

Searching for Impacts: Two Innovative Approaches to Measure the Effects of a Residential Energy-Efficiency Program

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ABSTRACT

This paper presents two analyses that address hard to measure impacts of a market transformation program. Pacific Gas and Electric's Time of Sale Energy Renovation Program (TOSER) uses primarily training to educate lenders and real estate agents about energy efficiency mortgages (EEMs). Homebuyers can use EEMs to finance energy-efficiency upgrades through their home loan. Previous evaluations of TOSER showed that the training was very effective at increasing awareness and knowledge. This paper presents results of two new quantitative impact analyses of the program.

The first analysis uses an econometric production function model to estimate program training effects on the number of EEMs issued. This analysis uses readily available demographics and housing market data and the number of program trainees to estimate a model treating the number of EEMs as the output of a production function. The analysis produced statistically significant, stable results that identified the effects of key variables, including the number of trainees, on the production of EEMs over time. The second analysis assesses the effects of a new element of this program, the Energy Snapshot, which provides an inexpensive tool for buyers to determine whether a house would be a good candidate for efficiency upgrades. Using homebuyer interviews, we were able to estimate the effect of this tool on energy-efficiency upgrades implemented by the buyers and quantify the associated energy savings.

Introduction

When an existing home is sold, the transaction presents a unique opportunity for making extensive energy-efficiency improvements to the home. It is not very common, however, for homebuyers to take the steps to make such improvements before moving into their newly purchased home. EEMs were first proposed at least 20 years ago as one way to alleviate many of the impediments to making such upgrades and were first implemented in 1980 (Farhar et al. 1997). The most common features of EEMs have been that they allow the buyer to include the cost of the efficiency upgrades in the mortgage and the added cost is not counted toward the maximum loan amount for which the buyer can qualify (or, alternatively, the qualifying debt-to-income ratio is "stretched").¹ Through a number of efforts, EEMs have been implemented in conjunction with energy ratings provided through home energy

¹ Note that various EEM programs, such as some funded by utilities, also have offered better lending terms such as lower interest rates, longer loan terms, or reduced downpayments.

rating systems (HERS). The use of some form of consistent, reliable, and accurate rating system is critical because it helps answer questions about how much energy and utility bill savings can be expected from specific efficiency improvements.

Both real estate agents and lenders can be key players in the EEM process. Real estate agents often act as a “gatekeeper” and first point-of-contact for the homebuyer (Staples-Hutchinson 1999). Often the agent is the conduit through which potential buyers learn about EEMs and their benefits. Consequently, the agent can be instrumental in initiating the EEM process. Our prior studies suggest that lenders, on the other hand, see their role in the EEM and energy-efficiency process as being more passive. They expect the real estate agent to bring up the EEM concept with the buyer. However, because EEMs are implemented through loans, lenders are the most important player when it comes to implementing an EEM, and lender attitudes, perceptions, and behavior can be critical determinants of the extent to which EEMs are applied.

The Time of Sale Energy Renovation Program (TOSER) includes an integrated set of activities designed to increase the use of EEMs. TOSER evolved out of a 1998 third-party program funded by Pacific Gas and Electric (PG&E). It targets primarily the market that includes all PG&E-area homes purchased through Federal Housing Administration (FHA) loans.² In the initial years of the program, most resources and effort were dedicated to training. Briefly, TOSER’s primary activities include the following:

1. Intensive real estate agent and lender training to increase their awareness and knowledge of energy efficiency and EEMs,
2. A broad-based promotion and communication strategy to inform and educate home buyers about energy efficiency and EEMs,
3. An Energy Snapshot tool to motivate buyers to pursue a HERS rating and EEM, and
4. Other training and facilitation efforts aimed at other market actors.

