Exploring the Application of Conjoint Analysis for Estimating the Value of Non-Energy Impacts[1]

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Abstract

As energy efficiency program spending continues to increase, refining the methodologies used to value associated non-energy impacts (NEIs) has taken on greater interest and importance.[2] This paper discusses limitations of the most widely used approaches to estimate the value of NEIs experienced by program participants and examines an alternative method.

The value of "hard-to-measure" NEIs, such as comfort, are primarily assessed based on feedback from program participants. Virtually all previous studies have either asked respondents to directly estimate their willingness-to-pay (WTP) for NEIs (referred to as contingent valuation), or have used various scaling techniques in which respondents' WTP is estimated based on their comparison of the value of NEIs to the value of project energy savings. Both approaches possess limitations. Most notably, they require respondents to directly consider the value of NEIs in dollar terms.

Conjoint analysis may be used to address these limitations.[3] Conjoint analysis survey instruments present individuals with hypothetical scenarios that force respondents to make tradeoffs and exercise "real-world" decision-making. WTP for NEIs is then calculated based on respondents' choices. In addition to providing a more realistic context for respondent preferences than other methods, conjoint analysis yields more comprehensive data on respondent preferences, and it limits the potential for gaming. However, the conjoint method also has limitations.

This paper examines the range of methods for valuing NEIs. Benefits and constraints of each approach are discussed, and results are presented in the context of one program administrator's multi-year application of these methods. This paper also discusses how best to apply these methods in the future.

Introduction

Non-energy impacts (NEIs) are those effects, besides energy savings, that accrue to customers as a result of their participation in energy efficiency programs. Many evaluators have expanded this definition to also encompass NEIs that accrue to utilities that administer energy efficiency programs or to society at large. However, this paper focuses only on NEIs that accrue to program customers or participants.

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[1] The views expressed in this paper are those of the authors and do not necessarily reflect the views of the New York State Energy Research and Development Authority.

[2] While non-energy impacts are also sometimes referred to as "non-energy benefits" this paper discusses both positive and negative impacts of energy efficiency measures, and therefore, uses the term non-energy impacts.

[3] The paper will focus on a form of CA that uses "choice experiments" as opposed to a system of ranking attributes.

Non-energy impacts can be positive or negative. Positive NEIs include impacts such as increased comfort from better insulation, reduced eye strain due to improved lighting quality, and higher resale value associated with energy efficient building upgrades. Examples of negative NEIs are aesthetic issues associated with compact fluorescent bulbs, or increased maintenance costs for new energy efficient equipment due to unfamiliarity.

The New York State Energy Research and Development Authority (NYSERDA) began assessing NEIs in 2004 using a "direct query" survey approach.[4] Respondents were asked to estimate the NEI value as it compared to the value of project energy savings using a qualitative scale (i.e., "NEIs are much less valuable than project energy savings").[5] The direct query method was refined and put to use again in 2005, but using a more directly scaled comparison to the value of project energy savings (i.e., "NEIs are 25% as valuable as project energy savings"). Beginning in 2006, conjoint analysis (CA) was used for the first time in NYSERDA's NEI evaluations. However, the conjoint approach was coupled with the direct query questions in order to test this new method and allow for continuity with previous evaluations. In the latest (2007) evaluation cycle, NYSERDA employed an enhanced version of the CA approach and continued use of the direct query questions. NYSERDA's multi-year assessment of NEIs has covered a wide range of programs and product categories including, but not limited to commercial/industrial energy efficiency, residential products and homes.

The results of NYSERDA's NEI assessments support the findings of other literature on the topic of NEIs (Hall & Roth 2003; Skumatz 2002) in that they demonstrate that the value of NEIs is not zero, and in some cases is very significant. Estimating the value of NEIs is important for both program evaluation and program marketing purposes. NYSERDA has translated NEIs into dollar values and counted these benefits in one scenario of its annual benefit-cost analysis. Results are presented in a manner that allows interested parties to view program cost-effectiveness results both with and without NEIs depending on their preference. This approach has worked well because the effect that including the NEIs has on program cost-effectiveness is apparent. Program implementers at NYSERDA have also used the NEI research to confirm what really drives customer decisions to implement energy efficiency measures. In some cases, customers state that the value of NEIs is actually on par with the value of the energy savings attained from their project. This is an indication that marketing should communicate the non-energy benefits as well as the energy savings to potential participants.

Methods for Estimating the Value of NEIs and other "Non-Market Goods"

Certain NEIs can be classified as "non-market goods," a term economists use to describe things that have value to individuals and/or society as a whole, but which are not actually bought and sold.[6] While estimating NEI values poses some unique challenges, economists have developed a variety of methods for assessing the value of non-market goods, such as clean air and habitat preservation.[7] "Stated Preference" is one category of methods in which surveys are used as a means of identifying the dollar value a respondent places on a particular good.

