the program as-is, focusing on the Total Resource Cost (TRC) test results for the electric program only. The TRC equation has been constructed per the California Standard Practice Manual (CPUC, 2001). In order to get a sense of which inputs to the TRC (savings, incremental participant costs, avoided costs, etc.) were most significant, we conducted a sensitivity analysis of each input by adjusting each "lever" one at a time by $\pm$ 20% and recording the change in the TRC. From this analysis we determined that some inputs have a greater impact on the TRC than others, allowing us to focus the analysis on those areas of high-impact that program administrators have some control over (e.g. per-unit savings and costs). The final step in the analysis involved modeling various scenarios for re-designing program elements to achieve a TRC ratio of 1.0 or greater.

Current Program Cost-Effectiveness

The analysis team created an Excel-based model to analyze the cost-effectiveness of the RNC program as it performed in 2013 from the perspective of the electric utility in the collaboration. An Excel-based model was chosen because the underlying program assumptions that guide the cost-benefit analysis are transparent and easily updated. The model used annual average avoided supply costs for simplicity of programming. Unit-level inputs (electric savings, participant cost, useful life and incentives per home) approximate ex-post program results for 2013 to calculate unit-level cost effectiveness. Table 1 shows the characteristics of the average home at each performance level relevant for the TRC, along with the TRC test result at the unit level (as opposed to program level). Initial results indicated that neither the ESv3+ nor the ESv2+ performance pathway was cost-effective in 2013.

Table 1. Cost-effectiveness of current performance pathways

Performance level (average HERS)	EUL (years)	Annual summer peak demand savings (kw)	Annual energy savings (kwh)	Incremental participant cost	Average incentive	2013 units rebated	Unit-level TRC test ratio
ESv3+ (HERS 54)	25	0.320	2,706	$4,207	$1,700	321	**0.71**
ESv2+ (HERS 60)	25	0.257	1,979	$2,628	$900	1,595	**0.82**

Total unit-level benefits and costs are subtotaled for each performance pathway. Program delivery costs approximate 2013 program spending and are used to calculate program level cost effectiveness. Table 2 shows the 2013 cost-effectiveness of the program (total unit-level benefits and costs plus program administrative costs). The program achieved an initial 2013 TRC test result of 0.68. The drivers of this TRC test result are explored in the next section.

Table 2. Cost-effectiveness of current program

Program summary	Gross annual energy savings at generator (mwh)	Gross annual summer coincident demand savings at generator (mw)	Incentives ($million)	Non-incentive costs ($million)	Program cost per lifetime kwh saved ($/kwh)	Program cost per first year kwh saved ($/kwh)	Program-level TRC test Ratio
2013 Program	4,435	0.6	$2.0	$0.9	$0.03	$0.66	**0.68**

Sensitivity of Key Inputs to TRC

In order to understand why the 2013 TRC was low and to focus re-design efforts, the analysis team conducted a sensitivity analysis of key inputs to the TRC to identify those elements with the greatest TRC impacts. Each variable in the equation was increased and decreased by 20% to measure the corresponding TRC impact. As demonstrated in Figure 1, some inputs have a greater effect on the TRC than others. For instance, a 20% increase in the avoided costs results in a 20% increase in the TRC. The horizontal axis of the diagram displays the TRC, with the center point being the 2013 program TRC ratio (0.68). The blue bars show the TRC resulting from a 20% decrease in each variable (savings, costs, etc.) and the yellow bars show the TRC resulting from a 20% increase in each variable.

