Using NEBs to Attract "Ordinary" Homeowners to Energy Efficiency: The New Zealand Case

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ABSTRACT

Household energy consumption depends both on activities and, to a high degree, the choice of technology used / installed in our homes. In many situations, energy-efficiency (EE) measures are associated with energy cost savings. However, these technologies also bring significant other potential benefits related to the natural environment and lifestyle. These issues tend to be more significant decision drivers to consumers than energy savings, but valuing and comparing these non-financial benefits is inherently difficult.

The new century is seeing a worldwide trend towards achieving a sustainable environment and eco-societies. New Zealand is an island country with limited usable resources and is also a developed country facing strong population and natural consumption growth. Given the resulting pressures placed on energy, housing, water, and the environment, the project was designed to quantify factors that influence program decision-making, and provide an opportunity to most effectively market programs that reduce the energy-related burdens on the environment.

The evaluation included a new home construction program, a weatherization program, and an insulation-retrofit program. The Non-energy benefits (NEBs) associated with each program differed – both in the most highly valued NEBs and the level of value compared to the program's projected savings. Highly valued benefits included improvements in comfort, bill control, health, noise, maintenance and the environment. Both positive and negative impacts were investigated to identify the net value that the occupant placed on the outcomes. The results suggest that most residents place a much higher value on the lifestyle benefits from energy-efficiency features of their homes than on energy savings. The paper presents these quantitative results, which are being used in program targeting, and marketing of program homes, barriers analysis, and benefit-cost analysis.

Introduction

This article addresses an analysis of the non-energy benefits (NEBs) associated with three energy efficiency building and retrofit programs in New Zealand.

- The Zero and Low Energy Homes Program (ZALEH) (Up to four measures): This new construction program encouraged installation of up to four measures – double glazing, super insulation, solar water heating, and/or solar design features. The questionnaire was administered on-line to a random set of participants that had received at least two of the measures. Homeowners did not receive incentives.

- The "Dunedin" participants (Insulation only): This retrofit program provided insulation upgrades to existing homes in the Dunedin area. The participants owned their homes and had received a small subsidy from the local electricity supply company for the insulation retrofit. The survey was administered by phone to a sample of households whose homes received insulation upgrades.

- The Energy Smart program (Up to 2 measures): This program provided insulation and/or hot water cylinder upgrades to state housing tenants. The program was fully subsidized by the state

housing company, and the surveys were administered by phone, although interviewees could also download the questionnaire from the web to have it in front of them during the phone interview.

SERA developed the survey approach, which was implemented / administered by BRANZ.

NEBs from The New Zealand Energy Efficiency Programs

This project is the first in New Zealand to attempt to quantify a wide range of NEBs for home occupants. Although energy efficiency (EE) programs are designed to save energy, the reality is that households participate in EE programs or adopt energy efficiency measures for a host of reasons in addition to the specific program's interventions. When participants in programs in the US are asked, they routinely cite non-energy impacts and considerations either as a component of decision-making or as benefits they recognized after installing energy efficient equipment, and residential participants mention non-energy benefits (NEBs) as important reasons for their satisfaction with various programs. This project was interested in examining whether similar results were found in New Zealand.

NEBs[1] include a variety of impacts — positive and negative — that result from a particular program. Strictly speaking, NEBs are "omitted program effects" – impacts attributable to the program, but often ignored in program evaluation work. They can be classified into three "perspectives" — effects on the agency or utility (bill payment improvements, etc.), on society (environmental, etc.), and on the participants. This paper focuses on the third category — participant effects.

Participant (or "user") benefits consist of non-energy factors that benefit or affect the participant users of the energy efficient equipment – for example, comfort, improved ability to pay bills, and a wide variety of factors. These effects are valued in terms relevant to the participant. The benefits to participants derive from several main "drivers" – specifically "net" impacts from:

- Payment and collection-related effects,
- Education and knowledge of energy use, building, and equipment,
- Changes in building stock / building value,
- Health-related changes,
- Direct and indirect changes from equipment service (including comfort, maintenance, etc.)
- Changes in other utility bills (e.g. water bills, etc.)

