Zero and low energy homes in New Zealand: The value of non-energy benefits and their use in attracting homeowners

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Abstract
This paper details an analysis of the indirect, hard-to-measure "Non-Energy Benefits" (NEBs) associated with a residential energy efficiency initiative in New Zealand called Zero and Low Energy Homes (ZALEH), a program that integrated double-glazing, super insulation, solar water heat, and solar design features into new homes. The paper reviews an array of measurement methods and uses one of the methods to estimate program-attributable NEBs. Using survey-based data, we found that the program delivered positive and negative impacts beyond energy savings. In particular, we found barriers for the solar water heat and solar design measures included appearance and maintenance concerns. If these concerns are overstated, they may need to be addressed in program literature or discussed with vendors in order to equip them to allay consumer fears. If the concerns are based on actual performance, the barriers may need to be addressed through adjustments in incentives or warranty enhancements or similar strategies. Positive benefits that may appeal for marketing purposes included: reduced noise, improved comfort, better control over bills, health benefits, and environmental benefits, with variations depending on the measure(s) installed. 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 considerable value on the lifestyle benefits from energy-efficiency features of their homes, beyond benefits from energy savings. The paper presents these quantitative results, which are being used in program targeting, marketing of ZALEH homes, and other purposes.

Background on NEBs
New Zealand is an island country with limited usable resources and is also a developed country facing strong population and natural consumption growth. Pressures are therefore placed on energy, housing and water often with detrimental effects on a wide range of environmental aspects (as well as social and economic effects). Concern about sustainable environment has led to pilot tests of several energy conservation programs in the country. This paper examines the non-energy benefits results for one of these programs – the Zero and Low Energy Homes program (ZALEH).

The level of our household energy consumption depends not only on our activities, but also to a high degree on the choice of technology we use in our homes. Energy-efficiency (EE) measures are designed to deliver energy cost savings. However, these technologies also have the potential to bring significant other benefits related to both lifestyle and the natural environment. These issues can be large enough to influence program decision-making and benefit cost / payback analyses associated with the program. Households participate in EE programs or adopt energy efficiency measures for a host of reasons in addition to the specific program's interventions. Participants cite non-energy impacts and considerations either as a component of decision-making, as benefits they recognized after installing energy efficient equipment, or as a contributing reason for their satisfaction with various programs (Mills and Rosenfeld, 1994, Skumatz and Dickerson 1998 and many others). However, valuing and comparing these non-financial benefits is inherently difficult, and that challenge is the focus of the paper.

A significant body of work has developed around recognizing and measuring net non-energy benefits (NEBs). NEBs[1] include a variety of impacts — positive and negative — that result from energy programs. Strictly speaking, NEBs are "omitted program effects" – impacts attributable to the program, but often ignored in program evaluation work. After years of research, more and more utilities and regulators are considering these effects in program design, benefit / cost analysis, marketing, and other applications.

Over the last 20 years, a wide range of NEBs from home-based programs have been identified in studies.[2] Early publications focused on enumerating potential categories of benefits or theoretical discussions (Mills and Rosenfeld 1994, Flanagan 1995 and many others), but quantitative work was scarce. The early work in non-energy benefits (NEBs) was applied to low income programs. The best early quantitative work was conducted in association with two programs, including the nationwide Weatherization Assistance Project (Brown et.al. 1993) and a Colorado homes program (Magouirk 1995). Brown examined NEBs related to property values, reduced fires, reduced arrearages, tax and economic benefits and environmental externalities. Magouirk included estimates of impacts from emergency gas service calls, payment-related effects, and other effects. These studies provided useful early estimates of NEBs, but suffered from several problems. They estimated benefits in only a scattering of topics, mixed benefits that accrued to different beneficiaries, and used different "units" – with some benefits expressed in net present value and others in on-going terms (although Magouirk provided measurements in more consistent units). One additional difficulty in these and other early studies was that all the benefits were computed using secondary or independent data, which severely limited the array of benefit categories that could be estimated. Work in categorization and measurement of NEBs are described in the next sections.

