Why Comprehensive Residential Energy Efficiency Retrofits Are Undervalued

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ABSTRACT

For comparing efficiency programs to conventional supply investments, metrics such as the "total resource cost" (TRC) are used. Such comparisons of costs and benefits have provided a generally accepted decision framework. However, sometimes that framework may disadvantage particular types of programs and lead to long-term lost opportunities for energy savings. This paper focuses on the case in which the conventional TRC methodology is used to evaluate comprehensive whole-house retrofit programs. In those programs, such as those of the national Home Performance with ENERGY STAR® initiative, participant and program investments are undertaken to gain a range of non-energy benefits in addition to maximum energy cost savings.

This paper analyzes data on homeowners' motivations for undertaking such retrofits. The results illustrate the potential for increased energy-savings that can result from incorporating non-energy motivations into energy efficiency program design and evaluation. We suggest a way to use such motivational findings, if borne out by more extensive research, to more accurately assess returns on investments made in these types of programs. This proposal involves adjusting the total participant *costs* in the TRC and related tests to remove the effect of non-energy motivations. This more fairly balances the energy-saving benefit against its appropriate share of participant costs and avoid the bias in TRC-type tests. The potential value of such modifications in standard evaluation procedures justifies serious study of buyer motivations based on our initial results, possibly leading to more effective residential program portfolios and greater energy efficiency gains in the nation's huge existing housing stock.

Introduction

This paper focuses on an emerging innovation in energy efficiency, comprehensive "whole house" residential retrofit programs. These programs save energy in each home through a building science-based custom diagnosis delivered together with a trained contractor's offer to provide the required high-quality home improvements. Typically marketed under the Home Performance with ENERGY STAR® existing home initiative administered by the Environmental Protection Agency, such programs consider the home as an integrated system managing air, heat, and water movement. Contractors trained in such programs provide a set of recommendations that correct energy waste as well as a broad range of non-energy deficiencies such as poor thermal distribution, excessive equipment wear, indoor air contaminants, and moisture-related dangers to the structure and its occupants.

At issue here is the difficulty such programs face in competitive selection and evaluation, primarily due to a bias inherent in conventional benefit/cost assessment methods and tools. For comparing energy efficiency programs to conventional energy supply investments by utilities, metrics such as the Total Resource Cost (TRC) test have been developed (CPUC, 2001). Such weighings of costs and benefits tend to consider *total* costs, including all participant costs, but only *a part* of the actual benefits, i.e., energy generation and delivery cost savings realized by the utility. This ignores most "non-energy" benefits (NEBs), which may actually be powerful determinants of a homeowner's decision to undertake a major energy-saving home improvement project. Those conventional assessment methods have provided a generally accepted decision framework because most single-measure energy efficiency programs provide relatively little in the way of non-energy benefits. For example, upgrading some types of equipment, such as water heater or air conditioner, typically provides few noticeable changes besides a possibly lower energy bill.

When the conventional benefit/cost methodology is used to evaluate comprehensive whole-house programs, in which investments are undertaken by homeowners to gain a range of non-energy benefits in addition to energy cost savings, the result is an unfair imbalance between the allowable benefits and costs. This basic flaw disadvantages the public by often disqualifiying such comprehensive programs and thereby losing their longer-term energy and peak demand savings in favor of single-measure programs which result in major lost opportunities in each home. We will expand on this point in a later section.

In this paper we propose an alternative approach involving accounting for NEBs versus energy cost saving benefits through proportional reduction of the *homeowner's cost* of a comprehensive home retrofit in the standard benefit/cost tests. We present some initial empirical support, and also illustrate that energy saving benefits can actually be increased by acknowledging and engaging buyer NEB motivations in energy efficiency program operation. The paper concludes with a call for further consumer decision-making research to test and verify this approach, followed by revision of conventional program assessment practices and inclusion of comprehensive home retrofit programs in program portfolios.

Background

In this section we consider the conventional approach to assessing benefit/cost ratios of energy efficiency projects, briefly review the extensively researched option of monetizing and including NEBs in those calculations, and summarize other issues in accounting for NEBs in program selection and evaluation. The next section presents a proposed alternative approach.

Conventional Energy Savings versus Costs

The common benefit/cost methods used in recent years for assessing the value of energy efficiency programs are often variants of the basic concept such as the Total Resource Cost (TRC) test, Participant test, Program Administrator test, and Societal test (CPUC, 2001). As the names imply, these tests look at the benefit/cost equation from the viewpoints of different constituencies, and therefore involve different kinds of costs and benefits.