XENERGY has conducted several evaluations of TOSER, treating it as a market transformation program (see Lee et al. 2000). Key elements of successful market transformation programs are reductions in market barriers that lead to market effects—changes in market structure and behavior—that reflect increased adoption of energy-efficiency products, practices, or services causally related to the program, and these market effects are lasting ones (Eto, Prah, and Schlegel 1996). Based on a program theory developed to identify expected market effects, XENERGY focused on measuring proximate indicators of program effects. These proximate indicators (e.g., increases in market actors’ awareness and knowledge of EEMs) provided evidence that the program was having positive effects that were consistent with long-term increases in the use of EEMs and energy-efficiency upgrades of existing homes. However, we did not have sufficient data to conduct an analysis to determine whether, in fact, the program translated into increased adoption of efficiency upgrades and implementation of EEMs, and what effects TOSER was having on energy savings. Given over three years of program implementation, the availability of critical data, and the application of two methodologies, we were able to expand our analysis in 2001 to explore the quantitative impacts of TOSER in two areas discussed in this paper.

² Note that we have included HUD EEMs for new homes as well as for upgrades of existing homes. This was done to maintain consistency in the tracking between years when HUD distinguished and did not distinguish home vintage. In 2001, about 80% of FHA EEMs were for existing homes.

Estimating Training Effects on EEM Originations

The ultimate purpose of TOSER is to transform the market for EEMs through education of lenders, real estate agents, and others in the housing market about the benefits of residential energy efficiency and the usefulness of EEMs. Over the first three years of the program, we documented and compared the number of EEMs implemented in the program area and in the rest of California. Initially the number rose in the PG&E area, but we had no way to attribute the increase to the program. For the 2000 program evaluation, we included development of a model to analyze the effects of TOSER on the number of EEMs. When the 2000 data became available, we found that the number of EEMs processed declined, bringing into question the effects of the program, and this made it especially important to determine what factors, including the program training, influenced the generation of EEMs.

Study Purpose

This study was conducted to test or examine a number of structural questions about the effect of TOSER training on the number of EEMs generated. Principle questions examined were the following:

1. How important a factor is lender/agent training in the number of EEMs generated?
2. How important are other factors affecting the number of EEMs?
3. Is the responsiveness of EEM generation to training fixed across all regions (as defined in terms of zip codes) and over all periods spanned by the training program?
4. Is it possible that some combinations of agent and lender training are more productive in creating EEMs, and what might these be?
5. How easily substitutable are lender and agent training in achieving specific levels of EEM originations?

Approach and Data

We took the perspective that the lender and agent training could be treated as a production activity, where training inputs can be combined in various ways to produce EEMs, or the output of the process. Initial analysis showed that the number of FHA loans issued was a key driver in the number of EEMs generated.³ Recognizing that a production function model might better represent the process involved in EEM generation opened up a rich set of approaches to estimate impacts and to examine even more informative hypotheses about the elements of the training program.

The training production function models we explored were formulated in terms of a general power function of lender training and real estate agent training, coupled with an array of demographic factors. The power functions themselves can be quite simple—they can be simply scalar functions of fixed coefficients, linear functions, or higher order functions.

The more general forms permit the production elasticities of lenders and agents to vary across the sample and the lender-agent substitutability parameter to vary. Production

³ TOSER targeted EEMs originating through HUD FHA loans. An examination of the FHA loan data for 2000 revealed that they fell by nearly 40% from the 1999 level and this drop coincided with the decline in EEMs.

elasticities refer to the proportional response of EEMs to percentage changes in lender and agent training. For instance, a production elasticity of 0.5 for agents would indicate that a 10 percent increase in agent training would be expected to increase EEMs by 5 percent.

The substitutability parameter reflects how easy it is to substitute one type of trainee for the other type while still achieving the same level of EEM production. A smooth and fairly continuous degree of substitutability would have a parameter near one. A value of the parameter less than one would suggest that there is some rigidity in freely combining these two groups of trainees to achieve a given level of EEM originations. A value greater than one suggests that training of one group can be substituted very easily for training of the other in achieving a given level of EEMs.⁴

The statistical approach we used was to test hypotheses about the general model and to accept special sub-cases based on traditional levels of statistical significance of the resulting estimates. This is referred to as a “nested-hypothesis” approach, where a special case is “nested” within the more general equation.