CATEGORIZATION OF NEBS

Starting with work in the mid-1990s, the literature began to explore more consistent measurement methods, and sort these benefits into three "perspectives" (Skumatz 1997) based on the beneficiary of the effect: [3]

- **Utility/agency benefits.** These are positive or negative impacts that affect ratepayers and utilities and reduce revenue requirements – for example lower bad debt because of lower arrearages, lower line losses, power quality issues, and reduced labor cost from fewer bill-collection-related calls. These effects are generally valued at utility (marginal) costs.
- **Participant (or "user") benefits.** These consist of non-energy factors that benefit or affect the participant users of the energy efficient equipment beyond energy savings – for example, comfort, improved ability to pay bills, and a wide variety of factors. These effects are valued in terms relevant to the participant.
- **Societal benefits.** Non-energy impacts that (positively or negatively) affect the greater society or that cannot be attributed directly to utility/ratepayers or participants. These include emissions/environmental benefits/health benefits, direct and indirect economic multipliers, water system benefits (if they need fewer treatment plants, etc.), or similar items. These effects are valued as appropriate to the benefit category.

Note that benefits can arise in multiple perspectives without being redundant. For instance a reduction in bill-related calls to the utility company benefits both the utility / ratepayers *and* the participating households making or receiving those calls. This is not double-counting benefits – rather, it recognizes that some effects have multiple beneficiaries and each is valued at the appropriate tailored valuation method. The utility benefits would be valued at utility marginal wage rate for customer service staff, and the household would have the same amount of time valued at minimum wage, leisure wage, or some other appropriate value.

Benefits are recognized and realized by both groups. However, whether either or both of these benefits are included in the ultimate sum total of the NEBs for the research or calculation depends on the purpose of the research. Elements (e.g. utility impacts) may be included in direct program-related benefit cost work , but these computations would likely ignore the participant impacts. Analysts choose the appropriate NEB categories based on the purpose of their research, or the appropriateness to their decision-making objective.

Given that one of the key objectives of this project was to identify NEBs that might be used in program marketing, this paper focuses on measuring the participant benefits. 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.), and
- Other changes.

Care is needed in defining the specific NEBs measured within these categories to minimize overlap and double-counting.[4]

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. In addition, the literature historically calls these effects "non-energy benefits" even though they may be negative. There have been several suggestions to call them non-energy effects or non-energy impacts (See Skumatz 2004), using the traditional term better respects the literature, and there is nothing lost by calling them net-NEBs or NEBs, and the literature remains more robust.

2. A detailed literature review is included in many previous studies conducted by the author (see Skumatz 1997, Skumatz and Dickerson1998, Weitzel and Skumatz 2001, and others) covering more than 300 studies. An abbreviated review, focused on measurement approaches and issues, is provided here.

3. The authors established, and the literature has adopted, the convention of categorizing NEBs into three groups based on beneficiary (Skumatz 1997).

4. For instance, owners may have difficulty separating out labor changes from maintenance benefits.

Negative NEBs include production disruption during installation, negative values of the categories above (often maintenance), and other effects. The authors use several approaches to minimize these overlaps.

Measuring NEBs: Methods and Selected Approach

Well-researched measurement work on NEBs, based on detailed literature research and work in contingent valuation, scaling techniques, revealed and stated preference and other methods were pioneered in the late 1990s.[5] Granted, NEBs are, almost by definition, Hard to Measure (HTM); however, not measuring the effects means that decisions about programs are likely to be suboptimal because they ignore key effects. Running scenario analysis around ranges or order of magnitude values would be preferable to excluding the impacts altogether. Thus, approximate estimates provide value; the improving sophistication of measurement methods implies that these approximations are getting better and better.

We have examined a number of different possible measurement approaches with applicability to NEBs. We have evaluated 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:

- Direct computational approaches, and
- Survey-based approaches, including: Willingness to pay (WTP) / willingness to accept (WTA) / contingent valuation (CV); comparative or relative valuations; discrete choice and ordered logit approaches, and other revealed preference and stated preference approaches.[6]

A number of these approaches are discussed below.

DIRECT COMPUTATION:

Some categories of NEBs can be estimated fairly directly. For example, lost work time can be calculated using wage rates[7] or other monetary values for time, and water/sewer savings can be calculated using data on actual water and sewer rates. In some cases, statistical and regression approaches have been used to develop estimates of productivity or other effects that can be affected by confounding factors (Okura, et.al. 2000). Unfortunately, an extensive array of less tangible but potentially important benefits cannot be estimated directly, including comfort, aesthetics, and other factors. Relying on computational methods are not sufficient in deriving overall estimates of participant-perspective NEBs.

SURVEY-BASED APPROACHES:

A variety of survey-based valuation methods have been used by economists, social scientists, and researchers in the environmental and advertising fields to develop estimates of the monetary value of externalities and intangible goods. Methods with particular applicability to energy are discussed below (Skumatz and Gardner 2006).