Among the Stated Preference methods, the most basic distinction made by many economists is

[4] For each of the NEI studies listed, the year referenced is the year in which the study was completed.

[5] The actual qualitative scale presented respondents with the following options for comparing the value of NEIs to the value of project energy savings: "much less valuable," "somewhat less valuable," "same value," "somewhat more valuable," "much more valuable."

[6] Some NEIs experienced by program participants, such as changes in maintenance costs, actually are bought and sold in real markets. However, for many participant NEIs, this is not the case.

[7] Measuring the value of consumer preferences for various products and product characteristics has posed similar challenges for the field of market research as well.

between "contingent valuation" (CV) and "conjoint analysis" (CA) techniques (Denier, Mullser & Robb 1998; Johnson et al. 1998; MacIntosh, Donaldson & Ryan 1999; Merino-Castello 2003).[8] CV techniques use a survey approach which *directly* queries respondents on their willingness to pay (WTP) for a particular good. In contrast, CA techniques use more *indirect* survey approaches. Respondents are provided with descriptions of different goods that are characterized in terms of a consistent set of distinct attributes (the levels of which vary across questions), and respondents are asked to either rank or make choices between the different options presented. Econometric techniques are then used to calculate the "utility" of each attribute, and if price/cost has been included among the attributes, WTP can be calculated as well. CV questions provide values for a single attribute or scenario with each question, while CA approaches provide values for several distinct attributes with each question.[9]

Virtually all previous studies using participant surveys to gather data for estimating the value of "hard-to-measure" NEIs (i.e., occupant satisfaction and worker productivity) have either used the CV method (Hall & Roth 2003), or a scaling approach in which respondents are asked to indicate the value of the NEI relative to the value of project energy savings (Skumatz & Gardner 2006).[10] The scaling approach, described further below, does not fit neatly into either of the two primary categories described above. However, because this approach has been applied extensively in NEI studies, it is included in this discussion of relevant methodologies. Methodological and study design issues associated with CV, relative scaling, and CA techniques are discussed in the following sections.

Direct Willingness to Pay (Contingent Valuation) Approach

The CV approach consists of two different types of question formats: open-ended questions (i.e., "what would you be willing to pay?") and referendum questions (i.e., "would you be willing to pay X?").[11] The economics literature has highlighted several limitations to the CV approach, in particular for the open-ended question format. A commonly cited weakness is that CV questions are difficult to answer because respondents are not accustomed to thinking of non-market goods in monetary terms (Arrow et al. 1993; Merino-Castello 2003; Price 2000). Additionally, there can be inconsistency in respondents' understanding of the non-market good in question. That is, given the limitations of survey length, respondents are often provided with only a limited description of the good they are being asked to value. Therefore, they may have different interpretations of the scope or details associated with the good in question, which can affect their responses (Price 2000). Inconsistencies in the logic applied by respondents can produce erratic results (Arrow et al. 1993). Another weakness of the CV approach is that questions only address one attribute at a time (Merino-Castello 2003).

A common criticism of the open-ended CV question format is that respondents may try to be strategic and affect the outcome of their survey response. As noted in a National Oceanic and Atmospheric Administration (NOAA) study, respondents who recognize that they will not actually be

[8] Techniques for valuing multiple attributes simultaneously are commonly referred to as CA. However, a lack of standardization exists in the terminology used to describe this category of techniques. The term "discrete choice experiment" is often used to describe the form of CA most commonly used today.

[9] Three primary types of CA question formats exist: rating, ranking, and choice-based. Each requires its own econometric model for calculating utility and WTP estimates (Louviere, 2005; Ryan, 2000; Merino-Castello, 2003). The choice-based format, called "discrete choice," is most commonly applied today, as it is thought to be most representative of actual decision-making (Ryan, 2000; Louviere, 2005).

[10] In contrast, several NEI studies using a case-study format have used levels of absenteeism and/or employee turn-over rates as the basis for estimating the value of NEIs such as occupant comfort and productivity. These estimates have factored in costs such as average employee salaries and the cost of recruiting new employees (Loftness et al, 2004; Romm, 2006).

[11] Note that CV questions can also be framed in terms of the respondents' willingness to accept (WTA), though WTP questions are typically used.

held to their WTP estimate may view CV questions as simply an opportunity make a statement with no consequences (Arrow et al, 1993). In the case of NEI studies, respondents' answers to CV questions may reflect their motivation to maintain the financial incentives associated with the energy efficiency programs in question.

In general, the referendum, or "dichotomous choice" question format is the preferred approach for CV studies since it is thought to avoid the strategic bias described above (Arrow et al.1993; Merino-Castello 2003; Price 2000; Skumatz & Gardner 2006; Wiser 2003). However, the approach is subject to the "yeah saying" effect in which respondents feel compelled to choose the "right" answer (Arrow et al. 1993; Merino-Castello 2003; Price 2000). Furthermore, the results are sensitive to the values presented in the question options (Skumatz & Gardner 2006).