In this study we were careful to define the specific NEBs measured within these categories to minimize overlap and double-counting. In addition, to the extent possible, we examined the NEBs as "net" in three ways:[2]

- Net to include both positive and negative impacts (for example, allowing for noise increases, disruptions from contractors, worsened O&M, etc.);
- Net to include impacts for efficient equipment above and beyond standard equipment that might otherwise have been installed; and
- Net to include only the effects on those that were influenced toward energy efficiency because of the program (net of free riders, for example).

Methods for measuring specific categories of participant NEBs vary based on the category. Some can be measured directly (for example water savings); however, for the vast majority of participant impacts, participant surveys are needed. We have examined a number of different

[1] Note that the literature has used the designation "non-energy benefits" although we examine both positive and negative impacts from energy efficiency measures. Although the conventional term NEB is used in this project, the name refers to "net" non-energy benefits. We do not adopt other terms like non-energy effects because that "loses" the past literature addressing the topic.

[2] For more information on these "net" concepts, see Skumatz 2005.

approaches, and have had the opportunity to evaluate a number of them with respect to a number of criteria: credible methods / demonstrated in literature; ease of response by respondent / comprehension of the question by respondents; reliability of the results / volatility; conservative / consistent results; and computation clarity, among others. Using phone, mail, web, and email approaches, we have tested, refined, and used more than a dozen variations of several core measurement approaches, including:[3]

- Willingness to pay (WTP) / willingness to accept (WTA) / contingent valuation (CV)
- Alternative methods of comparative or relative valuations
- Direct computations of value to owner
- Discrete choice and ordered logit approaches, and
- Other revealed preference and stated preference approaches.[4]

Detailed studies of the relative performance and consistency of these results have been conducted to identify the "best" and most defensible methods of measuring NEBs. This information was used to select the measurement approaches applied to the New Zealand housing program work. The surveys for this project used two main non-energy benefits valuation questions; Labeled Magnitudinal Scaling (LMS) questions and Contingent Valuation (CV) questions.[5]

NEB Valuation Results for the Three Programs

The results for both the value of all the NEBs for each program, as well as the value of the individual categories of NEBs for each program, are provided below.

- **ZALEH Program**: Double glazing, super insulation, and solar design all provided very valuable net benefits to residents, each representing value of a quarter or more of the energy savings, and representing $118-250 worth of annual benefits to the resident ($537/year or $45/month).

- **Dunedin Program**: Each of the two measures included in this program deliver benefits worth one quarter or more of the energy savings attributable to the equipment. Given the more limited nature of these measures, the monthly savings are more modest than for the more "whole house" ZALEH program.

- **Energy Smart Program**: Insulation upgrades appear to deliver a reasonably "big bang" impact in terms of non-energy benefits, representing almost three quarters of the value of the direct energy bill savings attributable to the measure.

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[3] Note that other non-survey-based measurement approaches include: direct measure based on pre-post or other method; regression approaches; and others. Most of these approaches are very costly, and therefore, suffer from large missing data or small sample issues. We have adapted multiple survey-based measurement methods to estimating NEBs, including willingness to pay (WTP) / willingness to accept, bounded WTP, card ranking, ordered logit, and others. Generally our results indicate that the comparative and LMS methods, and the ranking and ordered logit approaches work well; bounded WTP performs better than open-ended WTP. We base these conclusions on consistency of results, ease and speed of response by interviewees, among other criteria (see Skumatz 2002, Skumatz and Gardner 1/2006, Skumatz and Gardner 7/2006. The survey approaches we have tested work well, are well-grounded in the literature, and offer the opportunity to have much larger samples, presumably improving the quality of the results.

[4] As mentioned, some analysis of approaches is provided in Skumatz 2002 and Skumatz and Gardner 2006.

[5] To compute the value of the NEBs, we asked households about the value of the NEBs relative to the energy savings realized from the program (which is a known value). Using multipliers derived from the literature and from the results of thousands of previous surveys in a proprietary model, we were then able to translate these verbal results into numeric multipliers to develop the estimates. For detailed discussions of these approaches, see many of the works provided in the references, including Skumatz 2002, and Skumatz and Gardner 2006.