- *Contingent Valuation and Willingness to pay (WTP) surveys*. Contingent valuation surveys are widely used in the environment and natural resources fields to estimate the value of intangible or hard-to-measure impacts including recreation, environmental and other effects. The contingent valuation (CV) method of non-energy benefits valuation, in its most basic form, entails simply asking respondents to estimate the value of the benefits that they experienced in dollar terms (willingness to pay WTP/ willingness to accept WTA are common approaches). An advantage of WTP surveys is that they provide specific dollar values for benefits that can be compared to each other and to the value given for the comprehensive set of program benefits. Disadvantages include the difficulty that many respondents have in answering the questions, the volatility of the responses, and significant variations in responses based on socioeconomic, demographic and attitudinal variables. Responses to open-ended contingent valuation questions are more prone to bias (Arrow et al. 1993), and the experience of the authors has been that such responses vary more than those provided by any of the other valuation techniques discussed in this paper (Skumatz 2002, Skumatz and Gardner 2006).[8] Arrow et al. (1993) list the following criticisms of the contingent valuation (CV) method for environmental valuation: 1) CV can produce results that appear to be inconsistent with assumptions of rational choice; 2) responses can seem implausibly large when considering multiple programs; 3) relatively few previous applications of the CV method have reminded respondents of relevant budget constraints; 4) it can be difficult to provide adequate background information on the programs and assume it is absorbed by respondents; 5) it can be difficult to determine "extent of market" in generating aggregate CV estimates , and 6) CV respondents may be expressing the "warm glow" of giving, rather than actual willingness to pay for the program in question.[9]

5. Measurement methods have been discussed in detail in previous papers including in Skumatz 2002, Skumatz and Gardner 2006. Choice models have also been applied in several projects, including projects in this paper, with strong results. Results for this paper were gathered via phone, in-person, fax, and web approaches.

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

7. As noted in Skumatz and Gardner, 2006, there are weaknesses from some of the direct computation methods as well. As an example, if we are examining impacts to participants in a business program, and gathering data the businesses measured on productivity or other impacts, we are likely to find that these measurements are missing for many participants. If we constructed average findings from these data, the results will suffer from missing data, but a strong case can be made that the results will be biased (upward). Businesses likely to conduct these studies will be those that expected or experienced significant impacts; others will remain unstudied. Survey-based approaches that all can answer may, in fact, be an important source of data even when direct computations might theoretically be computed.

8. The authors point out that, regardless of the refinement for the open-ended willingness to pay question approach, rrespondents pause and ask many questions and remain uncertain about how to answer. Based on our experience with thousands of phone surveys, these questions are apparently even more difficult using written or web surveys. We did not receive sufficient WTP responses in this project to analyze.

9. Despite the well-known limitations of direct or open-ended contingent valuation questions, there are certain situations in which they can be of use in measurement of NEBs. However, while open-ended WTP can sometimes be useful in generating a baseline, to provide more consistent and credible survey information, several variations on WTP/CV approaches can be used. 1) Discrete contingent valuation