Scaling Approach

Skumatz and Gardner characterize scaling techniques as questions that ask program participants to express the value of the NEIs they experienced relative to a value with which they are more familiar, such as project energy savings (Skumatz & Gardner 2006). They separate the scaling techniques into two categories: *direct scaling* and *relative scaling*.

Under the *direct* scaling format, respondents are asked to value the NEIs they experience as a percentage of energy savings. This format was used in the 2006 and 2007 NYSERDA NEI studies. The primary benefit of this approach is that the respondents' answers can readily be translated into actual dollar values without any doubt as to what was intended by the respondent (i.e., if the respondent says they value a particular NEI at 50% of the project's $1,000 in annual energy savings, it is clear that they value the NEI at $500). The main drawback of this approach is that the questions can be difficult for respondents to answer with accuracy. While providing some context for the respondents by using the energy savings value as a benchmark, the respondents are still effectively being asked to come up with a dollar value for the NEI, which presents many of the same challenges as an open-ended WTP question.

The *relative* scaling approach is intended to make questions easier for respondents to answer. Rather than expressing the NEI value using an exact percentage, respondents are presented with a qualitative scale and asked to identify a point along that scale that is most consistent with their experience. Researchers translate respondent answers into dollar values using multipliers for the different levels of the qualitative scale. In prior studies, the multipliers were developed based on data collected from previous work. In an earlier paper, Skumatz explains that methods used to translate from qualitative responses to quantitative values are based on labeled magnitude scaling research conducted by scientists Green et al. (1993) and Bartoshuck et al. (2000), which found predictable and consistent spacing between different levels along qualitative scales (Skumatz 2002).

Both the direct and relative scaling approaches possess deficiencies. Skumatz and Gardner characterize the tradeoff between the direct and relative scaling approaches as follows, "One presents a harder-to-answer question to respondents, but potentially offers more accuracy; the other presents an easier-to-answer question, but is less directly translated into a dollar value" (Skumatz & Gardner 2006, 3). In addition, it is virtually impossible to test the validity of the estimates from both approaches since it is not possible to obtain alternative or proxy estimates from real markets. Given the similarity in values resulting from the direct and relative scaling techniques, and because, based on the authors' previous studies, relative scaling questions are easier for respondents to answer, the authors advocate the relative scaling approach.

Skumatz has conducted several studies using both direct and relative scaling techniques, as well as the CV method, and notes that CV results tend to produce larger and more volatile values than scaling techniques (Skumatz & Gardner 2006), and the author favors the scaling techniques because they tend to produce more conservative results than the CV method. However, these positive aspects of the relative

scaling technique are partly an artifact of researcher-defined parameters, and do not necessarily mean that the scaling approach produces more accurate results than CV. When using the relative scaling method the range in the multiplier values selected by the researcher will define the range of results, while no boundaries exist for values provided in response to open-ended CV questions. Myers and Skumatz note that the methods used to generate NEI values through the relative scaling approach were developed over a 10-year period using data from numerous survey efforts (Myers & Skumatz 2006). However, the various studies used as the basis for developing the multipliers possess unique elements and limitations. It is important to ensure that differences in the scope and type of programs studied are accounted for when using data from other studies as the basis for establishing multipliers to estimate NEI values using the relative scaling technique.

Second, both the direct and relative scaling methods provide the respondent with project energy savings as a benchmark value. In contrast, the CV method provides the respondent with no benchmark value. Gregory et al. note that providing respondents with benchmark values for context will substantially affect the responses (Gregory et al. 1995). If a low dollar value is used as a benchmark, the responses will tend to be much lower than if a higher dollar value is used. Of course, the effect of this bias must be weighed against the value of providing respondents with a consistent frame of reference and, potentially, increasing the number of individuals who will feel comfortable answering the questions. However, when drawing conclusions about the range of values resulting from different NEI valuation methods, it is important to recognize that this benchmarking bias exists.

Conjoint Analysis Approach

The CA approach has the potential to address several of the limitations of the CV and scaling approaches described above.[12] First, using widely accepted econometric techniques, CA enables WTP estimates to be developed in a systematic manner without actually asking respondents to provide a dollar value estimate. In CA questions, respondents are presented with alternative hypothetical scenarios to choose or rank. Since one of the attributes is expressed in dollar terms and varies across the attribute groups, a statistical model can be used to develop values for those attributes that are not directly measured in dollars. The question format is similar to the real-world consumer product decisions respondents make everyday (Merino-Castello 2003; Telser 2002). Therefore, it is generally held that CA questions are easier for respondents to answer than CV questions. The similarity of CA questions to real-world decision-making is a fundamental benefit of the CA approach.