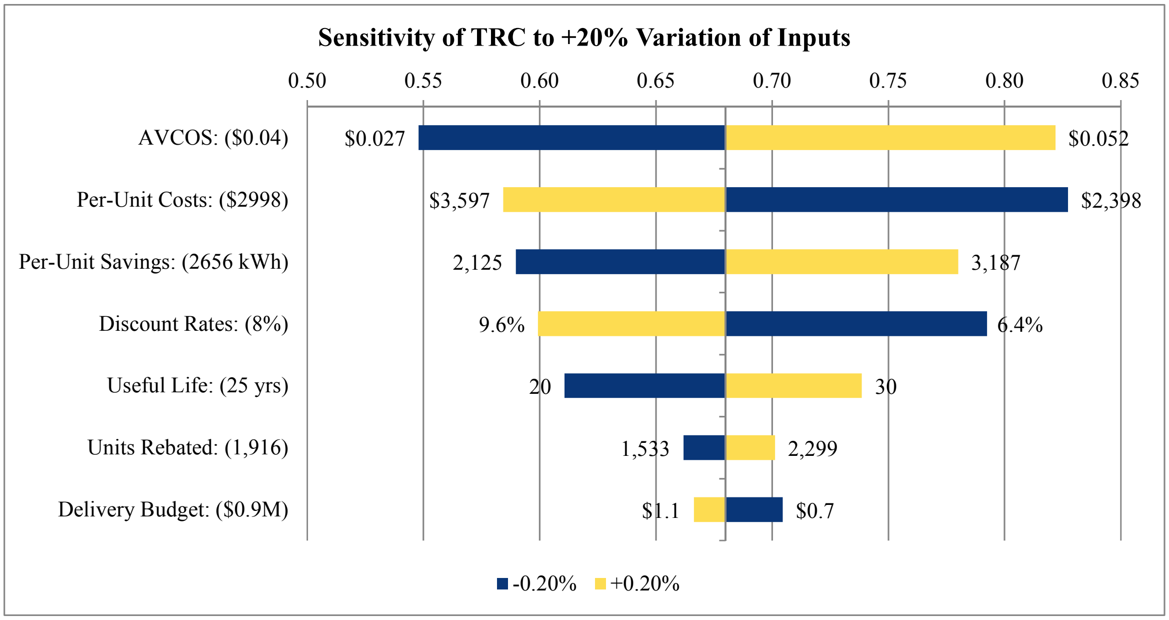

Figure 1. Sensitivity analysis of TRC test inputs.

This analysis indicates that fluctuations in the avoided costs have a large impact on the TRC, while the program delivery budget has a much lower impact. For program designers and administrators, the results indicate that, of those variables under their control, the per-unit costs and savings have the greatest impact on the TRC test results. Increasing the number of units rebated and decreasing the delivery budget result in only minor improvements to the TRC, therefore for the purposes of this analysis these variables are less likely to be influential on the overall program redesign. It should be noted that most program administrators face considerations of budget and savings targets when planning programs, though this analysis does not consider those factors.

The 20% change in variables was presented here for ease of illustrating the relative sensitivity of each variable in the TRC equation, and identifying variables with the greatest impact on the TRC. An additional level analysis was conducted with input from the program manager by altering each variable according to reasonable expectations specific to that variable. This analysis also resulted in the per-unit savings and costs emerging as the variables with greatest impact on the TRC.

Scenario Analysis

The following section presents the resulting program re-design opportunities along with their modeled impact on the program TRC ratio. The results are organized into two sections, 1) building performance scenarios, which involve changes to program eligibility requirements for building performance and 2) accounting scenarios, which involve customizing TRC inputs or accounting methodology to more accurately reflect conditions in the service territory. Implications of the results from each scenario are discussed in the conclusion.

Building Performance Scenarios

The following section presents program re-design scenarios that are related to the building performance requirements for rebate eligibility. Each scenario will present the resulting TRC at the unit level and the program level. The unit level TRC analyzes the cost-effectiveness of one home built to each performance specification (ESv2+ and ESv3+). The program-level TRC analyzes the cost-effectiveness of all the homes participating during the program year and the costs for program administration and delivery. In other words, the program-level TRC includes the total costs and benefits accrued from all of the homes rebated through the program (at any performance level).