- *Relative scaling*: The relative scaling method of non-energy benefits valuation is a stated preferences approach in which survey respondents are asked to express the value of the non-energy benefits that they experienced relative to a well-understood numeraire, such as the energy savings due to the energy-efficiency measures installed through the program, program costs, or potentially any of a host of outside / non-program factors.[10] There are several variations on the basic approach. In the direct scaling variant, respondents are asked to estimate their non-energy benefits (both positive and negative) as a percentage of their cost savings on energy. In the Labeled Magnitude Scaling (LMS) variant, respondents are asked to rate their non-energy benefits as being more valuable, less valuable or as valuable as the numeraire (e.g., their energy savings). Responses are then scaled using multipliers derived from academic sources modified by extensive empirical work from energy surveys. The relative scaling method has several advantages for use in survey research. First, program participants often find it difficult to express non-energy benefits, which are intertwined with more directly energy-related aspects of the efficiency measures that they receive, in absolute levels. However, as participants in energy efficiency programs, they are often well-attuned to changes in household or business energy costs, and therefore fully cognizant of the value of reduced energy use. Expressing the value of non-energy benefits relative to more obvious energy savings is a natural comparison that most respondents can easily make (Skumatz and Gardner 2006). As noted in Amann (2006), Skumatz developed this approach for use in studies of residential appliance and low-income weatherization programs (Skumatz and Dickerson 1998; Skumatz, Dickerson and Coates 2000) and has since applied it in studies of ENERGY STAR home performance, new homes, and appliance programs (Fuchs, Skumatz and Ellefsen 2004). In these studies, respondents found the relative scaling questions much easier to answer than WTP questions and the responses were more consistent than those from WTP surveys.
- *Hedonic regression*: Most of the other methods presented have been stated preference methods; they require program participants to directly disclose, in one way or another, their preferences for non-energy benefits. Stated preference methods are most common in the valuation of non-market goods, and specifically, environmental goods (such as clean air) which are not bought and sold on an open market and to which property rights are not assigned. Non-energy benefits, however, are market goods. They are purchased by consumers, bundled with the energy-efficiency appliances that produce them. It makes sense, then, that a hedonic approach to the valuation of non-energy benefits may be possible. Traditional hedonic price decompositions estimate the price of a particular good as a function of its different characteristics (Shelper 2001). Because many of the characteristics of goods that give rise to non-energy benefits are abstract and subjective (e.g., light quality), the traditional hedonic regression approach may be difficult to apply. However, using the more restrictive definition of non-energy benefits, a hedonic approach to the estimation of the non-energy benefits that arise due to increased levels of energy-efficiency technology is possible and has been used.[11] This technique may not be as robust as the stated preference approaches discussed above in that it is not capable of estimating all types of non-energy benefits because the more subjective characteristics of energy-using measures (aesthetics, contribution to household comfort and aesthetics, impact on health, etc.) are not available on a product-by-product basis, and are difficult to distill into readily interpretable units. This limitation notwithstanding, the hedonic regression approach non-energy benefits valuation uses data that are (a) readily available for most energy-consuming measures and (b) less susceptible to bias than direct estimates obtained from surveys.[12]
- *Reported Motivations and Factor-Importance Judgments.* Customer-reported motivations for pursuing home performance projects and the relative weighting of those motivations can also be used to determine the value of the energy and non-energy benefits resulting from the project. Lutzenhiser asked customers in a California project about their motivations for buying comprehensive home performance retrofits. The reported multiple motivations among six categories (in order of frequency): specific system/building concern; environmental health and energy costs (tied); comfort; resource conservation; and other (Lutzenhiser Associates 2004). Future work is planned that will weight motivations by importance to help determine the relative portion of project costs paid for energy and non-energy benefits.

questions, in which respondents are asked to give a binary "yes/no" response regarding whether they would be willing to pay a given amount for a specified good (e.g., the non-energy benefits that they experienced). This is the CV question format recommended by the 1993 NOAA panel on contingent valuation (Arrow et al. 1993). 2) Double-bounded or one-and-one-half bounded question formats, in which respondents are asked (a) to give a yes/no response to a first value, then give a follow up response to a second value, which is higher or lower depending on the response to the first question, or (b) told that the true value of the goods in question are thought to exist within a certain range, and asked to give a yes/no response to a random value, then asked to give a second response to a lower or higher value depending on the first response, unless the first response was a no to the lowest value or a yes to the highest value. These variations may increase the quality of the willingness to pay estimates obtained from referendum-type contingent valuation questions. See Cooper, Hanemann and Signorello (2002) for a discussion. 3) Ranking cards to estimate willingness to pay (also called ordered logit). The survey instrument used in this approach differs and asks respondents to rank several hypothetical scenarios in which the amount of non-energy benefits, other characteristics of the program, and a numeraire are varied at random. A rank-order logit model is then used to estimate the parameters on the utility function. The advantage to the rank-order approach is that it neither asks respondents to provide percentage or dollar estimates of the value of the non-energy benefits that they experienced nor does it ask them, hypothetically, whether predetermined values would be acceptable in exchange for those benefits. An additional advantage of this approach is that the information obtained is very robust, and the models can often be estimated with relatively small sample sizes (Weitzel and Skumatz, 2001)

10. The use of this technique and this numeraire for application to energy efficiency programs was pioneered in Skumatz and Dickerson 1997.

11. Caroll (Caroll 2005) discusses a similar approach, suggesting statistical analysis of revealed preferences. Revealed preference models using a combination of program data and survey results can be used to derive estimates of NEB value. The models are used to determine how reported intent translates into action, incorporating information on, for example, the cost of the installed measures, the NEBs reported by participants, and the value of those NEBs as determined through a CV survey to derive estimates of the actual costs participants paid for the energy and NEBs associated with common projects or measures (Carroll 2005). One drawback of this approach is the time and expense associated with data collection and analysis.

12. Of course, the hedonic regression approach also assumes that the characteristics of a good are the only significant determinants of its price – an assumption which may or may not be reasonable depending on the good under investigation.