Since CA uses an indirect approach, calculating WTP based on responses to a series of questions, respondents cannot "game" the system as they might with questions in which their WTP estimate is the obvious focus of the question (Denier, Mullser & Robb 1998; MacIntosh, Donaldson & Ryan 1999). Another key benefit of CA is that it enables researchers to calculate the values of several attributes at one time, and each question provides researchers with more data about respondent preferences. Therefore, CA can be more efficient, as the number of responses required is lower than for the CV approach (Denier, Mullser & Robb 1998; Johnson et al., 1998).

Conversely, the fact that CA questions include a consistent set of attributes across an entire question series effectively limits the number of attributes that can be examined in a given survey; if too many attributes were examined in each question, the questions would be too complex for respondents to process. Green and Srinivasan (1990)[13] recommend limiting the number of attributes to six or fewer.

[12] A variety of sub-categories of "multi-attribute valuation" techniques exist, but all are referred to broadly here as "CA."

[13] This recommendation was cited in Hann et al, 2003, and was taken from Green, Paul E. and V. Srinivasan "CA in Marketing: New Developments With Implications for Research and Practice," Journal of Marketing, vol. 54, no. 4, 1990, pp. 3-19.

Since it is important to accurately and fully describe the question scenarios in order for respondents to provide meaningful responses (Denier, Mullser & Robb 1998), this argues that questions should be limited to a rather narrow topic area. Torok and Cavalli, who conducted a CA study focusing on energy efficient clothes washers, argue that within the energy field, certain topics are better-suited to the CA approach than others. The authors state, "Conjoint analysis works the best to analyze the decision process for products that are fairly homogenous, with a manageable number of defining features." (Torok & Cavalli 2000, 8.398). One strategy that has been used to address the challenge of having too many relevant attributes to examine in one study was to split the sample and use questions with different attributes for different subsets of the sample (Goett et al. 2000).

Another limitation of CA is that results are sensitive to the attribute levels presented in the questions (Ryan 1999; Hann et al. 2003). For example, most conjoint studies only use two or three different levels for each attribute which are pre-defined by the researcher, though in reality a much broader spectrum of levels exists.

Finally, it is important to remember that the choice scenarios presented to respondents are hypothetical. While attributes and levels should be developed, and results applied, based on careful research to depict conditions that closely approximate those actually experienced by program participants, gaps will inherently exist between conjoint scenarios and actual project conditions.

2007 NYSERDA NEI Assessment

Prior to 2006, NYSERDA's research approach valued NEIs using a qualitative scale ranging from "much less valuable than the energy savings" to "much more valuable than energy savings."[14] The limitations of a qualitative scaling approach are discussed above. Like the scaling approach, other methods for estimating the value of NEIs also possess strengths and weaknesses and vary in the degree to which they are suitable under different conditions. This forces researchers to make tradeoffs and to pay close attention to the unique needs and resources available when determining an appropriate study design. This also underscores the need to test alternative methods and to approach the research questions from different view points to verify the robustness of the results. Since 2006, NYSERDA and Summit Blue have taken this approach in designing NEI assessments.

In an effort to maintain continuity with past research while continuing to explore new methods, the 2006 and 2007 NEI evaluation efforts employed an extension of the direct query/scaling method used in the 2004 and 2005 NYSERDA NEI assessments (Direct Query, "DQ"), as well as a conjoint method that was first tested in the 2006 NEI assessment.

In the most recent NYSERDA NEI assessment, the Summit Blue Team built upon lessons learned from initial testing of the conjoint method conducted during the 2006 assessment. The form of CA applied in this assessment allows respondents to choose between bundles of attributes (both positive and negative) that they can, theoretically, relate to as real-world consumer product options. In each bundle of attributes, or choice option, one attribute is expressed in dollar terms allowing for estimates of the dollar value of the non-market attributes included in the bundles.

Survey Sampling and Administration

For the 2007 NYSERDA study, the sample consisted of building managers whose companies had participated in NYSERDA's Commercial / Industrial Performance Program (CIPP) or Small Commercial Lighting Program (SCLP) within the last three years. Survey respondents were pre-

[14] Lisa Skumatz, of Skumatz Economic Research Associates, Inc., devised this approach and led past NYSERDA NEI studies as a subcontractor to Summit Blue Consulting.

recruited by phone and then were sent an email link to complete the survey online. Recruited survey participants received multiple follow-up emails and phone calls in an effort to improve the response rate. A total of 210 respondents agreed to participate in the survey effort, and 91 respondents actually completed the survey, resulting in a 43 percent response rate. Of these 91 respondents, 75 completed all CA questions.

Direct Query Method to Assess NEIs

This approach carried forward the basic elements of the direct query question structure used in past studies as a means of maintaining consistency and facilitating the comparison of results across years. For each NEI included in the DQ portion of the survey (*e.g.*, lighting quality, occupant comfort, operation and maintenance costs, etc.) respondents were asked whether they had experienced the NEI and the magnitude of each NEI. Respondents were then asked to note whether their *overall* experience with all the NEIs associated with their project was positive, negative or zero. Respondents were presented with an estimate of the annual energy cost savings resulting from their project and asked to provide a correction if they believed the estimate to be inaccurate. Respondents were then asked to indicate, in percentage terms, how valuable all the projects' NEIs were to their company in comparison to the value of the project's energy cost savings.

