RECOGNIZING ALL PROGRAM BENEFITS: ESTIMATING THE NON-ENERGY BENEFITS OF PG&E'S VENTURE PARTNERS PILOT PROGRAM (VPP)

Lisa A. Skumatz, Ph.D., Skumatz Economic Research Associates, Inc., Seattle, Washington
Chris Ann Dickerson, Pacific Gas and Electric Company, San Francisco, California

Synopsis

The authors developed a quantitative modeling approach for estimating non-energy benefits and applied it to derive estimates for a low income weatherization and education program.

Abstract

In conjunction with the evaluation of PG&E's Venture Partners Pilot Program (VPP), a low income weatherization and education program, the authors conducted a quantitative assessment of the program's non-energy benefits. The study reviewed the literature and developed a methodology to determine credible categories of non-energy benefits associated with residential programs. The methodology and quantitative estimates developed served several purposes:

- to identify and quantify the broad range of non-energy benefits associated with the program;
- to formally recognize and estimate the benefits from three separate perspectives: utility, participant, and society;
- to provide information and a modeling approach to allow internalization of non-energy benefits into program decision-making; and
- to use the results to develop a filter to help target marketing to those customers with greatest potential for benefit from the program.

Introduction

Although a number of sources in the literature address non-energy benefits in a conceptual way--usually itemizing the list of topics that might qualify as non-energy benefits--few have conducted applied research and developed quantitative estimates to identify the size of these benefits. Certainly, for a number of years, programs have been approved on the basis of energy benefits alone. However, recent changes in industry avoided costs are leading to an increasing attention on incorporating what was always a logically appropriate piece of the benefits and cost analysis --non-energy benefits.

Understanding the magnitude of all program benefits, including non-energy benefits, can help utilities maximize the overall benefits from a particular program, or help select between alternative programs, holding program costs constant. By identifying all program benefits--not only to the utility, but also to customers and society--a utility could conceivably provide better service to customers and can emphasize the benefits of those services to its customers.

The model developed applies a two step process to estimate benefits: multiplying the potential *value* of a change or improvement in a non-energy benefit times the expected change in *incidence* or occurrence in the factor based on program participation. That is, we develop an estimate of how valuable the savings or benefit is per occurrence, and then scale it by the impact the program is expected to have on the occurrence of that benefit. Non-energy benefits are then summed by perspective, and paybacks and other program metrics are calculated.

The authors applied this methodology to more than two dozen specific program effects, and developed both ranges (based on a range of alternative program and impact assumptions) as well as a point estimate of the dollar value of non-energy benefits specifically associated with PG&E's Venture Partners Pilot Program (VPP). Given that energy savings are specified in dollar terms, identifying the non-energy benefits in dollar terms allowed us to identify the total of all benefits (energy and non-energy) of the program. The results indicate that the program leads to non-energy benefits to PG&E and its ratepayers of approximately $35 annually per participating household, deriving in large part from a combination of reduced arrearages and shutoffs, and fewer gas emergency calls. The estimated payback to PG&E from the non-energy benefits alone is approximately 8.5 years for this jointly funded program, and the payback is improved from 7 years to 3.8 years when utility non-energy benefits are added to the energy savings. The study also developed estimates of the benefits to society, which, for the PG&E VPP program represented approximately $60 in additional program benefits.

Exploratory work was also conducted to develop order of magnitude estimates of benefits from the perspective of program participants. These efforts identified significant additional benefits to participants, totalling $210 per household. This level of benefits exceed the estimates of energy or bill savings to customers from weatherization programs, and confirms the suspicions of researchers in the field. The results provide quantitative information that can be used to better represent programs to customers, and provide a more

comprehensive evaluation of program impacts and payback, based on a variety of perspectives.

The work also led to specific suggestions for PG&E on program targeting, as well as methods for broadening application of the model to other PG&E programs, beyond the low income category. In addition, the research identified those areas of non-energy benefits where estimates had greatest uncertainty, and where future research should be focused.

Literature Review

The authors conducted extensive literature review, as well as interviewing a number of energy professionals active in this area to construct an analytical approach and develop quantitative estimates of the non-energy benefits associated with DSM programs. Because of space considerations, the literature review could not be included in this publication. The author(s) can provide copies of the full version of the literature review and the appropriate references. We found that a great deal of the literature addresses the issue of conceptual benefits categories; however, two key papers go further and incorporate quantitative estimates of a subset of the benefits we address in this paper. Information from these two papers are referred to extensively below in developing the estimates of specific benefits estimates we consider; they are papers by Brown of ORNL, (Brown, et.al. 1993), and Magouirk from Public Service Colorado (Magouirk, 1995).

Developing Estimates of Non-Energy Benefits

This study gathered information from a combination of the literature and utility-based sources to accomplish four objectives: (1) develop an approach to identify the range of benefits in a range of applicable categories, recognizing benefits from three perspectives; (2) attempt to apply the methodology to develop estimates of the non-energy benefits associated with PG&E's Venture Partners Pilot Program; (3) develop a quantitative tool or model to provide non-energy estimates for alternative scenarios and programs, and to allow internalization of the results into decisionmaking; and (4) assess those areas of non-energy benefits that should be focussed on in further research.

The focus was to develop preliminary estimates of the non-energy benefits associated with PG&E's Venture Partners Pilot Program. The first step in the process was to identify the types of non-energy benefits that might be associated with the program and which might lend themselves to quantification. Next, quantitative estimates related to each of these benefit areas were assembled and reviewed. Where possible, quantitative data related to key factors (costs, customer counts, benefits, etc.) based on the specific Venture Partners Pilot Program (or in some cases, other elements of PG&E's assortment of related low income or weatherization programs) were developed. Because the program is new and a pilot program, it was not always possible to develop specific estimates; however, our goal was to move beyond showing "placeholders" and elected to make educated assumptions using the available data to develop "order of magnitude" estimates wherever possible.

Further, a key objective was to develop "ranges", reflecting alternative sets of assumptions, that would help narrow the focus for follow-up research to those that would be most effective in refining future estimates of non-energy benefits for program analysis (for PG&E or other research). For example, if the literature showed a 100 percent range for some key variable, but the end result made only 10 cents difference in the non-energy benefits estimate for a program, that may not be as important a priority for further research or program-related data development as another variable.

Analytical Approach

As mentioned in the introduction, the analytical approach is based on a two step process to estimate benefits: multiplying (1) the potential *value* of a non-energy benefit times (2) the expected change in *incidence* or occurrence in the factor based on program participation.