Table 1 presents the dollar value of total array of NEBs recognized by the residents for each of the three programs. Table 2 reports the share of the total NEBs assigned to each category.

Table 1. Total NEB Results for the Three New Zealand Programs

Double Glazing	Annual Energy Savings ($)	Annual NEBs (LMS) ($)	Implied NEB Multiplier (NEB/Energy Savings)	Percent of Total Program NEBs
ZALEH Program				
Double Glazing	448	118	0.26	20%
Super Insulation	678	249	0.37	44%
Solar Water Heating	796	29	0.04	5%
Solar Design	685	170	0.25	30%
Dunedin Program				
Insulation	96	29	0.30	59%
Hot Water Cylinder Wrap	130	20	0.22	41%
Energy Smart Program				
Insulation	112[6]	79	0.71	100%

The respondents were also asked about the value of specific benefits they received from the program measures. The results for the programs and measures are presented below.

Table 2 Percent of Total NEBs by Category

	Double Glazing	Super Insulation	Solar Water Heat	Solar Design
NEB Category	**Share**	**Share**	**Share**	**Share**
Comfort	22%	19%	14%	21%
Noise	23%	14%	1%	2%
Appearance	0%	1%	-49%	-2%
Maintenance	1%	3%	-30%	-3%
Features	5%	3%	21%	6%
Environment	0%	12%	60%	22%
Health	12%	17%	10%	14%
Energy bill control	19%	16%	55%	24%
Moving avoidance	7%	5%	13%	12%
Bill-related calls	5%	5%	5%	6%
Other	7%	6%	0%	-2%

ZALEH Program

The NEB results are discussed below.,

- **Double Glazing:** The value of the NEBs is about $117 annually, or just over under a quarter of annual energy savings. Noise reduction and comfort were the most important non-energy aspects of double glazing, with energy bill control a close third. None of the categories had benefits that were negative on average.

- **Super Insulation**: Respondents found insulation to be among the most beneficial measures, in terms of both energy savings and non-energy benefits. The average dollar value for the non-energy benefits associated with insulation was $250, or just over one-third of the value of the annual energy savings. As with double glazing, comfort, noise reduction and energy bill control were important components of aggregate non-energy benefits. However, respondents also

[6] This represents the energy savings associated with the insulation, not total program savings.

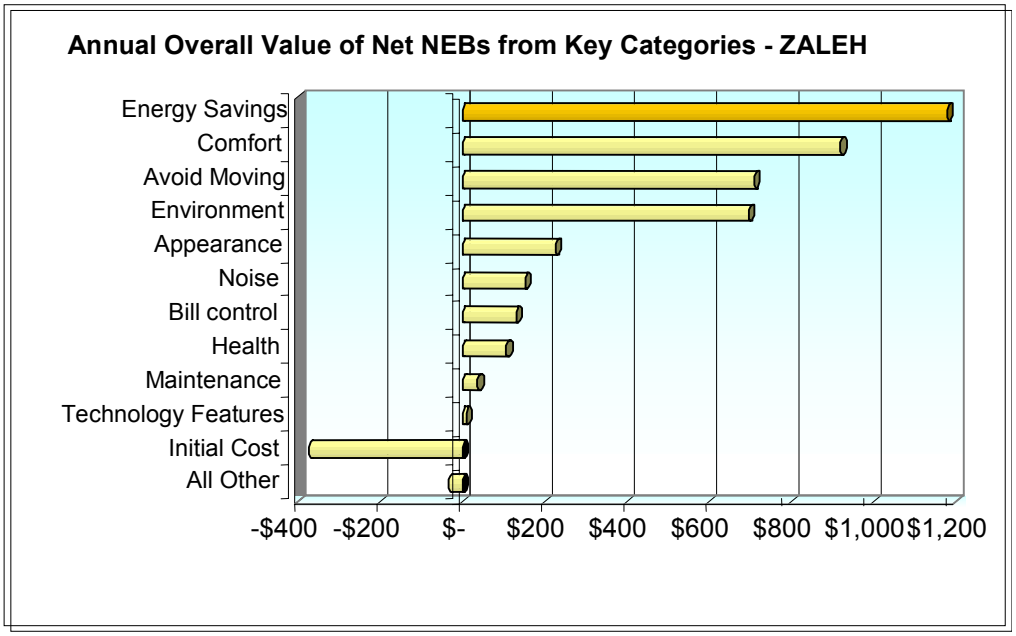
reported significant benefits associated with helping the environment and increased health. Once again, the average benefit for each category was positive.