As a check, respondents were presented with the dollar value equivalent of the answer they had given (which was calculated based on the energy cost savings estimate they had confirmed in an earlier question), and asked to confirm that the dollar value estimate was appropriate. If they believed the estimate to be inappropriate, they were asked to provide an alternative dollar value estimate. Finally, respondents were asked to apportion the overall value of all the NEIs across various NEIs for which they had reported a positive experience.[15] This was a departure from earlier NYSERDA NEI surveys in which respondents were asked to provide a value estimate for each individual NEI. This more streamlined approach was used in the 2007 survey to avoid double counting of NEI values and to decrease the burden on respondents.

Conjoint Analysis Method to Assess NEI Values

NYSERDA and Summit Blue determined that CA held promise for addressing several of the limitations of prior NEI study designs and tested the method for the first time in the 2006 NYSERDA NEI study. While CA is widely used for valuing non-price factors in other contexts, and there have been some applications in the energy field (Grover, Torok, Babiuch 1999), it has not been applied to the types of energy efficiency programs that comprise the **New York Energy $mart^{SM}** portfolio. As a result, this is still a new approach for addressing NEIs.

Researchers faced a number of challenges in applying the CA approach to estimate NEI values associated with NYSERDA's **New York Energy $mart^{SM}** programs. First, CA studies should maintain a fairly narrow focus in order to present respondents with a comprehensive enough depiction of alternative "product" options (Denier, Mullser & Robb 1998; Torok & Cavalli 2000). If the "products" respondents are choosing between are too vaguely defined, this will limit the accuracy of the results. In addition, if the findings from the conjoint questions are to be used to gauge the actual experience of program participants, it is important for attributes (NEIs) included in the choice comparisons to be

[15] If respondents had reported in an earlier question that their overall experience with NEIs associated with their project was negative, their energy cost savings figure would have been used as the basis for calculating the extent to which the NEIs detracted from the value of energy savings from the project. Then the respondent would have been asked to apportion that negative value across the NEIs reported. In fact, no respondents reported an overall negative value associated with their NEIs.

realistic to the experience of NYSERDA's program participants. Furthermore, the Team needed to avoid using attributes that are too closely correlated with one another so that it could be determined which attribute was driving the respondents' decision-making. Finally, attributes should be characterized in quantitative terms to the extent possible in order to ensure that all respondents interpret the choices in the same way.

Given these constraints, the Team chose to focus on lighting project attributes for the conjoint component of the 2007 NEI study. Lighting projects are narrow enough in scope to facilitate the selection of the recommended six to eight attributes while still providing respondents with a comprehensive characterization of the choice scenarios. The attributes of advanced lighting technologies and design are also well documented in manufacturer product literature (i.e., color rendering index and lamp life) and the results of field studies (Boyce et al. 2003). Furthermore, the majority of projects in the CIPP NEI sample were lighting projects, and the Small Commercial Lighting Program (SCLP) emerged as another program which would easily facilitate surveying end-user participants. Focusing only on lighting attributes for the CA survey component also enabled the Team to conduct the thorough research that was necessary to define an appropriate set of attributes and levels.

Defining a set of attributes and levels that met the constraints identified by the Summit Blue Team through secondary research represented a great challenge for the Team and some tradeoffs were necessary. For example, the Team considered including both lighting quality and occupant comfort among the list of attributes as they are both NEI categories commonly associated with lighting projects. However, it was determined that these two attributes were too similar to one another, and it was not possible to identify actual data to use as the basis for defining "occupant comfort" in objective terms (i.e., number of employee complaints). "Color rendering index" was selected as a proxy for lighting quality, as it is a real numerical scale used by all lighting product manufacturers to measure the extent to which the light from a particular lamp portrays an object's true colors. According to CIPP participating ESCOs, "color rendering index" is a key product feature they discuss with their clients.

These attributes were used to develop a set of eight conjoint choice questions used in both the CIPP and SCLP surveys.[16] Respondents were asked to pick the favored group of attributes (scenario) from the two choice scenarios posed in each question. The project cost and operating cost attributes, expressed in dollars, vary across the question scenarios presented to respondents, and these attributes are used as the basis for calculating respondent WTP.

[16] Eight versions of the question series were developed, each presenting a different combination of levels for the attribute. The version given to each respondent was randomly determined.