This approach allowed incorporation of quantitative information from the literature, as well as allowing us to insert tailored information from PG&E or the Venture Partners Pilot Program where it was available. This two-step calculation approach also allowed us to create a flexible tool that could be easily adjusted and adapted for scenario analysis. Parameters related to number of participants, anticipated impacts of program design or target audience changes, or other alternatives can be readily changed in the model and the impacts on non-energy benefits from each of three separate perspectives can be analyzed and evaluated.

The non-energy savings are treated in "per participant households" terms in all cases. This makes it easiest to scale the benefits up and down based on alternative program scenarios. However, the benefits can be translated into other terms (including total program terms), depending on the analytical application. The program's non-energy benefits were evaluated based on payback, benefit-cost ratio, present value, and a variety of other criteria.

The sections below discuss, in turn, important areas of non-energy benefits. They are generally sorted by perspective: first, benefits to the utility and ratepayer; then society; and then customer or participant benefits (note that participant benefits can also be considered part of societal benefits). Each section addresses relevant quantitative literature on the topic; the types of data and assumptions we applied in developing the PG&E VPP program estimates; and the approximate "range" that we identified based on alternative assumptions about "value" and "impacts" related to the program or the range of quantitative results from the literature. Overall "best guess" point estimates of non-energy benefits associated with PG&E Venture Partners Pilot from each of the three perspectives (utility, participant, and societal) are presented and discussed at the end of the section. Both the ranges and the total "point estimates" are presented in Table 1.

Table 1: Table of Estimated Non-Energy Benefits: Approximate Range provided for "Generic" Low Income Weatherization Program with Alternative Impact, Design, Value, and other Assumptions

Non-Energy Benefits or Savings Category	Approximate range of benefits value ($ per participating household) Annual	PV (d)	Non-Energy Benefits or Savings Category	Approximate range of benefits value ($ per participating household) Annual	PV (d)
Perspective: Utility and Ratepayer Benefits			**Perspective: Societal Benefits**		
Payments-Related			Economic and Environmental		
Carrying costs on arrearages	.50-7.50	4-63	Economic benefits (b)	2-100	17-840
Reduced size of bad debt written off	1-4	8-33	Environmental benefits (b)	3-20	25-170
Decreased number of accounts written off	1-3	8-25	Health and safety (CO only) (f)	0-.15	0-1
Fewer shutoffs and reconnects	.25-1	2-8	Other externalities (f)	0-.50	0-3
Fewer notices	0-.15	0-1			
Reduced customer calls	0-.25	0-2	Water Savings		
Reduced collection costs	(c)	(c)	Water and wastewater (avoided) (b)	2-45 (a)	17-380 (a)
Gas Emergency Items			Transfer Payments		
Fewer emergency gas calls (b)	10-20	84-170	Reduced public transfer payments (unemployment)(e)	0-10	0-84
Flex connector replacements (one-time) (f)	0-5	0-5			
Fewer emergency calls from flex connectors (f)	0-2	0-9	**Perspective: Participant Non-energy Benefits**		
Self insurance savings to utility	0-.15	0-1			
			Water/sewer savings (average: annual $36; PV $304)(b)	8-110(a)	18-900 (a) 0-840
Other			Reduced mobility (education) (b)	0-100	0-3
Transmission and distribution savings (b)	0-6	0-50	Comfort, health and safety (mostly fire) (e)	0-.25	0-5
Rate subsidies avoided (b)	5-32(a)	42-270 (a)	Reduced transactions costs (limited measures) (g)	0-5	0-1300
			Fewer illnesses (b)	0-150	0-425 (a)
			Fewer service terminations/value of service survey (b)	0-50 (a)	0-8
SUMMARY OF NON-ENERGY BENEFITS (ranges are			Fewer service terminations/cost to re-start	0-1	0-1
overstated because of zeroes)		148-637	Fewer service terminations/lost rental value	0-.15	0-150 (a)
Utility and ratepayer perspective	18-81	59-1,478	Housing stock value, neigh. preservation (one time)(e)	0-150 (a)	(c)
Societal perspective	7-176	18-3,630	Other (comfort, noise, safety, maintenance, etc.)	(c)	
Participant perspective	8-566				

Table Notes:

(a) Item shows large range, but is easily narrowed using information from program design, local data (e.g., local rates, etc .)

(b) Item is large contributor to PG&E Venture Partners Pilot program non-energy benefits

(c) Not included, not estimated.

(d) Present values calculated as 10 year lifetime, discounted at 4% annually.

(e) Source for high-end estimate: Brown (1993) (f) Source for high-end estimate: Magouirk (1995) (g) Source: used Feldman (1996)

The Venture Partners Pilot Program (VPP) is an enhanced low income weatherization and education program, part of an array of PG&E low income programs. The "eligible" customer base is assumed to be qualified low income customers, with qualifications similar to the Utility's CARE (California Alternative Rate for Energy) program, a low income rate assistance program. The VPP program delivery consists of several steps, including outreach; on-site audit and education; weatherization; and follow-up education visit, presenting an energy use disaggregation (based on inputs from the walk-through audit). The VPP is provided as a joint effort with the California Department of Economic Opportunity, with funding shared by the two agencies. Because of the similarity in programs, in a number of cases we used quantitative estimates from Magouirk (1995) where information specific to PG&E's VPP was not available.

Non-Energy Benefits from the Utility and Ratepayer Perspective

Carrying Costs on Arrearages. Utilities realize financial savings when customer bills are paid on time. Weatherization programs help reduce customer bills, improving the chances that customers will be able to keep up with payments. In addition to its weatherization component, PG&E's VPP includes a significant education component, designed to help customers adopt behaviors that will lead to additional (and hopefully, long-lasting) reductions in their energy bills. The greatest number of studies containing original, quantitative research were found in the area of arrearages. This includes work by Brown, et.al. (1994), Magouirk (1995), and a number of others. These studies examined payments impacts for a variety of programs, and incorporated analyses of reductions in incidence and levels of arrearage, payment patterns, and carrying costs. Based on these studies, we developed a potential range for the percentage that arrearage balances might be reduced for a utility, depending on program and participant parameters. Our preliminary calculations from this literature developed a range of arrearage reductions from 6 percent to 73 percent (a very wide range), depending on the source and the program design.

The point estimates for carrying cost on arrearage balances for PG&E's VPP were based on (1) an assumed reduction in arrearages of 26 percent from the Magouirk (1995) study and (2) PG&E specific information on percentage of customers in arrears and arrearage balances for customers eligible to participate in the program. An assumed interest rate was applied to reflect carrying costs.