All the models were tested using 4-digit level zip code data (e.g., 9721_). The number of lenders and agents trained in each period, EEM quantities, etc. were aggregated to the 4-digit zip code level from the 5-digit level. There were 176 observations with these data at the 4-digit level. We combined the training data with the following demographic and weather variables in our model to explain the pattern of EEMs observed:

1. Household formation over the period 1990 to 2000
2. Median age of head of household
3. Median size of household
4. Ethnic composition of population
5. Median household income
6. Household disposable income
7. Average house price
8. Cooling degree-days for air conditioning uses
9. Heating degree-days for space heating end-use

Using a nested-hypothesis testing framework, the preferred form of the production model that resulted was the following:⁵

$$EEM_{ij} = \exp\{\rho(\mathbf{D}) * FHA_{ij} + \varepsilon_{ij}\} TL_1^{(\alpha_1 + \alpha_2 TA)} TA_1^\beta,$$

Where

EEM_{ij} is the number of EEMs in period i for the j -th zip code;

⁴ Discussing this substitutability feature could have been illustrated in terms of substituting training of lenders for training of real estate agents, with exactly the same relationship to unity—the direction of substitution is arbitrary. This is because we are referring to the same point on the production surface that relates the levels of agent and lender training to a fixed number of EEMs.

⁵ The basic form of the production model using power functions is

$$EEM_{ij} = \exp\{\rho(\mathbf{D}) * FHA_{ij}\} TL^{g(\alpha, TA)} TA^{h(\beta, TL)} \exp\{f(TL, TA)\}$$

TL, and TA are the number of lenders and agents, respectively, trained for the corresponding period and area;
 $\rho(\mathbf{D})$ is a market share or penetration function, with demographic factors as arguments (\mathbf{D}), and FHA is the total number of FHA loans for scale purposes;
 ε_{ij} is a random disturbance term.

Results

Under the EEM production function approach, we obtained consistent results across all periods in the following areas:

1. Both lender training and agent training enter significantly and jointly into the model explaining EEM generation over the different spans analyzed.
2. Demographic factors play a significant role in explaining the number of EEMs generated. If demographic factors are not included, training effects can be easily overstated.
3. Training accounts for one-half of the explained variation in EEM generation.
4. Production elasticities for both lenders and agents are found to vary as functions of the agent-lender combination ratios.
5. The substitution possibilities between agents and lenders appear to be fairly rigid (less than unitary).

Program effects. The final model produced consistent and robust results across the time periods. This form allowed the production elasticities to vary and permitted the substitution parameter to depart from unity.⁶ Table 1 summarizes the estimated training-related parameters from this model. In addition to the composite period estimates (the “Full Period” column), results are reported for the individual years of 1998,⁷ 1999, and 2000.

The production elasticities for lender and agent training are all positive and statistically significant. Over the full period they are 0.33 and 0.58, respectively. They vary by period,⁸ and those for lenders are all less than those for agents.

“Returns to Scale” represents the sum of the lender and agent production elasticities. This is the proportionate response in EEMs to an equal relative change in training for both groups at the same time. The range of 0.91 to 0.95 indicates slightly decreasing returns to scale so that a 10 percent increase in both groups simultaneously would increase EEMs a slightly smaller amount—about 9.1 to 9.5 percent.⁹

⁶ This would be a particularly restrictive assumption, if not tested.

⁷ The 1998 model includes data for the last 4 months of 1997, as well.

⁸ The reported elasticity estimates are evaluated at the sample means.

⁹ A 95 % confidence interval around the returns to scale estimate includes unity (1.0), however, so that constant returns to scale cannot be rejected. Thus, a 10% increase in lender and agent training leading to a 10% increase in EEMs cannot be ruled out.