Table 1. Sample CA Question

Attribute/Description	Scenario A	Scenario B	Difference
Project Cost *Upfront cost of lighting project, including both labor and equipment.*	$40,000	$12,500	Project A is more expensive than Project B.
Lighting Energy Cost per Year *The annual energy costs associated with operating the lighting system.*	$3,500 / year	$4,500 / year	Project A has lower annual energy costs than Project B.
Color Rendering Index of Lamps *Ability of light to accurately convey colors on a scale of 0-100*	70 - 80	70 - 80	No difference.
Lighting Controls *Existence of occupant and / or automatic control over lighting*	Occupant has control over lighting	Lighting is centrally controlled	Occupants in Project A have the ability to turn their lights on and off.
Lamp Life *Average rated lifetime of lamps (# of hours until lamp failure)*	30,000 hours	20,000 hours	Project A has lamps lasting longer than Project B.
Light Distribution *How light is dispersed throughout the space*	Spacing of fixtures results in ***dark spots*** on walls and ceilings	Light fixtures are configured to provide ***uniform*** light distribution	Project B has more even light distribution than Project A.
Please Choose Scenario A or B *We ask that you choose one of the options even if you do not consider either option to be ideal.*	○	○	

Assessment of Project and Respondent Characteristics

The NYSERDA surveys also incorporated questions intended to provide a greater understanding of the companies the respondents represent, the nature of the projects they completed, and their awareness of NEIs both before and after program participation. Of particular importance was a series of questions on lighting project details. These questions were asked both as a means of gaining a greater understanding of the types of lighting projects being completed through the CIPP and SCLP, and to determine how to apply the results of the CA questions. Since the CA questions produce estimates of respondents' average WTP to go from a low to a high level for each attribute, it is important to determine what percentage of respondents are likely to have experienced the NEIs included in the conjoint questions, and at what levels.

Analytic Methods

Responses to the DQ series of questions were entered into spreadsheet data files and frequencies and tabulations were computed using standard analytic techniques. The analytic goals for the conjoint question results were to: 1) calculate the respondents' relative preferences for the attributes presented for

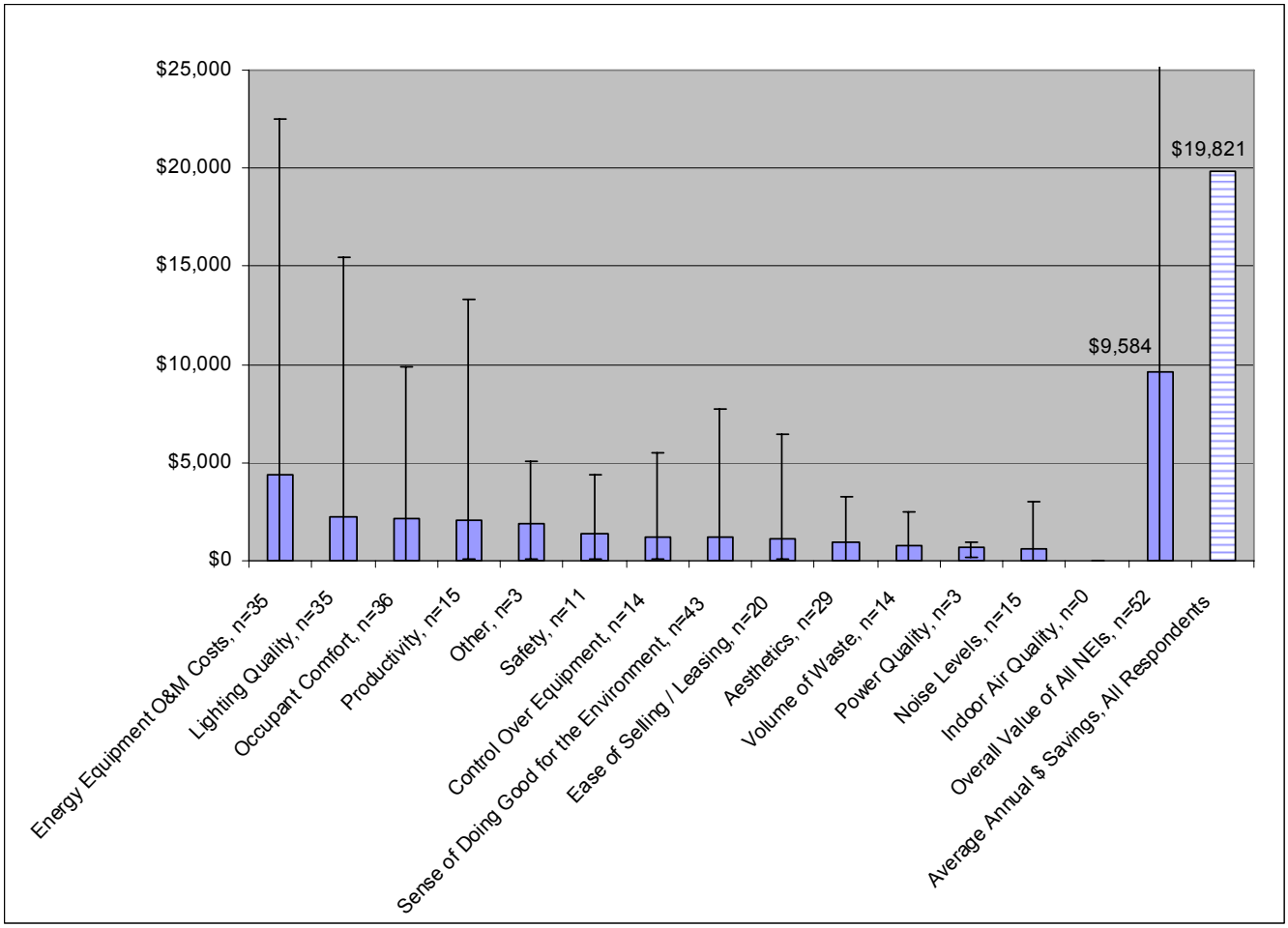
each project; and 2) determine the amount respondents would be willing to invest, on average, to increase from the less preferable to the more preferable level associated with each attribute.