Program Performance Levels

The EPA's introduction of the new Version 3 standard was contentious due to a disproportionate increase in the cost of building certified homes compared to the energy savings over code homes. Many of the Version 3 requirements related to health, comfort and durability of homes, which are acknowledged as good building practices, but are not included as benefits cost-effectiveness testing. As a result, many RNC programs throughout the country decided to no longer sponsor the ENERGY STAR New Homes program, while others added additional performance levels short of full ENERGY STAR certification (such as ESv2+). Table 3 shows the unit-level TRC ratio along with the resulting program-level TRC ratio when only ESv3+ homes are eligible for rebates. The program TRC ratio decreases to 0.45, an almost 35% decrease relative to the current program (0.68).

Table 3. Cost-effectiveness of ENERGY STAR New Homes program

Performance level	Summer peak demand savings (kw)	Annual energy savings (kwh)	Incremental participant cost	Average incentive	Units rebated	Unit-level TRC ratio	Program-level TRC ratio
ESv3+	0.320	2,706	$4,221	$1,700	321	**0.71**	**0.45**

By comparison, Table 4 shows the TRC ratio resulting from removal of the ESv3+ performance level from the program. The TRC ratio improves slightly to 0.69.

Table 4. Cost-effectiveness of "Version 2+" program

Performance level	Summer peak demand savings (kw)	Annual energy savings (kwh)	Incremental participant cost	Average incentive	Units rebated	Unit-level TRC ratio	Program-level TRC ratio
ESv2+	0.257	1,979	$2,768	$900	1,595	**0.82**	**0.69**

Building Performance Requirements

Since the introduction of a sliding, HERS-score based incentive structure, HERS ratings for program homes have decreased dramatically (averaging 54 in 2013). Most builders prefer the flexibility of a HERS-based incentive structure, so they have multiple options for achieving program eligibility and higher incentives. However, the HERS index is a measure of whole home performance regardless of fuel type. Envelope and furnace upgrades can significantly improve a home's HERS rating without saving significant electricity (according to REM/rate models), which is the only benefit the electric utility counts for the TRC test. The analysis team used REM/Rate models representing the average program home to assess the sensitivity of building performance requirements on the HERS score and energy savings. Table 5 shows the resulting electric savings over the baseline home and the change in the HERS score for the ESv2+ home.

Table 5. Comparison of electric savings and HERS score (Climate Zone 5)

Building component	Base case (minimum program requirements)	High efficiency case	Electric savings over baseline	Change in HERS score
Cooling Equipment	13.6 SEER	15 SEER	3%	1
Heating Equipment	80 AFUE	93 AFUE	6%	7
Ceiling Insulation	R-38	R-50	0%	1
A-G Wall Insulation	R-14	R-19 R-5 cont.	0%	3
Foundation Insulation	R-9	R-18	0%	2
Floor Insulation	R-32	R-40	0%	1
Infiltration	5.0 ACH50	2.8 ACH50	0%	4
Windows	U-value: 0.35 / SHGC: 0.35	U-value: 0.35 / SHGC: 0.2	10%	1
Water Heater	.91 EF	.95 EF	5%	1
Duct Sealing - Total Leakage	12 CFM per 100 SF of CFA Total Leakage	1.67 CFM per 100 SF of CFA Total Leakage	8%	4
Lighting	80% ENERGY STAR CFLs	100% ENERGY STAR CFLs	10%	1

It is evident from Table 5 that certain efficiency improvements save significant electricity without profoundly affecting the HERS index (lighting, water heating, and the solar heat gain coefficient). On the other hand, envelope measures can substantially influence the HERS index without affecting electricity consumption (according to the REM/Rate models).

The results of this analysis were used to assess the optimal building performance package from the electric utility's perspective by comparing the cost of each requirement to the resulting electricity savings. The additional prescriptive requirements for high-efficiency HVAC (0.92 AFUE furnace and 14.5 SEER central AC) were determined to be adding a total of $925 of incremental cost per home, though only saving around 200 kWh (9% savings over the baseline home). By removing these requirements from the program, the incremental cost of the ESv3+ home is reduced by 10% to $3,789 and the cost of the ESv2+ home is reduced by 25% to $2,051.