SELECTED MEASUREMENT METHODS FOR NEW ZEALAND WORK

The problem is to come up with a well-grounded, consistent, reliable, defensible, *and practical* way of valuing these "real", but hard to measure impacts caused by program interventions. We conducted an analysis of the pros and cons of the measurement alternatives (theoretical and practical), considered limitations of the project budget, and conducted an assessment of detailed studies of the relative performance and consistency of these results to identify the "best" and most defensible methods of measuring NEBs for the New Zealand program work. Survey-based approaches[13] have been repeatedly applied in energy and resource-related literature, and provide the most effective method of developing estimates of the broad range of hard-to-measure participant NEBs. The surveys for this project used two main non-energy benefits valuation question;

- Labeled Magnitudinal Scaling (LMS) questions and
- Contingent Valuation (CV) questions.

We also undertook extra efforts to make sure we were measuring effects attributable to the program by measuring "net" benefits, defined in several ways, including: 1) "net" including both positive and negative effects, and 2) "net" impacts above and beyond the standard efficiency[14] equipment that would otherwise have been installed.[15]

As a final adjustment, the authors worked to provide a comprehensive list of NEB categories, yet one that was non-overlapping. Thus, we incorporated questions that asked about NEBs in an open-ended format, followed up by questions about a pre-determined list of NEBs. Then we asked if any of the benefit categories "overlapped" or were hard to separate in the respondent's mind. This helps assure we are not double-counting NEB values.

NEB Valuation Results for the ZALEH Homes

New Zealand is an Island country with limited resources and a reputation for adopting environmental initiatives. The New Zealand Foundation for Research Science and Technology has undertaken several residential building energy efficiency pilot programs. In this project, we evaluated the "Zero and Low Energy Homes (ZALEH)" program (Isaacs, et.al, 2003), which integrated double-glazing, super insulation, solar water heat, and solar design features into new homes. Using survey-based data, we analyzed the NEB impacts beyond energy savings. One of the key purposes of the research was to identify features with strong value that would attract homeowners to ZALEH homes. The survey was conducted using an on-line format, and was administered to a sample of randomly selected owners of program homes –each asked to respond on two of the measures installed under the program.[16] The questions on the web-site survey that were important to the analysis in this paper include:

- An LMS battery of questions, asking about the relative positive or negative value of particular categories of NEBs relative to the energy savings from the program. Respondents were also asked about the relative value of total benefits.[17]
- A set of questions about their willingness to pay for the NEBs overall.[18]
- Demographic, and other context questions about the measures in place, etc.

The results are discussed in detail in the following sections.

ONLINE SURVEY RESULTS

Table 1 presents the mean relative importance of the different categories according to the dollar values obtained for the benefit by applying the LMS technique to the non-energy benefits.[19]

Double Glazing

The value of the NEBs is about NZ$ 117 (61 Euros) annually, or just over under a quarter of annual energy savings. Clearly noise 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.

Table 1. Basic Results for Various Categories

Double Glazing	Mean (NZ$)	Euros
Annual Energy Savings	448	233
Annual NEBs (LMS)	118	61
Implied NEB Multiplier (NEB/Energy Savings)	0.26	
Super Insulation		
Annual Energy Savings	678	353
Annual NEBs (LMS)	249	129
Implied NEB Multiplier (NEB/Energy Savings)	0.37	
Solar Water Heating		
Annual energy savings	796	414
Annual NEBs (LMS)	29	15
Implied NEB Multiplier (NEB/energy	0.04	
Solar Design		
Annual energy savings	685	356
Annual NEBs (LMS)	170	88
Implied NEB Multiplier (NEB/energy savings)	0.25	

13. As discussed in Gardner and Skumatz, 2006, prior research has discussed the difficulties that arise when households attempt to quantify changes in energy use (Kempton 1984, Kempton and Montgomery 1982). The Kempton work. also highlights the role in quantifying energy use household perceptions of the amount of energy that different appliances consume, as well as the limitations of using energy bills, which aggregate all energy use into one number, in decomposing the effects of energy-conserving behavior on household energy use and costs. While previous research into the behavior and perceptual aspects of household energy management acknowledges that the household measurement of energy costs differs in both technique and result from expert energy analysis, this paper is not attempting to measure or use household recollections of energy savings, but perceived values of NEBs relative to energy savings.

14. However, some caveats are needed, depending on how the work is to be used. It may be that in the case of residents that would not have purchased new equipment at all without the program, a case may be made that for participant NEBs, they recognize all the change from old equipment to the new efficient equipment. Also, if the measures would not have been installed for a period of time, the full NEBs may be appropriately credited (as should the savings) during the interim. However, these are fine points on the principles discussed above.

15. In most studies we also compute the NEBs net of "free riders", or program participants that would have purchased the same equipment without the program. However, this project did not include computation of these tpes of net factors, although they may be incorporated into next stages of the research.