Choice models were developed based on CA question response data and the models were then used along with plausible assumptions about actual respondent project characteristics to estimate values for each NEI/attribute. The desirability or utility of each lighting attribute was modeled as a linear function of the lighting characteristics examined in the study. Estimates of respondents' preference for each attribute were calculated. These preference estimates were interpreted as the marginal utility of an attribute, or the marginal disutility for the cost attributes.[17] From these initial preference estimates, WTP estimates for an increase in attribute level were derived for each attribute.[18]

Results

Results for the DQ survey component are highlighted in Figure 1.

Figure 1 Average and Range of Direct Query Survey Results from CIPP and SCLP Respondents



[17] The value of a parameter represents how much better or worse off one would feel if that attribute were increased by one unit (or attribute level).

[18] WTP is calculated as the negative of the ratio of the parameter of the attribute to the parameter of cost. Further detail regarding the methodology used to calculate the CA results can be obtained from the full NYSERDA NEI Assessment Report.

Results for the CA survey component are highlighted in Table 2. [19]

Table 2 Summary of Conjoint Analysis Survey Results (n=75)

Attribute	Attribute Value (% of Energy Savings)	Attribute Value ($)
Even Light Distribution	6%	$2,046
Lighting Quality	3%	$1,121
Lamp Life	2%	$586
	13%	**$3,753**

Key Findings for the DQ Survey Component:

- The most highly valued NEI was "Energy Equipment O&M Costs," which was valued by respondents at a level equal to approximately 22% of the energy savings realized by respondents. It was also the second most commonly reported NEI, with 58% of all respondents reporting a decrease in Energy & Equipment O&M costs as a result of completing their project. Approximately half of the respondents reporting a positive experience with this NEI stated that the decrease in costs was due to longer equipment lifetime. About 15% said the decreased costs were due to improved equipment reliability.
- The next most highly valued NEIs were "Lighting Quality" (with an average value of 11% of annual electricity cost savings), "Occupant Comfort" (with an average value of 11% of annual electricity cost savings), and "Productivity" (with an average value of 10% of annual electricity cost savings).
- In terms of the most commonly reported NEIs, "Sense of Doing Good for the Environment" ranked highest with 66% of all respondents reporting a positive experience with respect to this NEI followed by "Energy Equipment O&M Cost Savings," (58% of respondents reporting a positive experience) and "Occupant Comfort" (45% of respondents reporting a positive experience.
- Twenty-three percent of respondents reported productivity improvements as a result of completing their project, noting an average productivity increase of 13% compared to conditions prior to completing their project. Increased productivity was attributed to a variety of related project impacts, such as improved equipment reliability and worker comfort and satisfaction. Productivity increases also resulted from increased sales at retail facilities and decreased defects at manufacturing facilities, both of which were attributed to improved lighting quality.

Key Findings for the CA survey component:

- The most highly valued NEI was "Even Light Distribution," which was valued by respondents at approximately six percent of average electricity cost savings across the CIPP and SCLP samples. This conjoint attribute is related to "Occupant Comfort," an NEI that respondents valued highly in the direct query survey component (valued at 11% of annual electricity cost savings).
- "Lighting Quality," presented in terms of "color rendering index," was the second most valuable conjoint attribute. It was valued at approximately three percent of average electricity cost

[19] Values for the two attributes presented in dollar terms ("Project Cost" and "Lighting Energy Cost per Year") are not shown as they were used as the basis for calculations estimating the value of the other four attributes.

savings associated with CIPP and SCLP projects. Lighting quality was also a highly valued NEI in the Direct Query survey component (valued at 11% of annual electricity cost savings).

- "Lamp Life" was the third most valuable conjoint attribute. It was valued at approximately two percent of the average electricity cost savings associated with CIPP and SCLP projects. The Direct Query NEI most closely related to this conjoint attribute is "Energy Equipment O&M Costs." Interestingly, that NEI was ranked highest among NEIs included in the Direct Query survey component.