Two simple, cost-effective prescriptive requirements were added (100% CFLs and 0.2 SHGC window glazing) resulting in a 20% increase in electricity savings over the baseline (400 kWh), while only adding roughly $100 of added cost. These two requirements were chosen for this analysis, though it is likely that many more such requirements could be added costeffectively depending on the characteristics of buildings in the territory the program serves. Table 6, shows the resulting energy savings and cost for each performance level along with the resulting program-level TRC ratio of 0.91, a 33% increase over the 2013 program TRC ratio of 0.68.

Table 6. Cost-effectiveness of program with optimized performance requirements

Performance level	Summer peak demand savings (kW)	Annual energy savings (kWh)	Incremental participant cost	Average incentive	Units rebated	Unit-level TRC ratio	Program-level TRC ratio
ESv3+	0.299	3,136	$3,789	$1,700	321	**0.87**	**0.91**
ESv2+	0.245	2,225	$2,051	$900	1,595	**1.18**	

Program Accounting Scenarios

The following section presents alternative design scenarios related to proper accounting of the costs and energy savings attributable to program homes to more accurately reflect conditions in the service territory.

Incremental Participant Costs

Given that the per-unit costs were the variable with the greatest impact on the TRC that program administrators can control, the analysis team conducted a detailed review of current incremental cost assumptions. The current incremental costs were developed using the EPA's *ENERGY STAR Version 3 Cost & Savings Estimates* (EPA, 2013), which presents an itemized list of the cost for each building element upgrade required to achieve certification. The EPA's assumptions driving the cost estimates (incremental unit cost, house size, window area, HVAC efficiency, etc.) were modified to reflect actual program homes using 2013 program data, extracted from program REM/Rate files. The key building elements driving the incremental cost of the ENERGY STAR v3+ home, as delivered in 2013, were air sealing ($1,767/home) and high-efficiency HVAC equipment ($925/home).

Infiltration reduction costs. EPA's itemized cost estimates for ENERGY STAR certification are based on per-unit multipliers, such as $/square foot of material installed. In some cases this multiplier approach is appropriate but in other cases, such as infiltration reduction, this method produces inaccurate results. According to the initial incremental cost assumptions, the cost of air sealing the average program home in 2013 was $1,767, based on an estimated $0.47 per square foot of conditioned floor area. However, due to the relationship between ACH50 (air changes per hour at 50 Pascal) and larger, more voluminous homes, the cost for air sealing should not increase linearly with house size, as the multiplier suggests. ACH50 is calculated according to the following equation:

$$ACH50 = CFM50^{1} * 60 \text{ minutes} \ / \ \text{house volume } (ft^3)$$

With building volume in the denominator, higher CFM50 values in larger homes can potentially result in a lower ACH50. While CFM50 would also likely increase in a larger home due to more opportunities for air leakage, we argue that the increase in volume of the house can potentially outpace an increase in measured CFM50 air leakage, resulting in an overall reduction in ACH50. Our rationale is that during new home construction, properly installing drywall, applying a house wrap, and insulating the walls of the home to program specifications already significantly reduces air leakage without any incremental costs specifically associated with intentional air sealing efforts. As these standard construction practices are applied to larger and more voluminous homes, it is conceivable that a builder could construct a house with less than 5.0 ACH50 without putting forth significant additional effort to air seal the home. Therefore, the analysis team concludes that costs for reducing infiltration in ENERGYSTAR Version 3 homes should not be linearly scaled by house size as long as a volume-dependent infiltration metric (ACH50) is used as the target criteria.