Based on alternative assumptions, our estimated range for the benefits to the utility and its ratepayers from reduced carrying costs on arrearages is $0.50-$7.50. More program-specific information on program effect on arrearages, and utility-specific information on the interest rate to be used can significantly narrow this range.

Bad Debt Write-Off. Annual write-offs of non-collectibles by utilities represents a very real cost to utilities and their "bottom lines". Again, weatherization programs can help make energy bills more manageable for program participants, potentially reducing the bad debt for these customers. Writeoffs were examined in Magouirk (1995) and others. Magouirk estimated two parts to these savings, including reductions from the size of debt written off, and from the total number of accounts written off. His estimates showed an 18 percent reduction, leading to estimated savings to Public Service Colorado of $3.29 per participating household from the reduction in the level of writeoffs, and $2.77 from the reduced number of accounts written off.

In developing point estimates of these two impacts for PG&E's VPP, we calculated the product of the following inputs: (1) the 18 percent reduction in bad debt written off from Magouirk (1995), and (2) estimates of PG&E's annual residential write-off and (3) an estimate of the number of low income qualified customers as a percent of the overall residential sector customer base, translated to a per-household figure. Assuming that the percentage of bad debt written off is not simply proportional to the number of customers, but might be expected to be higher for customers who are more financially at risk (the target population for VPP), our point estimate probably understates the value of this non-energy benefit to PG&E.

We used a "scaling" approach to estimate the value resulting from reducing the number of accounts that must be written off. This involved taking the Magouirk (1995) estimate for this benefit and applying a similar proportion as the results of the estimate for the reduction in the amount of bad debt written off.

Based on alternative assumptions, our estimated range for the utility's non-energy benefit from reductions in the size of bad debt written off is $1 to $4; and the estimate of benefits from the decreased number of accounts written off for bad debt is $1 to $3.

Fewer Shutoffs and Reconnects. The program's combination of weatherization and education is expected to lead to an improvement in customer's abilities to pay their bills, and as mentioned before, to lower arrearage and write-off balances. As a corollary, we anticipate a similar reduction in the number of customers with service disconnected for non-payment. Magouirk (1995) includes estimates of utility benefits from the reduction in customer shutoffs due to the program. An estimate of this benefit would be provided by multiplying (1) the cost of shutoffs (and the uncovered cost of re-connections) times (2) the reduction in incidence anticipated because of the program. In developing the point estimate of the range for PG&E non-energy benefits from this source, we were unable to identify specific PG&E estimates of cost of shutoffs, so the estimate was based on Magouirk (1995). An adjustment was made to "scale" for the savings in a proportion similar to that resulting from the comparison of "bad debt" writeoffs. A rough

estimate of the range for the benefits to the utility from this source might be on the order of $.25-$1.

Fewer Notices and Customer Calls. Greater energy bill affordability and improved energy education resulting from the combined weatherization and education efforts of the program is expected to reduce not only the arrearages and payment problems, but the also lead to auxiliary benefits in the form of fewer customer notices of non-payments, and fewer customer calls to the utility. Both of these benefits result in real savings in staff time and materials to the utility.

Little specific work was available in the area of savings from fewer late payment notices or customer calls, etc. In addition, the magnitude of these savings would be tied to a specific utility's notice practices. Magouirk (1995) noted this as an area for future research.

For the purposes of estimating the "order of magnitude" of savings from these impacts for PG&E's VPP program, we assumed (1) that the reduction in customer calls would be proportional to the size of the anticipated reduction in writeoffs and arrearages (we used a figure of 18 percent reduction from eligible customers). This was coupled with (2) PG&E-specific information on the annual cost of customer calls. Information was not available on the percentage of calls that were from eligible customers, so the resulting point estimate likely understates the savings from this source--it is likely that eligible low income customers call the utility regarding late payments, notices, etc. more frequently than other customers.

Our point estimate of the per-household reduction in PG&E's costs from fewer late payment notices was calculated using estimates of (1) PG&E's annual costs to process late payment notices, (2) the percent of notices sent to eligible customers, (3) the assumed reduction in notices due to the program's effect (for consistency, we again used Magouirk (1995)'s 18 percent reduction. These figures were then translated to per-household basis.

Based on a range of assumptions about program impacts and savings, we estimate the range of savings from reduced customer calls to be about $0 to $0.15 per participating household; and about $0-$0.25 for reduced mailings of the utility's hierarchy of late payment notices. Benefits from this source were assumed to accrue to the Utility.

Collection Costs. To the extent that a utility expends additional efforts in attempting to collect late or non-payments (e.g., hiring a collection agency, or assigning additional staff), the utility could also realize some financial savings related to improved payment patterns resulting from low income weatherization programs. No efforts were made to quantify these benefits at this stage, although they could be a source of savings to the utility, depending on their collection procedures.

Immediate Response (Emergency) Gas Calls. The VPP program checks and replaces gas appliances when needed, and also checks gas connectors on appliances. One benefit to both PG&E and the customer is pro-active replacement of poor gas connections before they become problematic. This reduces costs from immediate response (or emergency) calls by the utility. Magouirk (1995) finds significant savings from the avoided emergency gas calls needed because the gas connections are checked and upgraded where necessary through the program. Based on Public Service Colorado's costs, Magouirk estimates savings on the order of $15.58 per participating household. This figure was based on original research on the percentage reduction in calls after the program (a reduction in households needing on-site calls from 27 percent prior to the program to only 7 percent after the program).

The point estimate of non-energy benefits from reduced emergency gas calls associated with PG&E's VPP was developed using estimates of: (1) PG&E's estimate of cost per emergency gas and (2) the reduction in the number of calls needed per participating household before vs. after the program (we used Magouirk's (1995) estimate). This was translated into a per-household figure.

Potential estimates of the order of magnitude of savings from reduced emergency gas calls from the utility's perspective are estimated between $10 and $20 per participant household.

Flex Connector Savings. Magouirk (1995) found program-specific savings associated with the fact that Public Service Colorado's program checks flex connectors for damage, wear, and replacement. He notes two sources of savings related to the replacement of gas flex connectors: one-time savings from their pro-active replacement, and reduced emergency gas calls owing to their replacement before they became problematic. Magouirk estimated significant savings from the one-time replacement of flex connectors (savings were estimated as $5.01 per household). Depending on whether these savings are appropriate for the program, the annual value of these savings can be calculated based on the (1) costs of the connectors ($7 each in Public Service Colorado's case), and (2) the expected lifetime and the discount rate to determine the annualized savings. Magouirk's estimate of savings from the associated reduction in emergency gas calls were $1.98.