Table 1. Estimated Production Function Parameters

Group	Value	1997-98	1999	2000	Full Period
Lenders	Elasticity	0.19	0.47	0.37	0.33
	#EEMs added per one additional trainee in each zip code area	1.9	7.2	4.3	3.9
Agents	Elasticity	0.74	0.48	0.58	0.58
	#EEMs added per one additional trainee in each zip code area	2.7	3.1	2.3	2.6
Returns to Scale		0.93	0.95	0.95	0.91
Lender-Agent Substitutability Parameter		0.40	0.27	0.39	0.16
Adjusted R ²		0.77	0.81	0.74	0.80

Note: All elasticity estimates are statistically significant at the .05 level or better.

A very important finding is that the substitutability parameter is considerably less than one. As noted earlier, this indicates that lender and agent training are not good substitutes for one another and that the blend of lender/agent training must be done in somewhat fixed ratios to be most effective in generating EEMs—extreme ratios of one group to the other (such as the low value of 0:1 and high value of 38:1 in our sample) appear to be uneconomic combinations.¹⁰

The final row of Table 1 reports the R-squared (adjusted for degrees of freedom) for the regression model. Generally, about 80% of the variation in EEMs is explained with our combination of program, demographics, and weather variables. If the demographics and weather variables are omitted from the model, the program variables explain only about 40% of the variation in EEMs. Moreover, omitting the demographics from the model causes an upward bias in the estimates of the production elasticities of lenders and agents, leading to an overstatement of their respective impacts.

The second and fourth rows of Table 1 recast the elasticity estimates for each group into absolute multipliers showing the effect of training one additional lender or agent. The impacts ranged from about 2 EEMs to 4 EEMs per trainee added, with the effect being somewhat larger for lenders in most periods. For the entire program period, an additional lender trained would have added about four EEMs, and an additional agent trained would have added between two and three EEMs.¹¹ The variations in these values by year suggest dynamic effects are occurring. In particular, the changes in the effects of lender training suggest that there may be a lag between the time training occurs and EEMs are produced. In fact, it seems likely that the effects of training would lag in this way and the effects would increase in future periods because trainees would take some time to increase their promotion of EEMs and they would disseminate their knowledge to other lenders and agents over time.

¹⁰ An evaluation of the incremental EEM production implied by the estimated models indicates that the favorable range of agent to lender training ratios is approximately 1:1 to 4:1. While the span of the training ratios in our sample information is considerably broader than this, the narrower band represents the more “economic” combinations of agent-lender training ratios. At ratios less than 1:1 or greater than about 4:1 we found that incremental products could diminish or become negative or production elasticities could diminish. Thus, more extreme ratios appear to be ineffective and even counterproductive in increasing the number of EEMs.

¹¹ These results suggest that training additional lenders is more effective than training additional real estate agents. This is valid for small changes in the number of people in these groups trained and the training levels observed, but this finding cannot be extrapolated with confidence to larger changes in the training levels and values beyond those observed in our data.

Testing this phenomenon was beyond the scope of this study, however; but these results suggest that this may be a useful avenue for further analysis.

The model also provides a direct and efficient means for measuring the number of EEM originations attributable to the training. Evaluating the estimated training function using the number of lenders and agents trained in each (4-digit) zip code location, the model predicts the number of EEMs as a result of training inputs only. By assuming that the demographic and weather variables are zero, we eliminate their contribution to the predicted level of EEMs. Evaluating the model using these assumptions, we estimate that 934 EEMs resulted from TOSER training between October 1997 and December 2000. This is slightly over 18% of all EEMs, or nearly 1 out of every 5 EEMs implemented during this period. We estimate that the EEMs attributable to the TOSER training in a typical year produced annual energy savings of 0.63 GWh and 0.0742 million therms.

Non-program effects. Table 2 summarizes the effects of non-program factors. The effects are reported as elasticities, so that inferences about the sensitivity to changes in these factors are more directly understood.

Table 2. EEM Elasticities for Non-Program Effects, Full Period

Variable	Elasticity
Hispanic % of population	0.26 (5.38)
Household Formation, 1990-2000	0.20 (6.94)
Weather-Cooling Degree-days	-0.19 (4.72)

Note: t-statistics are contained in parentheses.