We consider residential retrofit programs in California as a specific example. The California Public Utilities Commission and the utilities that select and manage programs under the CPUC's direction generally focus on the utility's direct energy generation and delivery cost savings, including an emissions reduction factor and a time-of-use electricity pricing adjustment, as the primary benefit of the installation of an energy saving technology or practice. California currently uses a combination of the TRC and the Program Administrator Test. In the TRC, for example, cost is formally defined to include the participant's total installation cost as well as certain parts of the program's implementation costs. The TRC calculation in California is done using a locked CPUC spreadsheet model in which measure-by-measure costs and associated energy savings are pre-set for comparability among competing programs and implicitly assign the total cost of an energy-saving benefit to the energy cost savings only. No other benefits to the homeowner are considered. This in effect is an attempt to include *all* the *costs* but allow only the *benefits* that directly relate to energy savings.

Most non-energy benefits are ignored in this approach, including societal gains (jobs, tax-funded public services, etc.) as well as the personal benefits experienced by the homeowners participating in the program. This omission is in part due to the difficulty in relating such benefits to a monetary value. In addition, in California law the funding for energy efficiency programs must be justified solely by energy supply savings. The result is a systematic undercounting of the actual value of any programs that generate significant non-energy benefits, and particularly those NEBs realized by the participating homeowners, including examples such as comfort, health, safety, home durability and value, and environmental consciousness—for which the homeowners demonstrate their support by voluntarily paying more than can be justified solely by energy savings.

Monetizing Non-Energy Benefits

Much effort has been exerted in attempts to monetize NEBs, although most of that effort has focused on societal benefits such as emissions reductions rather than homeowner decision making factors. This approach is readily understandable and convincing in concept: if all benefits could be measured monetarily, it should be easy to compare an energy efficiency project's benefits package with its costs. Moreover, valuing non-energy benefits so comprehensively might well dramatically increase the net benefit/cost ratio of energy efficiency options that can be shown to yield such benefits—and in so doing, substantially alter the optimal portfolio of energy efficiency investment. But the appeal of this approach is limited by the major difficulties in converting benefits such as comfort and peace of mind to dollar amounts. In addition, some programs such as California's require that their funding be targeted solely to energy savings rather than other societal values; they are not broad social welfare programs. Therefore NEBs are automatically excluded.

There is a substantial body of program data and analysis in monetizing non-energy benefits for energy efficiency program evaluation when such program limitations are not involved. One review of such efforts, focusing on economic and environmental benefits to society from comprehensive low income weatherization programs [Imbierowicz and Skumatz, 2004], concluded that just those two categories provided a range of benefits at nearly the same level as the energy bill savings of the weatherization programs studied. Other studies (cf. Skumatz 2001, Skumatz and Dickerson 1998) suggested that those two categories also provide more than 35% of all residential NEB benefits. Weatherization program data has been the basis of most such studies because of the similarity of weatherization programs to unrestricted whole-house programs and the lack of data from such whole-house efforts due to their relative newness.

From the results just cited for those studies, it follows that if only two of the many NEBs (economic and environmental) approximately equaled the energy savings benefit, but only 35% of all NEBs, then the total of all NEBs should be about 1/35% or nearly three times the energy savings benefit. These combined results are of course only suggestive, but imply that if a broader range of NEBs were included, the total non-energy benefits might be substantially greater than the energy bill savings in the weatherization programs studied. This suggests in turn that other comprehensive home energy improvement programs such as Home Performance with ENERGY STAR® may exhibit similar levels of NEB dominance over the basic energy cost savings. In fact, Fuchs *et al* [2004] studied those programs and found similar results.

Despite its conceptual appeal, the NEB monetization approach encounters a major problem. It is extremely difficult to reach broad consensus on the range of benefits to be included as well as an acceptable approach to their valuation for each type of energy efficiency program. Views vary widely, and progress toward convergence is slow—yet consensus is important for the method's use in program and policy evaluation.

Other Considerations

It is reasonable to ask, why bother with non-energy benefits in benefit/cost tests? The TRC test has been long used in program evaluation, with generally satisfactory results for most energy efficiency programs. Assessment of non-energy benefits has typically been avoided except for limited treatment of societal gains in energy-generation emissions reductions. However, there is credible evidence (notably in references involving Skumatz, q.v.) that such benefits may be substantially greater than the value of the energy savings.