Because flex connectors were not an emphasis of PG&E's program, no specific savings from this source were attributed to the VPP. Based on various assumptions about the percent of connectors needing replacement and other assumptions, the size of the calculated benefit from the one-time replacement of flex connectors might be $0 to $5; the savings from the reduction in gas emergency calls might be expected to fall in the range of $0 to $2. These benefits are estimated from the utility's point of view.

Insurance Savings. Because explosions and fires can lead to multi-million dollar claims, significant savings could be realized from weatherization programs (particularly at gas utilities) through reducing these types of risks. Brown (1993) developed estimates of the savings from this source, concluding non-energy benefits from reduced fires would be

on the order of $3 in net present value (in 1989 dollars). Magouirk did not estimate the savings from this source, but noted it as a potential source of savings.

In developing the point estimate of non-energy benefits for PG&E, we noted that many large utilities (including PG&E) self-insure for claims up to certain values. In these cases, if losses from residential claims can be reduced (and these claims fall below the level of the deductible), this provides direct and full-value savings to the utility and its ratepayers. The estimate of savings to PG&E from reduced fires was estimated using information on: (1) the claims from the relevant sector for an "average" year, changed to a per household basis, and (2) the reduction in risk from the program. Because the direct reduction in risk to PG&E was not known, we used as a proxy the Magouirk (1995) information on reduction in gas emergency calls of about 75 percent.

For those utilities not self-insuring, the reduction in costs would be more difficult to calculate, because the savings would be based on the change in impact on policy premiums. Depending on the program, utility, and reduction assumptions made, the utility and ratepayer savings from reduced claims might range from $0 to $0.15 per household per year.

Transmission and Distribution Savings. DSM programs also lead to savings in the form of transmission and distribution losses that do not occur because the power does not have to be delivered. The Northwest Power Planning Council (NWPPC, Harris (1996)) provides guidance for utilities comparing conservation to new power alternatives in the form of estimates that it attributes to transmission and distribution. The estimates used are 7.5 percent for T&D losses, and 2.5 percent for transmission deferral for a total of 10 percent savings applied to the program's avoided costs.

In estimating the benefits to PG&E, we applied the (1) 10 percent savings figure to (2) the program's savings in avoided cost terms. Whether these benefits apply to the specific utility may depend on whether the utility is in a competitive environment; however, the range of estimates may be on the order of $0 to $5.

Subsidies Avoided. The program's effect on reducing energy bills leads to a direct reduction in the burden on the Utility's low income rate subsidy program. The value of the latter savings would be based on the specific design of a Utility's assistance program, and on the amount of the program's anticipated energy savings. PG&E's program provides a 15 percent discount off rates for qualified customers subsidized by ratepayer funds.

Figures from the literature show a range of energy savings associated with a variety of weatherization and low income programs. Brown et.al. (1993), and others show savings estimates from this impact ranging from perhaps 4 percent to Magouirk's (1995) bill reduction figure of 22 percent. Programs with education components tended to lead to higher savings (Skumatz Economic Research Associates, 1996), and other literature indicates that these savings from educational efforts tend to be long-lasting enough to include as a persisting benefit.

For the PG&E project, the total reduction in subsidy avoided was calculated using: (1) the annual per-participant program subsidy, and (2) the expected percentage energy savings from the program. A similar number was generated using: (1) the average level of bills per household prior to the program, (2) the expected percentage savings, and (3) the subsidy percentage.

The range of benefits from the reduced low income assistance subsidy might range from $5 to over $32, and these benefits were assumed to accrue to the ratepayer and to society.

Non-Energy Benefits from the Societal Perspective

Benefits to society from conservation efforts are derived from an array of sources that provide "public" good, including direct and secondary economic impacts, environmental benefits, and a variety of other benefits that accrue beyond the direct participant or the utility.

Economic Benefits (Secondary, multiplier). Additional benefits accrue as secondary benefits to the economy from the program. These benefits include increased employment, earnings, and generated tax revenues; increased economic output, and decreased unemployment payments (addressed in the next section). Several agencies have attempted to develop estimates of these types of benefits. Pigg and Dalhoff (1994) provide estimates for economic impacts to the State of Iowa based on different aspects of program design. They noted that the net economic impact of Iowa's low income weatherization expenditures of $11.1 million was $14.1 million in industry output, $7.1 million in personal income, $7.6 million in value added, and the creation of 381 jobs. Dalhoff (1996) notes that 64 cents of every dollar spent on the program remained in Iowa as income). The estimates from Brown et.al. (1993) regarding economic benefits (in net present value terms) include: $55 in taxes from direct employment; $506 in income from indirect employment, and $82 in reduced unemployment benefits.

The Northwest Power Planning Council (NWPPC) established a policy related to the calculation of benefits from DSM efforts in relation to power from new supply. NWPPC policy attributes a 10 percent "adder" as an estimate for secondary economic benefits for conservation-based efforts. The NWPPC assumes that a conservation program leads to expenditures within the local area that have greater local impacts than if new power is purchased from outside. This factor is ordinarily assigned to the avoided costs for the program. Discussions with NWPPC staff (Harris (1996)) indicates that this economic benefits factor may understate benefits from certain types of programs, and in particular, for low income weatherization programs. The 10 percent factor was developed for "average" DSM programs; however,

weatherization programs tend to use more local supplies and are more labor intensive, indicating the factor for the VPP program might appropriately be higher.

In deriving the point estimate of non-energy benefits to society from the VPP program, we used: (1) the program's cost and (2) the (conservative) 10 percent multiplier factor appropriate for the program. We assumed that this factor incorporated the benefits from employment, local economic development, and taxes. This estimates for this item could vary widely across utilities.

Based on alternative assumptions, the value of benefits from secondary economic benefits can vary widely, perhaps from $4 to $100 on an annual basis.

Transfer Payments Avoided. Additional societal benefits are realized from lower unemployment benefits because of the job creation impacts of weatherization programs. A quantitative estimate of these benefits is included in Brown, et.al. (1993). The net present value is estimated as $1, which can be translated to an annual benefit of approximately $0.08 on an annual basis (using their assumptions of 20 year stream, discounted at 4.7 percent, 1989 dollars). Brown et.al. (1993) shows avoided costs of unemployment benefits of $82 net present value. On an annual basis, this represents a stream of about $6.25 per year in benefits to society.