A comprehensive analysis of true air sealing costs for new construction, associated energy savings, and complex interactions with other building elements is beyond the scope of this paper. In addition, secondary sources for infiltration reduction such as Technical Reference Manuals that provide deemed estimates of air sealing costs are based on retrofit scenarios. These estimates are not applicable to new construction because, as mentioned above, significant infiltration reduction is achieved through proper building practices at the time of construction, without significant additional effort. However, for the purpose of this analysis, the analysis team developed what we believe is a more accurate estimate of incremental cost for infiltration reduction, which is $600. This cost estimate is roughly equivalent to the additional cost for the installation of all additional insulation measures above 2009 code levels. The rationale for this cost estimate is that Grade I installation of insulation is a close proxy for the labor cost of infiltration reduction measures, since the task involves detail-oriented work across the entire house envelope. Improved air sealing is expected to incur little additional materials cost. Table 7 shows that the corresponding reduction in the overall incremental cost of each performance pathway results in a program-level TRC test result of 0.92, a 35% increase over the 2013 program TRC ratio of 0.68.

Table 7. Cost-effectiveness of program with modified infiltration reduction costs

Performance level	Summer peak demand savings (kW)	Annual energy savings (kWh)	Incremental participant cost	Average incentive	Units rebated	Unit-level TRC ratio	Program-level TRC ratio
ESv3+	0.320	2,706	$3,054	$1,700	321	**0.98**	**0.92**
ESv2+	0.257	1,979	$1,925	$900	1,595	**1.17**	

[1] CFM50 is cubic feet per minute of air leakage at 50 Pascals of pressure. A typical blower-door test measures infiltration airflow in CFM at a pressure difference of 50 Pascals.

Fuel-Type Cost Accounting

The modeled program is a joint, dual-fuel program that is co-delivered with the local gas utility, with the incentive and program delivery costs split for each home. The electric utility only reports electric benefits associated with program homes and the gas utility only reports gas benefits from those same program homes. To prevent unintentional double-counting of the incremental participant costs, each utility should only consider the costs associated with its own fuel savings in the TRC test. The analysis team has modified the incremental cost for program homes by scaling the per-unit costs according to relative participant benefits attributed to each fuel type (i.e. the ratepayer value of savings for each fuel). For the purposes of this analysis, participant benefits were chosen as the method for scaling participant costs though other methods may be justified. Table 8 shows the results of this adjustment in column H.

Table 8. Participant cost adjusted for electric utility

Home type	(A) Annual kWh savings	(B) Annual therm savings	(C) Total incremental participant cost	(D) Annual kwh benefits (A*$0.12)	(E) Annual therm benefits (B*$0.69)	(F) Total annual benefits (D+E)	(G) Electric benefits ratio (D/F)	(H) Modified incremental cost (C*G)
ESv3+	2,706	421	$4,221	$325	$290	$615	53%	**$2,228**
ESv2+	1,979	254	$2,768	$238	$175	$413	58%	**$1,593**

Following is the equation for calculating the modified incremental cost.

Electric Participant Cost = Total Inc. Cost x Electric Benefits Ratio

Where: Electric Benefits Ratio = kWh Benefits / (kWh Benefits + Therm Benefits)

Where: kWh Benefits = kWh savings X kWh retail rate
Therm Benefits = Therm savings X natural gas retail rate

Table 9 presents the increase in the TRC test at the unit and program level resulting from the decrease in incremental participant cost associated after applying this incremental cost accounting method. The program-level TRC increased to 1.10, a 60% increase over the 2013 program TRC ratio of 0.68.

Table 9. TRC for electric utility reflecting utility share of participant cost

Performance level	Summer peak demand savings (kW)	Annual energy savings (kWh)	Incremental participant cost	Average incentive	Units rebated	Unit-level TRC ratio	Program-level TRC ratio
ESv3+	0.320	2,706	$2,221	$1,700	321	**1.35**	**1.10**
ESv2+	0.257	1,979	$1,585	$900	1,595	**1.43**	

Accounting for Code Compliance Rates in the Baseline Home

The IECC 2009 User Defined Reference Home (UDRH) defines the baseline home from which energy savings are determined. Program administrators compare REM/Rate models for each new program home built against the UDRH feature in the REM/Rate software. The UDRH inputs (building component efficiency levels) are currently based on prescriptive compliance with the energy code. This analysis used data on 34 different residential code compliance studies complied by Lawrence Berkeley National Lab to determine more accurate savings estimates generated from program participation (Williams, et al 2013). The analysis team assumed 80% code compliance on an energy use basis, which is a conservative assumption based on the fact that a new code was adopted in the year of analysis and that the service territory includes jurisdictions with no code enforcement process.