The elasticity of 0.26 for the Hispanic composition of the population indicates that with a 10% increase in the percent of Hispanics in the population of an area there would be about a 2.6% increase in EEMs. We also found growth in the number of households to be an important factor in explaining the number of EEMs. For an increase of 1% in the annual¹² rate of growth in households, approximately 110 more EEMs would be generated over the entire program period.

Finally, weather variables affect the results, but in an asymmetrical and somewhat unexpected way. First, only cooling degree-days (and not heating degree-days) enter the model empirically. However, they do so with a negative sign and they are statistically significant (t-statistic=4.72). A priori, one would expect cooling degree-days to have a positive effect on the installation of measures to reduce energy used for air conditioning. This would imply that very hot climates would be expected to lead to larger numbers of EEMs, with all else held constant; this is the opposite of the effect we found. Based on the robustness of this result across the models that we estimated, cooling degree-days may be serving as more of a geographic proxy for variations in how the program was implemented than as a driver that would affect the installation of energy-efficiency measures.¹³⁻¹⁴

¹² The average annual growth rate across all the zip codes was 1.4 % per year.

¹³ We note that our cooling degree-day values were based on the California Energy Commission's data by climate zone. Since these climate zones cover large geographic areas, they do not capture localized variations in actual cooling loads so the effects of climate variations may be muted by this aggregation. Other factors that might be affecting these results include the fact there is a moderate negative correlation between cooling degree-days and household income and a moderate positive correlation between cooling degree-days and the

Although counterintuitive, the weather variable is retained here both to highlight the finding and because it increases the precision of the estimated effects of the demographic variables.

The results for the effects of non-program factors on EEMs hold across all the sub-periods of the TOSER program examined in Table 1, as well.

Estimating Effects of the Energy Snapshot

The Energy Snapshot is a simplified assessment of the potential for energy savings through energy-efficiency upgrades to existing homes. Staples-Hutchinson developed this tool in conjunction with TOSER. The Energy Snapshot provides homebuyers or owners a guide to energy-efficiency upgrade opportunities and, in cases where the potential for energy-efficiency improvements is large, it is anticipated that buyers will have complete HERS ratings performed to identify in detail the cost-effective upgrades that will then be implemented through an EEM.

The Energy Snapshot is generated based on simplified information about an existing home such as its age and basic energy-efficiency characteristics. Each component of the house is rated on a scale from 1 to 10 and an overall average rating is provided. The lower the rating is the more potential exists for benefits from performing energy-efficiency upgrades. Staples-Hutchinson began implementing and promoting the Energy Snapshot actively late in 1999. It is offered to buyers through the program website and by real estate agents and lenders who request it for their properties. It costs very little to prepare and is provided at no cost to homebuyers and others who request it. When this analysis was conducted over 3,000 Snapshots had been distributed.

Study Purpose

The purpose of this study was to ascertain whether efficiency upgrades were occurring in conjunction with the Snapshot and, if so, what upgrades were being implemented; whether the Snapshot led to an EEM; what role the Energy Snapshot played in the decision to use an EEM or make upgrades; and the energy savings associated with the resulting upgrades. Early feedback from the program implementers provided anecdotal evidence that the Snapshots were leading to efficiency upgrades without buyers going through the formal EEM process, so it was very important to structure our analysis so that we could identify any efficiency upgrades resulting from the Snapshot.

Data Collection and Analysis

The primary data used in this analysis were from interviews of homebuyers who had obtained Energy Snapshots. Staples-Hutchinson provided lists of properties for which Energy Snapshots had been prepared. As noted earlier, over 3,000 had been generated between July 1999 and when this analysis was conducted. The ultimate objective of the

household formation rate. In addition, geographic variations in building codes may influence the likelihood that houses would be good candidates for efficiency upgrades.

¹⁴ The program manager, Jim Staples, indicated that he did not find these results very surprising. He indicated that facilitators who promote home energy ratings for EEMs have been less active in the hottest parts of the PG&E territory.

interviews was to determine what effect the Energy Snapshot had on homebuyers' decisions about implementing energy-efficiency upgrades. As a first measure of the effect of the Energy Snapshot, we asked respondents whether they remembered it first through an unaided question and then an aided question.¹⁵ We used the count of people who were contacted and did or did not recall the Energy Snapshot as an initial metric of the effect of the Snapshot.