In developing the PG&E point estimate, we used the estimate from Brown. An estimate of the range of benefits to society from avoided transfer payments were assumed to be $0 to $10.

Environmental Benefits. DSM programs can provide environmental benefits to the region and to society, particularly due to their role as a pollution abatement strategy. These include assisting in meeting Clean Air Act goals, reduction in acid rain, and a variety of other environmental benefits. A number of these concepts are addressed in Ottinger et.al. (1990), and Consumer Energy Council of America Research Foundation (1993). Brown, et.al. (1993) develops quantitative estimates of these benefits relative to the low income weatherization assistance program. Brown attributes a net present value of $172 (1989 dollars, discounted at 4.7 percent over 20 years). This represents an annual benefit of approximately $13. The Northwest Power Planning Council (NWPPC, Harris, 1996) provides policy guidance to utilities in the area regarding valuing the benefits from conservation relative to new power. The NWPPC assigns a 15 percent "adder" for environmental benefits associated with conservation programs. This factor is applied to the avoided costs of the program.

In developing the estimate of environmental-related non-energy benefits from PG&E's VPP, we used the multiplicative product of (1) the NWPPC's 15 percent environmental factor and (2) the calculated avoided cost from the VPP program. This provided a conservative estimate of environmental benefits.

Considering alternative program and avoided cost assumptions, the range of environmental benefits to society from the program might be $3-$20 annually.

Health and Safety. One inherent risk that may be reduced through weatherization programs derive from carbon monoxide exposure. Brown (1996) notes that 4-5 crises may occur per heating season (out of 400,000 customers in the service territory for which data were available), and that crises are about twice as likely in low income households. Brown also notes that "crises" cost about $5,000 per incident. Reducing these emergencies through carbon monoxide monitors leads to benefits to society (through reduced emergency calls and health benefits) as well as to participants who are no longer threatened from this source. Certainly, this interpretation understates health benefits from programs; it does not incorporate the benefits of reduced illnesses, hospitalization, and quality of life issues related to weatherization programs.

In estimating the benefits to society from the PG&E VPP program, we applied the information from the Brown (1996) report, including: (1) the estimated likelihood of crises in eligible households, coupled with an assumption that all carbon monoxide risk for these households would be eliminated, and (2) the value of the crisis avoided. An estimated range for this limited definition of safety, based on Brown's calculations, would be $0-$0.50.

Other Economic Externalities. When weatherization programs include measures that reduce water usage, society, as well as bill-payers benefit. These water benefits are included as a joint discussion of water savings under the customer perspective. In addition, Brown, et.al. (1993) attributes about $3 in net present value to other economic externalities, specifically health and safety from reduced fires, etc. These figures were not included, assuming that they were incorporated in the NWPPC estimates we used for the PG&E program. However, if another approach is used in estimating externalities, this may warrant further investigation.

Non-Energy Benefits from the Customer Perspective

The literature contained at least some information useful in developing estimates of the non-energy benefits associated with the VPP from both the utility and societal perspective. However, with the exception of Brown et.al. (1993) there was a significant shortage of information on quantitative estimates of non-energy benefits from the customer point of view. In order to provide a more balanced picture of the non-energy benefits accruing from the program, significant exploratory efforts were conducted to identify effects for this sector, outside the scope of the project. A more detailed description of the quantitative approach is presented in Skumatz (1996), and the paragraphs below summarize these efforts. The customer side benefits are generated from a variety of effects, and abbreviated descriptions of the sources of these benefits follow.

Water Savings. One of the largest benefits to customers from weatherization programs can be the value of the water savings from reduced usage because of showerhead and faucet aerator retrofits. Skumatz (1996) provided estimates of the reduction in residential water use from new showerheads and faucet aerators, as well as information on water and sewer rates from several communities. Valued by full residential rates, water savings can represent strong non-energy benefits to customers through direct reductions in their water bills. Note that these savings accrue for both the water as well as wastewater or sewer bills. Valued by avoided cost, the water savings can provide additional non-energy benefits from a societal (and water ratepayer) point of view.

In developing an estimate for the water savings benefits to participants from PG&E's VPP program, we used (1) information on the number of new showerheads and aerators installed per dwelling through the program, (2) the expected water savings per household from each showerhead and aerator, and (3) combined residential retail water and sewer rates for San Francisco and San Jose. Estimates of societal benefits for the PG&E study were derived by valuing the savings at a range of estimates of avoided cost for water agencies (Skumatz 1996).

Given alternative assumptions about savings, local water and sewer rates, and program alternatives, the range of savings to participating may range from $8 to over $110 (variations in the consumption charge portions of local water rates, which can vary by a factor of nearly ten across the nation, account for the bulk of this variation). A fairly typical value, based on "average" rates is about $36 (Skumatz, 1996). The size of societal benefits depend on how close to maximum capacity the community's water supply or sewage treatment plants are, and may range from $2 to $45.

Reduced Homelessness and Mobility. High energy costs can make it difficult for residential customers to keep up with their bills, and this may include rent or mortgage payments. Brown et.al. (1993) notes that efficiency improvements can play a role in reducing evictions, by maintaining low income housing availability, and therefore, tenancy. Brown estimates that weatherization efforts may, conservatively, prevent two move-outs per 100 participants, although another interpretation of the data (Skumatz, 1996) may increase that estimate to a reduction of 7.5 moveouts per 100 participants. Rough calculations from Brown (1993) related to the avoided cost of reduced mobility averaged less than $1 per weatherized dwelling. Based on a recent study of Head Start families by Colton (1996), Skumatz (1996) notes that one of the most important benefits that may accrue from reducing household mobility is associated with reducing drop-out rates. Colton (1996) notes that households he classifies as "frequent movers" have high school dropout rates four times as high as families that move less frequently. Colton notes that in his study, 40 percent of the families were "frequent movers", and 50 percent of households that moved frequently cited high energy bills as an important factor in moving. To the extent that the weatherization program reduces household mobility, Skumatz calculates the non-energy benefits from lower dropout rates, valued by the difference in wages for high school graduates compared to dropouts.

In applying this information to the PG&E program, we used data on: (1) changes in frequency of moving expected from the program (we used data from Brown, 1993); (2) estimates of change in expected dropout rates, and (3) the difference in lifetime earnings between graduates and dropouts (assuming a 40 year working life starting 10 years hence).