The viewpoint of the buyer, moreover, has been largely ignored in the existing tests despite the fact that the buyer's judgment of the full set of benefits—rather than only energy savings—of a project determines whether that project is to be done or not. In voluntary energy efficiency programs marketed to the public, our studies suggest that such motivations need to be given greater consideration in order to create better programs, marketing, and energy savings. This does not imply that utilities and energy agencies should be funding social welfare programs; it merely asserts that buyer motivations, properly considered and aligned with program goals, may result in greater energy efficiency gains.

Parsing Participant Costs: Energy vs. Non-Energy Motivations

We propose that a way to avoid the difficulties of monetizing non-energy benefits is to assess the extent to which the consumer's cost for some energy-saving package is attributable to the desire to gain those energy cost savings *versus other benefits* of that package. This approach retains the conventional emphasis on energy cost savings as the primary benefit, but focuses on identifying the share of the participant's cost that was motivated by those energy cost savings. The remainder of the participant's cost is then attributable to the other (non-energy) benefits.

Energy and Non-Energy Motivations

Expenditure decision-making models vary, but all attempt to portray the decision-maker's balancing of the "regret" of the expenditure against gains in various kinds of needs satisfactions. The psychological literature is unified in acknowledgement that this is typically a complex and individualistic transaction; people vary greatly in the nature and extent of benefits that they recognize and value. It is rarely as simple as "I pay $1 now, I save $2 later." One person may value only one type of benefit and be unwilling to invest to get other types, while another may see much broader benefits and be willing to invest substantially to gain them.

It is also well documented in the economic literature that people vary widely in their valuation of future benefits versus present costs. This is typically presented as a variation in "revealed implicit discount rates." In the simplest cases of a present cost and some future energy cost savings, generally residential customers appear to devalue the future savings (high discount rate), suggesting that they are resistant to paying very much now for a future possible benefit. They seem to mistrust the future benefit and prefer to keep the money. But as the transaction becomes more complex, with a more varied set of desirable benefits such as health, safety, comfort, and home value improvements instead of just gradual energy savings, the reverse situation can easily appear: the customer may be willing to pay a higher price now than could be justified by the future energy savings, as is the case often with costly comprehensive home retrofits in the California program. Some economists attribute this to the customer's inadequate information and knowledge, but motivational surveys suggest that the customer is actually incorporating other perceived non-energy benefits into the decision, and thereby making a highly rational choice. We will demonstrate this in a later section of this paper.

In many programs, such as in compact fluorescent lighting retrofits or an air conditioner tune-up, non-energy benefits are relatively limited and the decision to undertake the expenditure can reasonably be justified or rejected based on project future energy cost savings alone. This indeed is the model implicit in most current energy-savings programs. But despite its support by particular economic perspectives and policy tools, it is a poor fit to some of the most powerful real-world energy efficiency choices.

Classical economic theory holds that rational choices are made among bundles of goods on the basis of the value or utility that they promise. One chooses an ax with wood-chopping in mind, or a coat with a thought about warmth. The *uses* of technologies determine their values to persons and influence what the technologies ought to cost in a marketplace. Other social scientists have elaborated this model by reference to how individuals *perceive* in different ways what they value, and how the actions and opinions of others influence perceptions (e.g., regarding style, status, and so on). So when an individual makes a significant choice regarding their home, they consider how well the new refrigerator will preserve their favorite foods, how it will fit into their décor, and what it will contribute to their standing (in their own eyes and those of others). The same is true of a new dishwasher, washer/dryer, bathroom remodel, window replacement, or major addition. These things all cost money, and are imagined to return value and utility along a variety of dimensions. They have energy efficiency implications—which are sometimes actually taken into account. However, they are not processes that can be captured in the energy accounting schemes of supply-side avoided cost.[1]

At the other extreme from compact fluorescents and air conditioner tune-ups, are comprehensive home energy performance analysis and retrofits. These are usually major undertakings, including combinations of improvements such as air sealing, insulation, crawl space isolation, high efficiency space conditioning equipment, sealed and upgraded ducting, improved filtration and air delivery, major appliance replacements, and hot water delivery improvements. They are selected to provide many benefits in addition to the energy cost savings, including increased comfort, quiet, health, safety, home and equipment durability, a sense of

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[1] For discussions of the complexities of energy-related choice in environments dominated by distinctly non-energy concerns, see Lutzenhiser et al (2001) and Wilhite et al (2001). Also, Lutzenhiser (2002) discusses the contexts of homeowner choice related to energy retrofits. The role(s) of NEBs in energy efficiency decision-making by commercial and industrial firms is considered by Hall and Roth (2004). A wide range of non-energy impacts of buildings technology, designs and retrofits on occupants is reviewed by Heerwagen (2000). A series of carefully constructed empirical studies have measured several sorts of NEBs in schools, offices and retail settings—see Heschong et al (2004), Peet et al (2004), Aumann et al (2004).

environmental citizenry, first-on-the-block status, long-term home value, and overall peace of mind.