Table 10 shows the TRC ratio resulting from adjustments to the baseline home and corresponding energy savings according to discounted rates of code compliance. In other words, the baseline home energy consumption was increased to account for areas of non-compliance with the code. As a result, the TRC improves to 0.73, an 8% increase over the 2013 program TRC ratio of 0.68.

Table 10. Cost-effectiveness of program after accounting for code compliance rates

Performance level	Summer peak demand savings (kW)	Annual energy savings (kWh)	Incremental participant cost	Average incentive	Units rebated	Unit-level TRC ratio	Program-level TRC ratio
ESv3+	0.320	2,818	$4,207	$1,700	321	**0.73**	**0.73**
ESv2+	0.257	2,237	$2,628	$900	1,595	**0.89**	

Energy Savings Not Accounted for in REM/Rate

The analysis team explored various methods for maximizing savings within the constraints of REM/rate models and an IECC 2009 reference home. Through this exercise, the team concluded that, much like on the cost side of the equation, several energy savings assumptions could be specified for the particular service territory and climate zone. A comprehensive list of the potential adjustments to the energy model and anticipated consequences of these adjustments are beyond the scope of this paper. However, the analysis team presents some considerations that may warrant further research for utilities determining savings with REM/rate models in Climate Zone 5.

Quality installation of air conditioning units. ENERGY STAR Version 3 requires quality installation of air conditioning (AC) units in terms of sizing, refrigerant charge, and airflow. Onsite metering data indicates that quality installation of high efficiency units can result in savings that are significantly more cost-effective than installing the nominally most efficient (and most expensive) unit (Spencer, 2010). This type of effect is difficult to capture in a REM/rate model, which only includes inputs related to the nameplate capacity and seasonal equipment efficiency of AC units. According to the EPA, energy savings from quality installation are approximately 2.5% of heating consumption for combustion appliances, and 5% of cooling consumption from air conditioners (EPA, 2013). Both program tiers currently require documentation of quality installation by the HVAC contractor through completion of the rigorous mandatory Version 3 checklists for ENERGY STAR or a simplified version of those checklists at the ESv2+ level. By adjusting the results of REM/rate models according to EPA assumptions, the analysis team determined quality installation results in a 39 kWh/year savings increase.

Electronically Commutated Motor (ECM) for gas furnaces. ENERGY STAR furnaces now require more efficient ECM which adjusts air handler speed to match heating load. While the primary reason for encouraging installation of high efficiency furnaces is to provide savings to the gas utility, the ECM also provides significant savings for the electric utility in cold climates. ENERGY STAR Homes Version 3 does not in fact require installation of ENERGY STAR qualified heating or cooling systems. However, this program does require that ENERGY STAR qualified systems be installed to qualify for incentives at the higher tier, therefore maximizing savings from the new specification requiring high efficiency fans in ENERGY STAR furnaces. While REM/Rate includes an input for auxiliary electric use of gas furnaces, examination of REM/rate files submitted through the program indicate that this input was not consistently adjusted by raters to account for the presence or absence of an ECM. Even if this adjustment were used, the rater would need guidance on the appropriate electricity use reduction to apply in the case of an ECM motor. There is no toggle for ECM motors available in REM/rate software. According to several Technical Reference Manual (TRM) sources, ECM electric savings estimates are between 600 and 800 kWh per year (Illinois, 2014; MI, 2014). Using 600 kWh represents a 28% increase in total house electric savings relative to base-case savings assumptions.