Considering alternative assumptions about program impacts on household mobility, dropout rates, and other factors, the range of non-energy benefits from reduced homelessness and mobility to participants may be range to $100 on an annual basis.

Comfort, Health, and Safety. Weatherization programs improve household comfort by making the house warmer (and making it more affordable to keep warm), reducing draftiness, reducing noise, and other improvements. Brown (1993) also notes the value of reduced fires because of improved safety checks of heating equipment, lower damage from better insulation, decreased use of substitute heating equipment. Indoor air quality is also affected by these types of programs, with mixed results depending on whether customers are in a radon area (Brown 1993). Because of the tradeoffs between various effects on health and safety, Brown quantifies only the benefits from a reduced risk of fires, estimating property value losses at $3 NPV. Skumatz (1996) includes a discussion of issues connected with increased comfort from weatherization programs. However, the information primarily addresses programs that incorporate storm windows or storm doors as retrofit measures. Skumatz (1996) cites one program that attributes only 25 percent of the overall benefits from storm windows to the energy portion, and only 10 percent of the overall benefits from storm doors to energy savings. Noise, comfort, and other non-energy benefits are considered very strong for these measures, making up the majority of overall benefits from the installation of these two measures. Alternatively, duct and caulking and similar measures are, in this program, assumed to have no significant non-energy benefits; the energy savings are assumed to fully represent the measure's benefits. Other utilities note customer willingness to pay for storm window-type measures as strong evidence of customer non-energy benefits from these measures. Finally, improvements in safety are noted from programs related to reduced maintenance needs and risks. For example, compact fluorescent lamps (CFLs) may be preferred because they have to be replaced less frequently, and elderly customers with high fixtures might feel the value of avoiding risk of broken bones might very well swamp the value of energy savings from the bulb. Similarly, double-pane windows can reduce noise and draftiness, and new metal or vinyl windows (which are frequently used for these programs because of their low cost) can significantly reduce maintenance time relative to existing, old, often damaged, wood windows.

At this stage, no estimates of safety or comfort benefits were specifically derived for the PG&E VPP, partly because the PG&E VPP program does not include storm doors or storm windows, which might have provided a useful avenue for calculation. However, this area shows strong potential for significant benefits, and should be a target for additional research.

Reduced Transactions Costs. Customers gain benefits from not having to educate themselves about conservation measures, not having to locate the items in the marketplace for purchase, and the reduction in transaction costs from having efficient products more widely available. As an example, Feldman (1996), described in Skumatz (1996), developed preliminary estimates of the transaction costs benefits to residents from programs including compact fluorescent bulbs. Feldman makes assumptions about the percent of persons in the territory that would be predisposed to fluorescents, the amount of time they would have to invest learning about bulbs, finding stores that carry them, and the time and money expended purchasing the bulbs. Valuing time at $6 per hour, Feldman estimates the reduced transactions costs of from $1.25-$5 per bulb. He also explores the costs involved in a generic information program and other related costs; and also notes that one commentor argues that his estimates may understate benefits by as much as a factor of four.

Recognizing that bulbs are only one component of programs, the Feldman estimates serve as a very conservative bound for the non-energy benefits from reduced transactions costs. In deriving estimates of the participant customer benefits from reduced transactions costs due to the VPP, recall that education components are a significant part of the program's efforts, and that customer receive a great deal of education both about measures and behavioral changes. To remain conservative, our estimates for customer benefits for the VPP were based on: (1) the number of compact fluorescent lamps (CFLs) installed per household in the program, and (2) the estimate of reduced transaction costs per bulb from Feldman's work. To take account of the wider range of measures and educational efforts for VPP (for example, the VPP includes efficient refrigerators, heating system upgrades, etc.), we conservatively doubled the resulting calculated non-energy benefit.

Considering alternative assumptions about measures included and avoided transaction cost estimates, these non-energy benefits to the customers might be expected to range from $1 to $10, and potentially higher.

Reduced illness. Households with sufficient and continuous heating would tend to experience fewer colds and other illnesses per year. Skumatz (1996) incorporates assumptions about lost work time due to colds or other illness of parents or children in participant households. Assuming household breadwinners are able to avoid days of lost time at work from parent or child illnesses or colds, significant savings can be realized, even valued at minimum wage--upwards of $60 per year per household. This estimate is probably conservative because it excludes doctor and other medical fees, and assumes the illnesses are not more severe, and that lost time from work does not lead to terminations in employment.

In deriving an estimate for PG&E's VPP, we used: (1) an assumed reduction of four lost workdays, (2) benefits accruing to one quarter of the participating households, and (3) minimum wage of $4.25 per hour. In addition, one bottle of over-the-counter cold remedy was included for the affected households.

Considering alternative program, climate, and illness frequency/severity assumptions, the range of benefits to participants from reduced illnesses might be $30 to several hundred dollars annually. Note that society also benefits from reductions in illnesses, medical costs, and lost time that may be due to weatherization programs.

Fewer service terminations. Providing customers with weatherization services and education on reducing energy use helps customers reduce bills and presumably improves their payment record. Customers experience fewer arrearages and fewer would be expected to reach the position of service terminations (TONP). Valuing the benefits can be accomplished through several avenues; Skumatz (1996) addresses several methods. Value of service surveys by utilities often ask for responses from customers regarding what they would be willing to pay to avoid service termination. These figures provide a customer-based value on service disruption, and provide area- and utility-specific information, although these responses generally address unanticipated outages, and responses would be expected to differ based on income group. Another method would be to estimate the cost to residents of getting power restored, including the cost of borrowing and lost time in arranging reconnection. A third method examines the lost value of the dwelling from it being uninhabitable for the term of the service disconnection. Precedent for this type of valuation is based in state and local housing ordinances, which at least in some areas, specify the formula to be used to value lost services from landlord neglect and loss of essential services (Colton, 1996b; Tackett, 1996).

In developing estimates of non-energy benefits to PG&E participating in the VPP program, we used: (1) information from PG&E's Value of Service Survey; and (2) estimates of current TONP rates for qualified customers; and (3) the percentage reduction in TONP anticipated based on the arrearage reductions from the Magouirk (1995) work. We performed additional calculations using: (1) the average balance to be paid by TONP customers at PG&E combined with the reconnection fee; (2) the estimates of TONP percentages and anticipated reductions as above; (3) an assumption of credit card interest rates to represent the cost of borrowing to this sector; and (4) the value of an assumed four hours of time at minimum wage getting power restored. The last calculation related to this non-energy benefit category was based on: (1) the loss of the value of one day of rent for a property and (2) the reduction in TONP occurrence

from the program as estimated above, multiplied by one-fourth. We discounted by a quarter to account for the fact that few properties would be turned off during heating season, and a full day might not be lost for others.