Those non-energy cost benefits may well *dominate* the decision for many consumers. If so, the implications for energy efficiency program choices would be profound. The present common program evaluation approach of ignoring such non-energy benefits would then tend to systematically undervalue programs with substantial non-energy benefits as perceived by the buyers, since the entire cost of the improvement would be evaluated against only a small part of the benefit. The buyer's own allocation of resources among the various benefits would be ignored, and the decision would be mischaracterized as not adequately cost-effective.

This is what happens with benefit/cost tests such as the TRC, due to its failure to either include the non-energy benefits or to adjust the total participant cost to recognize that much of that amount is being spent to achieve those NEBs. Consider a home in California's hot interior valley in which the participant's total comprehensive retrofit cost might be $20,000, covering thorough shell tightening, major insulation improvements, corrected duct sizing/layout and sealing, appliance and lighting upgrades, controlled ventilation, and a new properly installed air conditioner and furnace. If annual electricity savings are in the range of 300 therms and 3,000 kWh (from former totals of about 800 therms and 9,000 kWh), with a TRC avoided energy cost of about $700 per year, it would be difficult to justify much more than a $5,000 expenditure on energy cost savings alone. If in a TRC test the entire $20,000 is used as the participant's cost and the share of program implementation costs attributable to that one house is $1000, the resulting TRC benefit-cost ratio is less than 0.5. If only the fraction of the participant's cost attributable to the energy savings benefit is included (say 25% or $5000), the TRC ratio is about 1.7…a much more acceptable result as well as more logically correct.

Finally, we note that such comprehensive home retrofits by definition yield the greatest possible energy savings per home, because a broad array of complementary improvements are included to both reduce the home's thermal load and serve the reduced load more efficiently. In contrast, when an isolated single major improvement is made, such as a furnace replacement, the potential is lost for further improvements to allow a much smaller unit to be used. The furnace lasts for many years, during which substantial long-term energy savings are lost because of the unreduced building load in the piecemeal retrofit program.

Supporting Evidence

In this section we discuss a small-sample survey that provides initial support of the importance of homeowners' NEB motivations for expensive home performance retrofits. Although further research will be needed to confirm these initial findings, they demonstrate the potential power of NEBs for such major home energy improvements. The authors recently surveyed Northern California homeowners who purchased home retrofits in the California Home Performance with ENERGY STAR program operated by the California Building Performance Contractors Association (CBPCA) in the PG&E service territory (Lutzenhiser 2006). The survey included a battery of carefully structured questions to elicit information on the relative strengths of a list of possible motivations.

An earlier version of this survey effort, with a less detailed set of choices, a less precise response method, and a smaller set of similar respondents, was reported at the 2004 ACEEE conference [Knight et al, 2004]. This newer and more detailed question battery corroborated those earlier results, however, by providing data indicating that as much as three-fourths of the average (surveyed) buyer's motivation arose from the desire to gain combinations of the non-energy benefits, with something like the remaining quarter possibly attributable to energy cost savings. Table 1 reports some motivational results from the combined survey waves (n=57). The respondents were a complete set of all those in the California program who were identifiable, actually had a home retrofit project done through the program, and agreed to complete a detailed mail-back survey.

Table 1. Surveyed Importance of Different Motivations in Home Retrofit Purchase (n=57)

Motivational Factor	Rated "Very Important"	Priority Among "Very Important"			Total in Top 3	3-2-1* Weighted
		1st	2nd	3rd		
Improve home's comfort	50	15	8	8	31	69
Replace older equipment	47	14	1	3	18	47
Be more efficient (save energy & resources)	47	5	15	5	25	50
Reduce energy bills	45	8	14	12	34	64
Improve indoor air quality	36	4	1	4	9	18
Increase / preserve home value	31	4	5	4	13	26
Contractor Affiliated with E-Star	26	0	0	1	1	1
Address Health issues	25	1	5	1	7	14
Rebate Available	24	0	1	2	3	4
Retrofits indicated by contractor	15	0	0	0	0	0
Improve home's appearance	13	1	0	2	3	5
Work recommended by HP test	11	0	0	1	1	1
Add additional space	2	0	0	0	0	0
Interest buy down program	1	1	1	0	2	5
Customer choice (at Home Depot)	1	0	0	1	1	1
Reliable windows	1	0	0	0	0	0
Contractor's knowledge and reputation	1	0	1	0	1	2
TOTALS	376	53	52	44	149	307