16. Sixty completed surveys were obtained.

17. The survey responses provided multipliers that could be compared to energy savings to develop values in terms of 1) ratio or percent relative to energy savings, and 2) dollar (or Euro) value using energy savings estimates as the benchmark.

18. Too few responses were obtained for the WTP questions to support analysis.

19. Conversions in this paper used a ratio of 0.52 Euros per $ 1 NZ.

Table 2. Online Survey Results – Shares by NEB Category and End Use

	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%
Sum of NEB Values (NZ$)	118	250	29	170
Sum of NEB Values (Euros)	61	130	15	88
Share of Energy Savings	0.26	0.37	0.04	0.25

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 (130 Euros), or just over one-third of the value of the annual energy savings. As with double glazing, comfort, noise and energy bill control were important components of aggregate non-energy benefits. However, respondents also 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 shares information (Table 2) explains a great deal of the low non-energy benefits values associated with solar water heating. Respondents clearly 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

Table 1 and Table 2 show the non-energy benefits results for the solar design portion of the online survey. The estimated NEBs are $ 170 (88 Euros), which represent about one-quarter of the value the households received from the energy savings from the solar design features. Energy bill control, environmental benefit 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.

Drilling Down in NEBs: General Applications

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 for energy efficiency programs.

- **Barriers Analysis**: Negative benefits are indications of program barriers that remain – either perceived or real (or both) depending on which actors report the negative NEB. If, for instance, vendors or non-participants report a negative NEB perception, but the participants do not, then the program may benefit by providing greater education or data on that factor. The program would likely obtain more applicants, and the vendors may be able to make a stronger case for the energy efficient equipment. If, however, the barrier represents a real cost – if participants or others (architects, engineers, builders, contractors) notice the problem as well – the NEB results provide an estimate of the cost of the rebate, refund, warranty buy-down or other interventions that may help participants become indifferent to the barrier – and spur participation and adoption of new measures. Tracking these negative values over time provides useful information feedback to let program staff check whether the program is decreasing these barriers over time.[20] The dollar value provides information on the level of investment that may be needed to overcome the barrier.
- **"Disconnects"**: The authors have suggested[21] that the most robust evaluation of the NEBs gathers information from multiple actors involved in the program, including participants, non-participants, vendors, builders or other decision-makers involved in energy efficiency. Gathering results from multiple stakeholders allows an examination of differences in positive and negative perceptions about NEBs as well as differences in associated values. Using this approach, the authors have been able to identify situations in which

20. This feedback is potentially more useful than tracking barrier "scores", which provide less information on the importance of the barrier before or after.

21. Skumatz 2005, and elsewhere.

Table 3. Summary of Barriers and Selling Points

	Online Survey Results
Barriers – Negative NEB	Solar Water Heat & Solar Design: Appearance and Maintenance concerns, Other (overheating, power consumption, access)
Selling / Marketing 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

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

Negative NEB values / cost of barrier	Solar Water Heat NZ$ / Euros	Solar Design NZ$ / Euros
Appearance (NZ$ / Euros)	14 / 7	3 / 2
Maintenance (NZ$ / Euros)	9 / 5	5 / 3
Other (NZ$ / Euros)	-	3 / 2
Total value of Negative NEBs for Measure (and share of energy savings)	-23 / -12 (0.79)	11 / 6 (.06)

architects / engineers / contractors assign more "negatives" to NEBs than do owners – leading to underinvestment in energy efficiency. The implication is that bids and construction may be including less energy efficiency than owners might be willing to "buy". Additional education, incentives, or other program interventions targeted at those with more skepticism may aid the program; feedback on the owner perspective may also help. Interviews with multiple decision-makers support analysis of these differences in perception and help identify the source of lags in adoption of new technologies.

- **Marketing**: Highly valued NEBs are likely easier to "sell" than energy efficiency, and more importantly, they are likely to appeal to owners or decision-makers. Tailoring the program message to the high scoring NEBs for the audience of interest is potentially more fruitful than continuing to "push" energy efficiency on efficiency or bill savings grounds.
- **Benefit-Cost**: The NEB values provide information for the benefit/cost analysis from participant point of view, and may be useful as inputs for scenario analysis around regulatory tests as well. Some states in the U.S. are looking into scenario analysis around program benefit costs analysis. In addition, the NEBs represent better payback for the program participants themselves, and help explain program decision-making by participants.[22]

New Zealand ZALEH: Barriers and Opportunities Based on NEBs Analysis

The NEB results from the program were presented in Table 1 and Table 2. These tables presented the value of the total NEBs, and the ratio of these NEBs to the estimated energy savings. Discussion of the results in these tables is presented in the following sections.