Given alternate assumptions about the reduction in TONP occurrences, utility TONP practices, length of outages, and other variations, the range of estimated benefits to customers based on the customer value of service might be up to $50; the value of avoided reconnection costs might be up to $1; and the value of loss of property usage is likely less than $0.15.

Property Values and the Longevity of Structures. Weatherization programs often provide a number of services that improve the dwelling's value and longevity. These services include some shell-related measures that may improve aesthetics and value. In addition, some upgrades and measures may decrease maintenance requirements. Brown et.al. (1993) provided quantitative information on non-energy benefits related to the Weatherization Assistance Program. The Weatherization Assistance Program allowed expenditure of some resources on building rehabilitation and basic repairs; the study estimated that the average amount spent on structural repairs in 1989 was $126. This amount was assumed to represent the benefit in terms of maintenance of building value. Brown noted that these expenditures varied by building fuel type, dwelling type, and other considerations.

Repairs were an important component of the VPP, and conservative estimates of the benefits from these program efforts were incorporated into overall customer-side benefits from the program.

Omitted Customer-side Non-Energy Benefits. A number of other non-energy benefits from weatherization and education programs could presumably be attributed to customers, but were not incorporated into the estimate of savings at this time. These include: transactions costs related to other measures; value of noise reduction and additional comfort issues; value of lower maintenance; value of lower arrearages (psychic value and reducing tradeoffs with food and other bills); safety issues; other medical and doctor-related savings; and value of having more usable square feet in the dwelling (from improved ability to heat the dwelling), among other benefits.

Analysis of Non-Energy Benefits for PG&E's VPP Program

The Venture Partners Pilot Program (VPP), as mentioned before, is a low income weatherization and education program, funded jointly by PG&E and the California Department of Economic Opportunity. PG&E contributes 42 percent of the total program costs. The program combines weatherization activities with a significant education component, incorporating two on-site visits and an energy use breakdown tailored to the household (based on a first-visit walk-through). Income qualified customers are eligible for the program.

Table 2 summarizes the results of our estimates of the non-energy benefits for PG&E's VPP program, demonstrated from three perspectives. The table also reviews the revised payback results for the program.

Table 2: Estimated Non-Energy Benefits for PG&E's Venture Partners Pilot Program
Non-Energy Benefits (annual, per participating household)

Utility (PG&E and Ratepayer) Perspective:	
Total non-energy benefits	$35
Energy benefits	$43
Total benefits (energy and non-energy)	$78
Program cost (PG&E share)(*)	$302
Program payback (non-energy benefits only)	8.5 years
Program payback (energy benefits only)	7 years
Program payback (energy and non-energy benefits)	3.8 years
Societal Perspective	
Total non-energy benefits (societal perspective)	$60
Non-energy benefits including customer perspective	$270
Customer Perspective:	
Total non-energy benefits	$210
Customer bill savings	$85
Total customer benefits (including energy and non-energy benefits)	$295
Total VPP non-energy benefits (all perspectives)	
Payback (all non-energy benefits)	$305
Payback (all non-energy benefits and combined PG&E and DEO program costs)	1.0 years
	2.3 years
(*) Note: PG&E and the State DEO share program costs for VPP.	

Perspective

Non-energy benefits accrue to several entities: (1) the utility itself (including ratepayers and shareholders), (2) the participating household, and (3) society. The assumed beneficiary for each of the non-energy benefits was noted in the text, and was also noted in Table 1.

- *Utility, ratepayer, and shareholder perspective*: The non-energy benefits from the utility and ratepayer perspectives are estimated to be $35.33 annually. The results for the utility show significant improvements in the Utility's payback when the full range of benefits--from both energy and non-energy sources--are incorporated into the calculation. Payback improves from 7 years (with energy benefits only) to 3.8 years. The largest contributors to non-energy benefits for the utility and ratepayer perspectives were: reduced gas emergency calls; transmission and distribution savings; and avoided rate subsidies. The total of the payments-related benefits are also responsible for a significant amount of the utility's estimated non-energy benefits.
- *Societal perspective:* The non-energy benefits from this program are estimated to be $60 annually per participating household. The largest contributors to these estimated benefits were: economic benefits; and avoided costs from reductions in water and wastewater usage. Environmental benefits and reduced unemployment benefits were also significant, but the results indicate that additional work to better estimate the size of the benefits from economic and environmental sources may be useful. Note that the work indicates that society at large likely has larger non-energy benefits than the utility or its ratepayers.
- *Customer or participant perspective*: The results show that the under-examined participant perspective shows the largest benefit from the program--realizing perhaps $210 in non-energy benefits annually per household from the program. The largest sources of non-energy benefits were: water and sewer bill savings; educational and earnings benefits from reduced mobility; fewer illnesses; housing stock repair; and value of fewer terminations. Table 2 shows that the value of non-energy benefits were more than double that of expected annual bill reductions (almost 250 percent). It appears that benefits to this sector have been under-identified, and for programs that reduce noise or increase safety and comfort (those with new dishwashers, storm doors or windows, or other measures), the benefits to participants could be considerably higher.
- *Sum of all perspectives*: Overall, non-energy benefits from this program may total over $300. Incorporating non-energy benefits moves the program to an overall payback of 1 year (considering only PG&E costs). Indications are that non-energy benefits with value significantly above and beyond direct energy savings are derived from program efforts.

Targeting

Based on our internal analysis of the relative contributions of various sources of benefits to the overall non-energy benefits totals, we were able to provide recommendations about fruitful program design and targeting, including:

- low income customers in arrears: a large portion of the non-energy benefits of the program are derived from savings from reductions in subsidies and in reduced arrearages.
- households with gas service and/or those with older housing stock: significant benefits accrue from customers who might be at higher risk for gas emergency calls.
- low-income customers with high bills, and those with relatively short account histories: work by Weitzel (1988) indicates that risk of arrearages might increase with the ratio of bills to income and with shorter tenures in rental homes.

The analysis indicates that by targeting these types of customer groups, the program's total (energy and non-energy) benefits could be increased, not only to the Utility (and its ratepayers and shareholders), but also to participants and society. This type of targeting would improve program payback, as well as maximize overall savings due to the programs--holding program costs constant--benefitting customers, ratepayers, shareholders, and society in the process.