- **Solar Water Heating**: Significant energy savings are associated with solar water heating, however, the NEBs from these systems are only estimated to represent 4% of the energy savings. The results indicate respondents felt that such heating measures decreased the aesthetics of their home and required additional maintenance, to the extent that these disadvantages were burdensome. However, respondents also overwhelmingly felt that installing solar water heating was very helpful in controlling their energy bills, and had positive environmental implications. Together, the positive aspects of solar water heating, on average, outweighed the negative aspects (although for some respondents the net non-energy benefit was negative).

- **Solar Design**: The estimated NEBs from solar design are $170, which represent about one-quarter of the value the households received from the energy savings from the solar design features. Energy bill control, environmental benefits and comfort were the three most important non-energy aspects of solar design. The average respondent felt that appearance, maintenance and some other aspects of their home were affected negatively by solar design. However, these effects were small compared to the advantages in other areas.

Figure 1 shows the overall value participants placed on the NEBs associated with the ZALEH program.

Figure 1. Dollar Value of Individual NEBs for the ZALEH Program

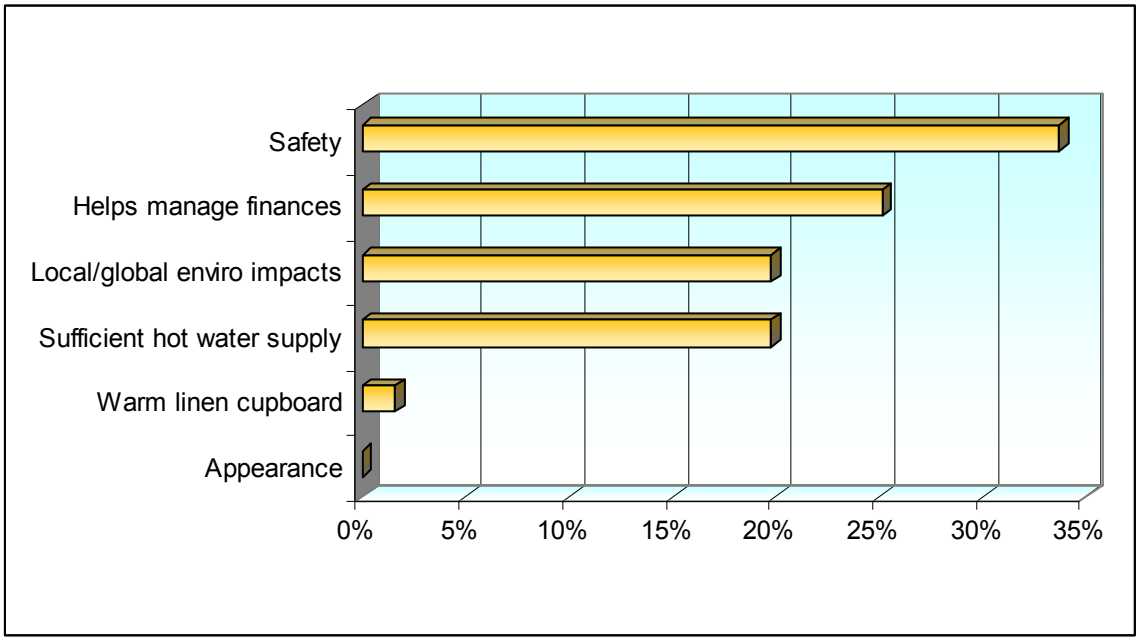


Dunedin Hot Water Cylinder Wrap

Energy savings for adding a hot water wrap were estimated as $130 per year, on average. Installing such a wrap also gave rise to an annual non-energy benefit of about $30. Safety and the management of household finances were the most important (positive) aspects of total non-energy benefits associated with installing a hot water cylinder wrap. The presence of a sufficient hot water supply and the environmental benefits associated with the wrap were also important. One respondent felt

that the wrap took up too much space; however, every other respondent felt that the effects of the wrap were positive. The results for the full range of NEBs associated with the Dunedin prorgram's hot water cylinder wrap measure are shown in Figure 2.