For those people who recalled the Energy Snapshot, we then asked a series of questions to address our objectives. They included the following topics: when they obtained the Energy Snapshot; the kinds of information they remembered that it provided; the usefulness of the information; whether and what energy-efficiency improvements were made after obtaining the Energy Snapshot¹⁶; the importance of the Energy Snapshot in making decisions to improve energy efficiency; how energy-efficiency improvements were financed; and whether the homebuyer had a HERS rating and used an EEM.

We designed these questions primarily to allow us to estimate the effects of the Energy Snapshot on homebuyer energy-efficiency upgrades. As noted above, the first measure of effects was what proportion of those homebuyers who obtained an Energy Snapshot reported that they recalled it. The second measure was what proportion of these respondents indicated that they had made energy-efficiency upgrades since obtaining the Snapshot. The third measure was how much effect the Energy Snapshot had on the decision to implement efficiency upgrades. To measure attribution, we included both respondents who could not recall the Snapshot and those who could. We measured attribution using two factors. First, for those respondents who could not recall the Energy Snapshot, we assigned a value of zero attribution. Second, for those who recalled the Snapshot and had made efficiency upgrades, we assigned an attribution value based on how important they said the Snapshot was in their decision. We assigned attribution values as follows:

1. Not at all important = 0
2. Slightly important = 0.33
3. Somewhat important = 0.67
4. Very important = 1.0.

We used the responses as to what efficiency upgrades were made and the estimate of attribution to estimate the energy savings due to the Energy Snapshot. Estimated energy savings for each measure were based on the data from the 2000 TOSER evaluation study.¹⁷ We extrapolated this result to the population of homebuyers who have obtained Energy Snapshots. In addition, for those respondents who had made upgrades, we calculated the percent who followed up the Snapshot with a HERS rating. We also calculated the percent that used different approaches to pay for the upgrades, including using an EEM.

¹⁵ We discovered during pre-testing that an improbably large percentage of respondents did not remember the Energy Snapshot when they were asked about their recall without any further information provided about the Snapshot. Consequently, we revised the interview to incorporate the aided question. This increased the recall rate significantly and, we believe, this modification provided much more reliable data.

¹⁶ Respondents were first asked what efficiency upgrades they recalled. We then used a predesigned list to ask specifically whether they had made any of the upgrades on the list that they did not mention unprompted.

¹⁷ We did not perform an independent energy analysis. The energy savings estimates used were those from HERS ratings.

Findings

The findings were mixed. Only 34% of respondents recalled the Snapshot. However, 54% of those who recalled the Snapshot said that they made efficiency upgrades after receiving it.

One initial objective of the Snapshot was to motivate homebuyers to have a HERS rating performed and then to obtain an EEM to upgrade their house. Of those respondents who made efficiency upgrades, 23% said that they had followed up the Snapshot with a HERS rating, but only 9% of those who made upgrades obtained an EEM to finance the upgrades.

Although most respondents who recalled the Snapshot could not describe its contents very accurately, 68% said that it was “somewhat useful” or “very useful.”

The most commonly implemented upgrade was weatherization measures; one-third of respondents who recalled the Energy Snapshot said that they had installed weatherstripping, sealed penetrations, etc. Almost a third of respondents also indicated that they had installed compact fluorescents and other efficient lighting. Almost one-fourth said that they installed duct insulation or sealed their heating/cooling ducts. Almost 20% said they had installed a setback thermostat. Higher cost measures such as wall insulation, energy-efficient windows, and higher-efficiency equipment were less common.