A combination of these two adjustments alone yields a 639 kWh/year savings increase. Table 11 below shows the TRC resulting from application of these adjustments. The TRC improves to 0.83, a 21% increase over the current program (0.68).

Table 11. Cost-effectiveness of program after accounting for additional energy savings

Performance level	Summer peak demand savings (kW)	Annual energy savings (kWh)	Incremental participant cost	Average incentive	Units rebated	Unit-level TRC ratio	Program-level TRC ratio
ESv3+	0.320	3,345	$4,221	$1,700	321	**0.83**	**0.83**
ESv2+	0.257	2,618	$2,768	$900	1,595	**1.00**	

Conclusion

The goal of this paper is to determine the most effective "levers" that program administrators have to influence the cost-effectiveness of their programs. In order to understand which inputs to the Total Resource Cost Test (savings, costs, avoided costs, etc.) were most important, the team conducted a sensitivity analysis on the TRC test variables. From this analysis the team determined that some inputs have a greater impact on the TRC ratio than others, allowing the team to focus the analysis on those areas of high-impact that program administrators have some control over (e.g. per-unit savings and costs). The final step in the analysis involved modeling various scenarios for 1) re-designing program elements related to building performance, or 2) accurately accounting for program-specific costs and benefits to achieve a TRC ratio of 1.0 or greater. The following are lessons learned from this analysis:

- Of those variables under program administrators' control, the per-unit costs and savings had the greatest impact on the TRC test results. Therefore, program administrators should consider an incremental cost study to refine estimates of incremental participant costs used in cost-effectiveness analyses, or consider re-designing program requirements to maximize per-unit savings from each home.
- Including additional savings/cost-optimized prescriptive requirements can improve the cost-effectiveness of the program.
- Options for re-design are limited by shortcomings of the REM/rate software, lack of quality incremental cost data, and limitations inherent to the TRC test itself (lack of consideration for non-energy benefits).
- When a program is operated in a dual fuel territory and mixed climate, the electric utility should find a way to partner with the gas utility to share costs. Otherwise, the electric utility should take credit for gas savings in recognition of the fact that the homeowner will benefit from those savings.
- The analysis of program performance levels (ESv2+ and ESv3+) demonstrated that focusing on TRC alone in program design decisions could result in a prescriptive program that moves away from whole home performance goals (durability, comfort, etc.). If the TRC were the sole basis for determining which performance pathways to rebate, then it would be most prudent to discontinue rebates for ENERGY STAR Version 3, due to the new standard's inclusion of non-energy benefits that are not accounted for in the TRC. However, the fact that the TRC and other tests do not fully reflect all the benefits that can be quantified is not a reason to abandon effective strategies such as encouraging lower HERS scores or non-energy considerations such as health and durability. Lower energy use, lower energy cost and healthier, better performing homes for homeowners and renters (and builders) should be the true goal. The constraints of the TRC test often do not support a whole-building model of performance and, if relied on exclusively, will lead to lost opportunities for development of a well-rounded RNC program.

In light of these findings, the analysis team combined the most cost-effective and feasible scenarios into an optimal program design. The resulting "optimized" program design includes both an ENERGY STAR performance path as well as a "Version 2+" option. Prescriptive requirements have been optimized for cost-effectiveness, the baseline has been adjusted to reflect code compliance rates, infiltration costs have been revised and the incremental participant cost only includes those costs attributed to the electric utility. The result, as seen in Table 12 is a TRC of 1.61, which is a 135% increase over the 2013 program TRC ratio of 0.68.

Table 12. Optimal program design

Performance level	Summer peak demand savings (kW)	Annual energy savings (kWh)	Incremental participant cost	Average incentive	Units rebated	Unit-level TRC ratio	Program-level TRC ratio
ESv3+	0.299	3,248	$1,814	$1,700	321	**1.86**	**1.61**
ESv2+	0.245	2,483	$1,110	$900	1,595	**2.37**	

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