Figure 2. Percent of Total NEBs for the Dunedin Program Water Heater Wrap Measure by NEB Category



Energy Smart and Dunedin Insulation Results:

The Energy Smart survey dealt with insulation retrofits only.[7] The average annual non-energy benefit associated with insulation the insulation retrofits was $78. This represents a value equal to almost three-fourths of the value of the energy savings derived from the insulation measures – higher multipliers than those associated with the measures discussed earlier. Overall comfort and ease of selling and renting the home were the most substantial non-energy benefits categories, suggesting that additional insulation is useful both as an upgrade for residents to enhance household comfort and as a selling point for potential renters or buyers. In addition, the results showed perceived improvements in counteracting dampness and mold also provided value.

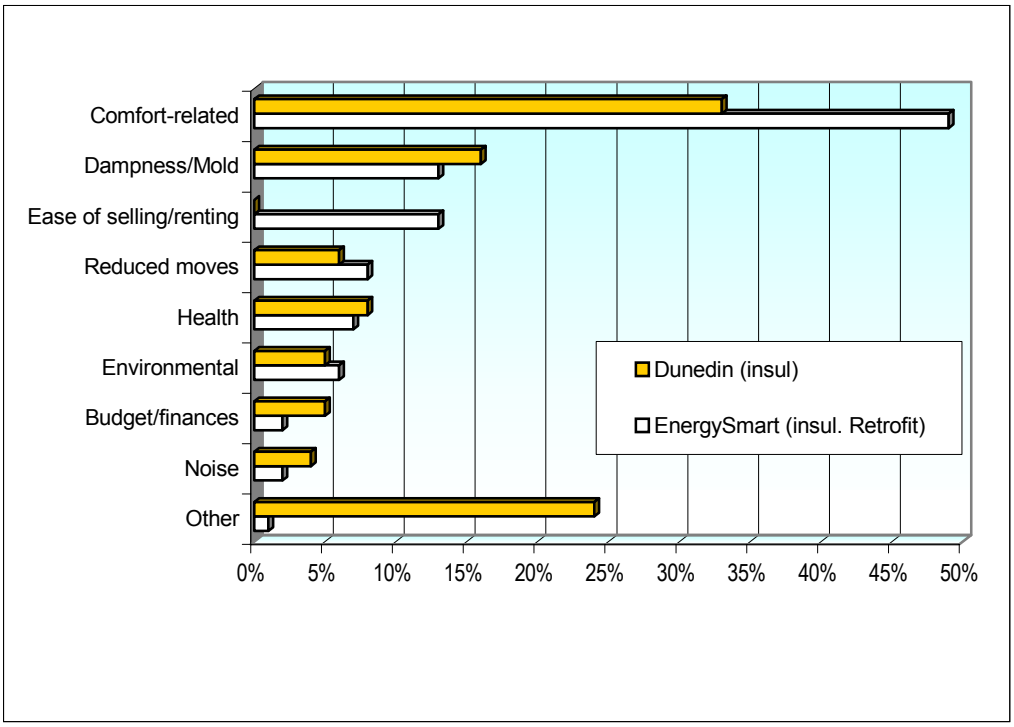
The results for the Dunedin insulation survey showed that total annual energy savings (attributable to insulation) were on the order of $96, with aggregate non-energy benefits of roughly $30 annually. On average, NEBs are valued at about 30% of the value of the associated energy savings.[8] Comfort-related improvements (specifically winter heating and floor temperature changes), improvements in humidity and dampness, and health related effects were among the most valuable aspects of the insulation measures for participants in the Dunedin program.

The results for the individual NEBs associated with the Energy Smart and Dunedin insulation programs are shown in Figure 3.