Volatility

Table 1 provides information on likely non-energy benefits from each of the major categories discussed in this paper. These estimates were calculated for a "generic" low income weatherization program, and the results are specified as a range. The range resulted from alternative assumptions from the literature regarding estimates of program impacts

and changes in occurrences due to the program; from program design alternatives; and from uncertainties regarding valuations of benefits.

The results show that some categories of benefits have greater associated uncertainty than other items. In addition, the results from some perspectives have greater ranges or are more volatile than others. Follow-up research should target those areas the greatest uncertainty and potential impact.

In the emerging restructured/competitive era, key concerns will be utility bottom-lines. Areas for further research would likely include better quantifying of the effects of credit and collections, customer contacts, turn-on and turn-offs, and similar effects. However, our estimates, based partly on research conducted by other authors, indicates that the savings from shutoffs/reconnects, notices/customer calls, and collection costs may not be very large, and if confirmed, may not be worth significant additional work -- unless costs for other utilities differ significantly.

Clearly, the area of customer-side benefits has been addressed least frequently, and there would be strong gains to further examination of these benefits. Indications are that non-energy benefits may be a very significant contributor to overall benefits from the customer's point of view. In addition, more comprehensive work in the area of measuring environmental and economic benefits would be beneficial. However, some of the benefits that have large ranges are due to alternative assumptions about energy benefits, or about the improvements in payment behavior due to the program. Program-specific information is crucial to "tightening up" these non-energy benefits. The ranges that can be easily narrowed by incorporating program-specific or local data were noted with an (a) in Table 1. Recommendations about specific areas for further research are provided below.

Areas of Future Research

Much of the literature in the area of non-energy benefits generally itemizes list of topics that might qualify as non-energy benefits, and concentrates on theoretical or conceptual level. This project developed estimates of relative *scale* of various categories of non-energy benefits to identify those sources with the largest impacts for each of three perspectives. Our method for estimating non-energy benefits was based on two key steps: multiplying the potential *value* of a change times the expected change in *incidence* of the factor based on program participation. Refinements continue in both these areas.

- *Estimates of "Value":* Based on the results and ranges identified in the research, continued efforts need to concentrate on items that (1) have the largest potential impact--or largest size of coefficient or impact, (2) have the greatest uncertainty attached, (3) have high potential for identifying quantitative and credible estimates, and (4) for which utility- or program-specific estimates can be developed.
- *Estimates of "Incidence"*: Using the model for programs other than the VPP requires adjusting underlying assumptions based on program design and target group. Examples of areas that would need adjustments, and therefore may need further research, include arrearage incidence and level; variations by *component or audience*; and similar program-specific factors.

Examples of specific target areas for further investigation are shown in Table 3.

Summary and Conclusions

The research presented in this paper demonstrates that non-energy benefits are strong contributors to overall benefits associated with DSM program delivery. And overall benefits may be especially important to consider with changes in avoided cost, industry restructuring, and other major shifts affecting the industry. Historically, program decisions were made based on expected energy savings from the program, compared to the costs. Given historical avoided cost, strong programs were implemented based on these criteria. However, with recent reductions in avoided cost in the industry, few programs could "pass" based on this partial assessment of costs and benefits. Our analysis shows that when a more complete benefit cost analysis is conducted, incorporating appropriate non-energy benefits, paybacks and other program indicators show significant improvement (and the analysis is very conservative in some respects). In the case of PG&E's Venture Partners Pilot Program, calculations of simple payback improved from 7 years (based on energy savings alone) to 3.8 years when non-energy benefits were included. Incorporating the societal or customer perspective lead to even greater overall benefits from the program.

In this research, efforts were made to move beyond "conceptual" lists of benefits. The paper uses a combination of information from the literature, program-specific information, and other assumptions to derive estimates and identify ranges for more than two dozen categories of non-energy benefits. In addition, the calculation approach and model developed allows the utility to easily examine the impact of changes in program or impact assumptions on the estimate of benefits. These impacts can be examined from the utility, participant, or societal perspective, and the effect on program payback and other metrics can be examined easily.

Our research also shows that important benefits accrue not only to the utility and its ratepayers, but the results indicate that customers realize large benefits above and beyond the basic energy savings they enjoy from programs.

Table 3. Examples/Candidates of "Target" Research for Non-energy Benefits

Priority category	Utility Perspective	Societal Perspective	Customer Perspective
Large potential impact, research needed to refine	■ gas emergency calls	■ direct and indirect economic effects, ■ transfer payments ■ environmental impacts	■ educational/employment benefits from reduced mobility ■ impacts on illness/ health/ safety
Most uncertainty, research needed to narrow	■ debt/arrearage impact ■ insurance/risk ■ T&D losses	■ environmental benefits ■ economic impacts ■ health and safety benefits	■ comfort, safety, maintenance ■ transaction costs ■ housing stock effects ■ reduced rental value from insufficient housing quality, services
Utility or program-specific information needed	■ arrearage carrying costs ■ arrearage levels ■ insurance/risk ■ modifications from target and program differences		■ neighborhood preservation effects and repairs from program
Small impact, not priority for extensive research	■ costs from shutoffs ■ costs from late notices ■ costs from customer calls		■ lost rental value from TONP
Not much research needed: can fairly readily estimate	■ rate subsidy avoided	■ water/sewer benefits	■ water/sewer benefits

Other Research Topics

- Variation in underlying "percentages" based on target groups for various programs under consideration
- Identifying additional types of non-energy benefits that need to be incorporated into the model because of different program design, target groups, etc.
- Work with "control" groups and participants to refine estimates of likely changes in key variables from participation (including arrearages, etc.)
- Variations by the types of *components* delivered with the program, including education, audit, retrofit, etc.
- Estimates of benefits of cooperation with other agencies (funding, administration, or other), where appropriate.
- Estimating the non-energy benefits associated with addressing potential combustion problems as part of programs, because of the significant non-energy benefits that might accrue.
- Refine liability benefits from potential gas explosions avoided from some programs.

These benefits could potentially play an important role in program targeting and outreach. The scenario and modeling approach described within the paper can be used to optimize programs by examining program design alternatives to maximize benefits to customers, society, and the utility and its ratepayers, keeping program costs constant. Finally, based on the results of the estimation process, the paper points out areas that would be most fruitful for future research in the area of non-energy benefits.

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Note: Recall that, for space considerations, the detailed literature survey was omitted in this published version. Additional references and the detailed literature survey can be obtained by contacting the author at (206) 624-8508.