APPARENT BARRIERS FOR THE PROGRAMS/MEASURES [23]

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.

Negative factors / Barriers

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 results show that these problems or barriers represent a significant "cost" to the residents. These results are summarized in Table 4.

These figures imply that to address these barriers in the marketplace may require interventions associated with the New Zealand ZALEH program. There are two potential "cases".

- **Negative NEB is mostly perception, not "real".** The NEB results show that participants perceived that maintenance for the EE equipment is worse (more expensive) than maintenance for standard equipment. If, in fact, this is not true, then the program may benefit by delivering targeted education materials to residents or to the vendors selling the equipment. To accomplish this, test data or demonstration sites may be needed, particularly to appeal to vendors.[24] This may help vendors recommend EE equipment and address these underlying concerns in the sales pitch. In other words, if the maintenance is not a real concern, but mostly

22. The participant benefits are, of course, perceived benefits. However, this is the appropriate measure by which to measure effects on participant decision-making and participant-attributed effects. Even if you could derive estimates of the "real" value of comfort, whatever that is, the perception of the person experiencing the benefit is presumably the driver affecting their program-related decisions.

23. 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, or 12 Euros) 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 (239 Euros). 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.

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

a perception, then education (to participants, vendors, non-participants) may address the concern.

- **Negative NEB is "real"**. 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 (12 Euros) for solar water heat, and $ 11 (6 Euros) for solar design 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.[25] 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.

BENEFITS AND "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 for most of the measures and contribute a great deal to the householder's payback for the measures.

The analysis also provides quantitative estimates that support anecdotal evidence that NEBs are important to participants. 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 (30 Euros) per year to the average homeowner with double glazed windows.
- 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 (86 Euros) per year for the average homeowner in super-insulated homes.
- 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 (19 Euros) per year for solar water heater homes, and $ 114 (59 Euros) for solar design homeowners.

Many of these benefits may be an easier "sell" than energy efficiency. This research and its results can be used to help design the marketing materials for the program, and the ZALEH program may be justified in considering modifying the mix of measures under a fixed program budget if it wishes to maximize participant appeal. Marketing that focuses on "winning" NEBs can increase program appeal and improve chances of adoption and attraction of measures.

25. 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, or 12 Euros) 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 (239 Euros). 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.

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References

Amann, Jennifer Thorne, 2005. "Valuation of Non-Energy Benefits to Determine Cost-Effectiveness of Whole House Retrofits Programs: A Literature Review", American Council for an Energy Efficient Economy, Draft Paper June.

Arrow, et al. 1993. Report of the NOAA panel on contingent valuation. http://www.darp. noaa.gov/library/ pdf/cvblue.pdf.

Brown, M., L. Berry, and R. Balzer, 1993. "National Impacts of the Weatherization Assistance Program", ORNL/CON-326, NTIS Report DE93018884, May.

Caplan, Arthur J. and Grijalva, Therese C. and Jakus, Paul M., 2002. Waste not or want not? A contingent ranking analysis of curbside waste disposal options. Ecological Economics. 43(2-3). December.

Carroll, David. 2005. Rethinking Cost-Benefit Tests: Practical Examples. Presentation to 2005 Affordable Comfort Conference. May 17. Indianapolis.

Cooper, Joseph, Michael Hanemann, and Givoanni Signorello. 2002. One-and-one-half bound dichotomous choice contingent valuation. The Review of Economics and Statistics. 84(4). November.

Feldman, Shel, Patricia Herman, and Athena Besa, 1997. "Shedding Lightt on the Indirect Costs and Benefits of Commercial Energy Efficiency Programs", 1997 Energy Evaluation Conference, Chicago, IEPEC, August.

Flanagan, T., 1995. "The 24 Benefits of Energy Efficiency to Electric Utilities", Cogeneration and Competitive Power Journal 10 (2).

Fuchs, Leah, Lisa Skumatz, and Jennifer Ellefsen 2004. "Non-Energy Benefits (NEBs) from ENERGY STAR: Comprehensive Analysis of Appliance, Outreach, and Homes Programs". In Proceedings from the 2004 ACEEE Summer Study on Energy Efficiency in Buildings, Washington DC, August.

Gardner, John and Lisa Skumatz, 2006. "Actual Versus Perceived Energy Savings: Results from a Low Income Weatherization Program", American Council for an Energy Efficient Economy, Summer Study on Buildings, Washington, DC, August.