[7] For both the EnergySmart and Dunedin surveys, respondents were asked to estimate both (a) their total energy savings and (b) the energy savings due to the particular measure in question. The valuation analysis for both of these surveys uses the latter in creating dollar value estimates.

[8] The CV questions were posed in a different way for the Dunedin survey, so the results are presented separately in a later section.

Figure 3. Individual NEBs for the Dunedin Insulation and Energy Smart Insulation Measures – Percent of Total Program NEBs



Effects of Demographics

In this study, we also examined the role that demographics had on the perceptions of NEB values from the programs. These findings could potentially help target programs to those households that would:

- realize greatest NEBs from the programs,
- realize the greatest payback from the program expenditures, and
- potentially be early adopters, with the easiest economic case to make for investment in energy efficiency.

We examined the effect of demographics by regressing the NEB values against the various demographic, attitudinal, and household characteristic information available from program records.[9] We present the results of the Energy Smart program as an example of these analyses. The following demographic factors were available from records:

- Number of residents in the household
- Annual household income (before tax) -
- Owner vs. renter
- Type of fuel used in the home (LPG, firewood, coal, and other sources)
- Total energy savings from the program
- Extent to which energy features were claimed as an important factor in selecting the current house, and the future house

[9] We have previously used regression techniques to attribute NEB values to specific measures when programs included multiple measures. See Skumatz and Gardner 2006.

The results indicate that larger households, and those with higher incomes, and those that owned their home generally reported lower NEB values; that is, small, lower income renting households perceived higher net benefits from the program. We also found that those households that used firewood reported lower NEB values from the program; the LPG users showed lower NEBs but the results were not quite significant. Finally, the results showed no relationships with the total value of energy savings, but those that were thinking about energy features when considering their next home were more likely to report higher NEBs. We found this to be an important (and heartening) result. Individuals do not seem to perceive NEB values simply as a ratio of energy savings, but the NEBs that individuals perceive are affected by their demographics. The ratio between energy savings and NEBs on an individual basis show a range of values based on other factors. The results indicate that program design and marketing staff can maximize total attributable benefits by targeting small, lower income homes – not only by targeting households with the largest savings potential.

Findings and Interpretation of the NEB Results

Analysis of NEBs has wide applications beyond the simple "valuation" of the NEBs. Examining the perceptions of NEBs that are positive and negative, and those that are most valuable, provide information important to program evaluation, decision-making, marketing, and other applications.

Opportunities and Apparent Barriers for the Programs / Measures[10]

The NEB analysis provides useful feedback on the program's design. The NEB results indicate that many factors were perceived as a net positive from the energy efficiency (EE) measures and the program. However, the feedback also shows that some of the benefits were relatively low – and in fact, in some cases the net NEBs were negative. The results for each program are presented in Table 3.

Table 3. Summary of Barriers and Selling Points

	ZALEH Program Results	EnergySmart Survey	Dunedin Results
Barriers – Negative NEB	Solar Water Heat & Solar Design: Appearance and Maintenance concerns, Other (overheating, power consumption, access)	None	Water heater wrap: Other
Selling Points	*Double Glazed Windows*: Reduced noise, improved comfort, better control over bills *Insulation*: more comfort, health benefits, control over energy bill, reduced noise *Solar Water Heat & Solar Design*: Environmental benefits, Control over energy bill, comfort	Overall comfort, winter heating, ease of selling / renting home	Other, heating / floor temperature, humidity/ dampness

Few of the programs had any negative NEBs. However, the solar water heat and solar design measures had net negative NEBs in a couple of areas: appearance, and maintenance concerns. These are important "barriers" that may be making potential homebuyers nervous about the technologies. The analysis showed that these problems or barriers represent a significant "cost" to the residents. These results are summarized in Table 4.

[10] No analysis of "disconnects" was possible, as only participants were interviewed. This may be a focus of next incarnations of this project.