*This column provides an alternative response valuation system in which a score of 3=1st priority, 2=2nd, and 1=3rd, in contrast to the previous column's implicit weighting of 1 for all three highest-priority choices.
Source: Lutzenhiser (2006)

Since comprehensive home energy retrofits can yield the highest possible energy and peak demand savings, but typically cost far more than justifiable through energy cost savings alone, it is reasonable to assume that buyers are valuing some combination of NEBs highly enough to justify the higher cost. The original survey data were in the form of ratings of the importance of each of a list of potential benefits in the decision to buy a costly home energy retrofit. To permit a finer-grain analysis, respondents were also asked to rank-order their three most powerful motivating factors.

Table 1 shows that, while the motivation to "reduce energy bills" was frequently reported, it was far from the only reason given. Certainly homeowners hope for some bill reduction if they are paying for energy-savings measures and higher efficiency equipment. However, other sources of value and utility are clearly the dominant rationale. Persons were clearly engaged in upkeep (e.g., replacing poorly-functioning equipment) and buying comfort, convenience, cleanliness, and a sense of doing the right thing (e.g., being efficient in energy and resource usage). In many cases (about 40%) bill reduction *was not mentioned at all* among the "top three very important reasons" to purchase home testing and retrofits.

The implications of these early findings are clear. If all the homeowners' perceived NEBs are to be excluded in assessing comprehensive home retrofit program costs vs. benefits, then *only the energy cost savings-related fraction of the participant's <u>costs</u> should be included*. Just how this fraction might be estimated remains to be determined. A number of possibilities are apparent in Table 1. Others are imaginable. Certainly further research is needed using larger samples and questions specifically designed to parse participant costs. But the survey data obtained to date in the CBPCA program indicate that the participant's costs for *non-energy values* dominate the calculation of standard benefit-cost measures such as the Total Resource Cost test. Thus a major reduction in the cost factor that takes participants' NEBs-motivated investments into account would dramatically improve the benefit/cost ratio of such programs and greatly increase their chance of selection in a program portfolio driven by such measures of effectiveness, as they are in the California Public Utilities Commission's energy efficiency program and others across the nation.

Conclusions

This paper presents an argument for why comprehensive home energy efficiency retrofits are undervalued in some types of energy efficiency program selection and evaluation processes. It also demonstrates why we believe that this leads to suboptimal residential energy efficiency portfolios and lost opportunities for long-term energy savings.

In sum, we conclude that conventional benefit/cost assessments—notably the TRC test—*overstate* relevant participant costs by implicitly assuming (contrary to theory and empirical research) that the homebuyer's overriding motivation for buying a comprehensive retrofit is to reduce the energy bill. Our survey results, though tentative, demonstrate that the reverse is more likely: most homeowners appear to value the variety of non-energy benefits much more highly than the energy cost savings.

The result is a major and automatic reduction in the estimated benefit/cost ratio (and net benefits) of comprehensive home retrofit programs. It is significant that comprehensive home retrofits inherently create larger energy and peak demand savings than any piecemeal program to replace or improve HVAC equipment or systems alone: the more conventional piecemeal approach, common in utility incentive programs, may result in major losses in long-term energy savings opportunities.

We readily acknowledge the inherent barriers in comprehensive retrofit programs. They may be difficult to administer, and they require the contractor to have more analytical capability, a broader range of retrofit capabilities, and some substantial changes in marketing and business models. Many find it difficult to surmount such barriers, so the adoption rate can be slow—a major disadvantage, especially when utility or regulatory policy demands immediate delivery of major energy savings—or "resource acquisition"—rather than a building of long-term capability to expand those savings. But the long-term potential energy savings power of comprehensive "home performance contracting" is too great to be ignored, and such programs are emerging and improving their effectiveness across the nation. We urge further study of buyer motivations and their potential effect on the assessment of program costs and benefits for programs such as these, which involve extensive non-energy benefits.

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