Graves, Phillip. 2003. The simple analytics of the WTA-WTP disparity for public goods. Center for Environmental and Resource Economics working paper. www2.ncsu.edu/

unity/lockers/ users/v/vksmith/opportunites/ Graves_paper.pdf.

Heschong, Lisa, Roger Wright, and Stacia Okura, 2000. "Daylighting and Productivity: Elementary Schools Studies", ACEEE Summer Study on Energy Efficiency in Buildings, Washington, DC, August.

Isaacs, N., L. Amitrano, M. Camilleri, A. Pollard, and A. Stoecklein, 2003. "Energy Use in New Zealand Households, Report on the Year 7 Analysis for the Household Energy End-use Project (HEEP)", BRANZ Ltd: Judgeford, New Zealand, November.

Kempton, Willet and Laura Montgomery. 1982. "Folk Quantification of Energy." *Energy*. 7(10): 817-827.

Kempton, Willet. 1984. "Residential Hot Water: A Behaviorally Driven System." In Proceedings from the ACEEE 1984 Summer Study on Energy Efficiency in Buildings, Washington DC, American Council for an Energy Efficient Economy.

Lutzenhiser Associates. 2004. *Final Evaluation Report: California Building Performance Contractors Association Comprehensive Whole House Residential Retrofit Program.* CPUC-172-02. August 15. Portland, OR: Lutzenhiser Associates.

Magouirk, J.K., 1995. "Evaluation of the Non-energy Benefits from the Energy $avings Partners Program", 1995 Energy Program Evaluation Conference, Chicago.

Mills, E., and A. Rosenfeld, 1994. "Consumer Non-Energy Benefits as a Motivation for Making Energy Efficiency Improvements", LBL Report 35405, Berkeley, California, Lawrence Berkeley Laboratories.

Okura, Stacia, Lisa Heschong, and Roger Wright, 2000. "Skylighting and Retail Sales", ACEEE Summer Study on Energy Efficiency in Buildings, Washington, DC, August.

Shepler, Nicole. 2001. Developing a hedonic regression model. http://www.bls.gov/cpi/cpicamco.htm. Accessed July 2006.

Skumatz, Lisa A., 1997. "Recognizing All Program Benefits: Estimating the Non-Energy Benefits of PG&E's Venture Partners Pilot Program (VPP)", 1997 Energy Evaluation Conference, Chicago, IEPEC, August.

Skumatz, Lisa A., 2002. "Comparing Participant Valuation Results Using Three Advanced Survey Measurement Techniques: New Non-Energy Benefits (NEB) Computations of Participant Value," Proceedings of the 2002 ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, Washington, DC, August.

Skumatz, Lisa A., Ph.D., 2003. "The "Mother" of Non-Energy Benefits (NEBs) Studies – Comprehensive Analysis and Modeling of NEBs for Resource Acquisition and Market Transformation Programs," Proceedings of the EEDAL Conference, Turin, Italy, October.

Skumatz, Lisa A., Ph.D., et.al., 2004. "Non-Energy Benefits from ENERGY STAR®: Comprehensive Analysis of Appliance, Outreach, and Homes Programs," Proceedings of the 2004 ACEEE Summer Study, Asilomar, CA, August.

Skumatz, Lisa A., Ph.D., 2005. "Techniques for Getting the Most from an Evaluation: Review of Methods and Results for Attributing Progress, Non-Energy Benefits, Net to Gross, And Cost-Benefit, European Council for an Energy Efficient Economy (ECEEE), Mandileu, France, June.

Skumatz, Lisa A., and Chris Ann Dickerson, 1998. "Extra! Extra! Non-Energy Benefits of Residential Programs Swamp Load Impacts!", 1998 ACEEE Conference Proceedings, Asilomar, California, August.

Skumatz, Lisa A. and John Gardner, 2006. "Differences in the Valuation of Non-Energy Benefits According to Measurement Methodology: Causes and Consequences, Proceedings of the Association for Energy Service Professionals NESP Conference San Diego, CA, AESP, Clearwater FL, January.

Stoecklein, Albrecht, and Lisa A. Skumatz, 2004. "Using Non-Energy Benefits (NEBs) to Market Zero and Low Income Homes in New Zealand," Proceedings of the 2004 ACEEE Summer Study, Asilomar, CA, August.

Weitzel, David, and Lisa A. Skumatz. 2001. "Making the Most of Your Data – Reliable Techniques for Estimating Baseline and Projected Market Shares from Market Transformation Interventions with Limited Observations", Proceedings from the 2001 Association of Energy Service Professionals (AESP) Conference, Ponte Vedra, Florida.