Table 4. Summary of the Value of the Barriers for NEBs

Negative NEB values / cost of barrier	Solar Water Heat	Solar Design	Dunedin Water Wrap
Appearance (NZ$)	$14	$3	-
Maintenance (NZ$)	$9	$5	-
Other (NZ$)	-	$3	$39
Total value of Negative NEBs for Measure (and share of energy savings)	-$23 (0.79)	$11 (.06)	$39 (1.36)

These figures imply that to address these barriers in the marketplace may require interventions. There are two potential scenarios:

- **Negative NEB is based perception, not supported in fact.** The NEB results show that participants perceived that maintenance for the EE equipment is more difficult (or more expensive) than maintenance for standard equipment. If the facts do not support this perception, then the program may benefit by delivering targeted education materials to vendors, or developing test data or demonstration sites, that address this issue.[11] This may help vendors recommend EE equipment to customers while alleviating their concerns.

- **Negative NEB is supported in fact**. However, if these results represent real costs or negatives (and perceptions like appearance would be hard to argue otherwise), then auxiliary interventions may be needed. The results indicate that the value of these interventions may need to approach a one-time or annualized rebate that would help allay an extra cost of $23/year for solar water heat, $11 for solar design, and $39 for water cylinder wraps on average to address the negative perceptions or negative costs realized by participants. If the program wishes to address the barriers for 50% of the participants (or potential participants), the median value for the negative NEBs could be expected to address the issues.[12] These interventions may take the form of rebates, mitigation results, improved / leveraged warranties, or other program benefits that would address the specific type of barrier.

"Selling Points"

The results indicate that there are highly valued non-energy benefits recognized and attributed to the energy efficiency measures installed in these homes. These benefits are worth a significant share of the energy savings (and up to several hundred dollars) for most of the measures and contribute a great deal to the
householder's payback for the measures.

Summary and Conclusions

The research focuses on quantifying hard to measure (and omitted) program impacts to provide information for marketing, resource allocation, and program refinement. State of the art measurement techniques

[11] Similarly, if maintenance or noise reduction effects (which had low NEB values) are positive, these may be additional points to be addressed for vendors.

[12] Of course, if a one-time rebate is planned, then some one-time fee computed from the annual perceived cost or barrier would be computed. For simplicity, assume the solar water heat measure (annual barrier value of $23) has a 20 year lifetime, and assume zero discount rates for households. Then the analysis would imply that the negative factors associated with solar systems would be offset (and households would be indifferent with respect to these features/barriers), with a one-time intervention valued at $460. This could be presented as a rebate, as a "buy-up" in a maintenance contract or warranty, or other intervention or set of interventions valued at about this amount. Incorporation of a discount rate would reduce this dollar amount; changes in lifetime assumptions would also change the result.

were used to derive estimates of NEBs. This included statistical analysis of surveys, and computation of an array of results using primary and secondary program-related and demographic data.

The analysis also provides quantitative estimates that support anecdotal evidence that NEBs are important to participants as recognized by participating vendors. There is general agreement that valued program and measure NEBs include:

- Double glazed windows: The highest value benefits include the noise insulating effects of double-glazing, as well as the improved comfort and ability to control energy bills. These three benefits are worth more than $75 per year to the average homeowner.
- Insulation: The most valuable NEBs from super-insulation include improved comfort and noise reduction, health benefits, and better control over the bill. These benefits alone total more than $165 per year for the average homeowner..
- Solar water heat and solar design: The NEBs that homeowners with these measures valued most highly were environmental benefits and improved control over the bill. These were worth $37 per year for solar water heater homes, and $114 for solar design homeowners.
- EnergySmart survey: The most highly valued NEBs for this group included comfort, winter heating, and ease of selling or renting the home. These key benefits were worth more than $35 per year.
- Dunedin results: The homeowners with insulation valued various comfort-related benefits relatively highly, and these benefits were estimated to be worth more than $17 per year to participants.

Many of these benefits may be an easier "sell" than energy efficiency. In addition, the results of the demographic analysis indicate that any targeted marketing might focus on households with smaller family sizes, lower income renters, and households using LPG or firewood.

This research and its results can be used to help design programs toward specific measures and actors to maximize NEBs. In addition, marketing that focuses on "winning" NEBs can increase program appeal and improve chances of adoption and attraction of measures.

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