We used the attribution values presented earlier and the upgrades installed by each respondent to estimate the energy savings attributable to the Energy Snapshots. The energy savings for those buyers who recalled the Snapshot, but did not obtain an EEM, are summarized in Table 3.¹⁸

Table 3. Estimated Energy Savings Due to Energy Snapshots in Typical Year

Type of Energy Saved	Total for Energy Snapshots Performed in Typical Year, Excluding EEMs
Electricity	0.259 GWh
Natural gas	20,300 therms

Overall Findings and Conclusions

Methodological

The impacts of market transformation energy-efficiency programs are typically measured initially in terms of proximate indicators of program effects such as number of people trained, changes in awareness, changes in knowledge, etc. Although these metrics provide reasonable measures of program effectiveness, they are not measures of ultimate program impacts, i.e., changes in the number of EEMs implemented and resultant energy savings, which are the key inputs to cost-effectiveness analyses. The two analyses described here have provided some of the first measures of such outcomes of one program, based on an innovative application of an econometric analysis tool to quantify program impacts and use of a more conventional methodology to address significant impacts that were not the expected program effects.

¹⁸ The energy savings for those buyers who used EEMs were separated out because they were included in our estimate of energy savings due directly to EEMs.

Our analysis of TOSER training effects on EEMs issued demonstrated that data readily available for this program could be used to estimate the number of EEMs attributable to the training. The key step was using a production function framework to estimate the relationship between training and the quantity of EEMs.

The analysis of the Energy Snapshot demonstrated how self-reported actions and attribution could be used to estimate the effects of a low-cost way to provide consumers with energy-efficiency information. The research showed that, although the expected effect of increased use of EEMs did not occur, there were significant energy savings attributable to homeowner actions taken as a result of the Snapshot.

Program Effects

Table 4 summarizes the energy savings that we estimated resulted from the TOSER training and Energy Snapshot. The combined savings were nearly 1 million kWh/year and 95,000 therms, or about \$160,000 in avoided energy costs for actions taken in a typical year. The energy savings attributable to the Energy Snapshot were surprisingly large compared to the savings attributable to EEMs. This finding provided useful insights about the value of the Energy Snapshot, particularly given its low cost, and demonstrated the merits of quantifying the savings due to actions taken by homebuyers who did not go the full route of obtaining an EEM to pay for the upgrades.

Table 4. Estimated Annual Savings Due to Program Activities in Typical Year

Type of Energy Saved	Total for EEMs Attributed to Program	Total for Energy Snapshots, Excluding EEMs	Program Total
Electricity	0.63 GWh	0.259 GWh	0.889 GWh
Natural gas	0.0742 million therms	0.0203 million therms	0.0945 million therms

In the context of the program theory describing how TOSER was anticipated to produce lasting changes in the market for EEMs (Lee et al. 2000), these results provided estimates of the quantitative effects of the program. Our previous evaluation findings revealed substantial program market effects based on leading indicators of market transformation. The current study, in combination with results from these prior evaluations, provide evidence that several of the market transformation processes hypothesized for the program have been occurring and resulting in quantifiable energy savings. Future analyses will be required, however, to determine whether the market changes are lasting ones and the program has met all the conditions of a successful market transformation program—reduced market barriers to efficiency upgrades and the use of EEMs and lasting market structural and behavioral changes causally related to the program.

Other Applications

We believe that the two methodologies discussed here could have applications in evaluating other programs aimed at market transformation or relying on education and information dissemination. The production function approach provides a particularly appealing framework for analyzing programs where there are measurable inputs (e.g., dollars, number of trainees, number of advertisements, etc.) that are indirectly linked to program outcomes. The Energy Snapshot analysis is similar to approaches used in prior studies of information programs; our approach, however, demonstrated the importance of examining additional impacts (induced efficiency upgrades) beyond those originally anticipated (EEMs that resulted from the Energy Snapshot, which turned out to be relatively few).

One key to applying both methodologies is to ensure that measurable inputs and outputs can be defined. Another critical requirement for the production function approach is the availability of data that can be linked consistently to a parameter such as location that allows measurement of different program activity and outcome levels. We believe that these analytic frameworks can be applied in studies of many other programs, but care must be taken in planning the programs and structuring the evaluations to facilitate the analysis.

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