The results from the most recent CIPP NEI study fall within the same general range as those from the NEI studies of this program conducted over the last four years (NYSERDA, 2007). There is less consistency across the four years of SCLP results, though the CA results from both the 2006 and 2007 studies are lower than the DQ results from those years. The variance in results from the series of NYSERDA NEI studies could be the result of a variety of factors. CA results have tended to show lower values than the DQ results, which could reflect that CA question sets have examined the value of just four non-cost-related attributes, while the DQ survey questions queried respondents on a substantially larger set of NEIs. A factor that may have contributed to the variability in DQ results across the four assessments is that the question format has undergone revisions with each subsequent year as the research team has worked to refine the analytic approach.

Comparing Direct Query and Conjoint Analysis results:

It is difficult to make a direct comparison between the DQ and CA results for a variety of reasons. First, the DQ questions probed respondents on a broad range of potential NEIs while the conjoint questions were more targeted and included only a small number of lighting-specific attributes. The CA component of the survey was narrowly focused because the literature indicated that conjoint questions which include too many characteristics can be overly burdensome for respondents. If respondents completed an additional set of conjoint questions addressing a different set of attributes, it is likely that further NEI value would be revealed.

While there were some NEIs from the DQ questions which closely paralleled attributes included in the conjoint questions (i.e., "Lighting Quality" was included in both question sets, and "Energy Equipment O&M Costs" and "Lamp Life" address similar issues), one would not necessarily expect that the two different methods would yield the same values. As discussed earlier, DQ results are affected by the fact that project energy savings are used as the benchmark for respondents when asking them to place a dollar value on NEIs (Gregory et al, 1995; Johnson et al, 1998). In contrast, the CA method uses an indirect approach to calculate NEI values based on the strength of respondent preferences for particular attributes. Therefore, results are less likely to be biased by other factors.

In addition, the literature indicates that respondents have difficulty placing a dollar value on attributes that they are not accustomed to thinking about in monetary terms, and that respondents often over-estimate the value of non-market goods when asked to do so in an open-ended format (Arrow et al, 1993; Skumatz, 2002). Therefore, it is not surprising that the conjoint results represent lower NEI values than do the direct query results. Recognizing the points highlighted above, it is notable that the DQ and CA results both fall within the same general range at the individual attribute level (i.e., within the range of 1-20% of annual electricity cost savings).

Implications for Future NEI Study Design

Additional applications of NEI assessment methods will help refine and improve upon existing techniques. For the time being, it is beneficial to employ multiple methods in each study as a means of establishing a range of values and to further explore the effectiveness of each method under different conditions. Selected lessons learned about the methodologies used are as follows:

- There are inherent limitations associated with estimating dollar values for NEIs. However, where value does clearly exist, it is important to apply well-defined techniques and to put forth as sound an approach as possible to capture the value of program-related NEIs.
- Tradeoffs and assumptions must be made when applying methods for estimating NEI values. This is acceptable as long as the tradeoffs and assumptions are well-justified and clearly communicated.
- Extensive background research and access to quantitative data on NEIs from other studies is necessary for developing focused, reasonable, and realistic attributes and levels for conjoint analyses.
- Gathering information on project details and incorporating qualitative feedback into Direct Query questioning is valuable for interpreting results and for providing a greater understanding of participants' NEI experiences. Careful consideration must be made at the outset of the study design regarding the project-specific data points that will be necessary for interpreting conjoint results.

Conclusions

There are strengths and weaknesses associated with each of the methods available for estimating the dollar value of NEIs and other "non-market goods." A key weakness of the contingent valuation approach is that respondents feel uncomfortable answering questions that force them to think about non-market goods in dollar terms. The qualitative scaling approach used in earlier NYSERDA NEI studies makes it easier for respondents to answer questions, but it depends heavily on the researchers' assumptions in translating the qualitative results into quantitative NEI value estimates. The direct scaling approach used in recent NYSERDA NEI surveys (DQ) has had the benefit of providing respondents with some context for thinking about the NEI values in dollar terms by providing the project energy savings as a benchmark value. However, the question format is relatively complex, and still ultimately forces respondents to think about NEIs in dollar terms.

The DQ component of the current survey does, however, represent a defensible and balanced approach for assessing NEI presence and value. This component of the survey, or some similar attempt to gather feedback on respondents' NEI experiences, will remain important in future NEI studies. This type of questioning is valuable in that it provides program managers with a better understanding of the types of NEIs experienced by program participants, as well as the magnitude of the impacts. DQ feedback on NEIs also provides researchers with information to help clarify other survey responses, and can potentially provide data to shape the attributes and levels used in future CA studies.

A key benefit of the CA approach is that it reduces the strategic bias of respondents by making the dollar value estimate an indirect function of the preferences demonstrated through the choices they make. Furthermore, this method presents respondents with more familiar real-world choice scenarios which may be easier for them to complete than contingent valuation or "scaling"-type questions. However, designing a CA study that is narrow enough in scope and that reflects accurate and relevant data can be a significant challenge for researchers. In addition, interpretation of conjoint results requires

access to detailed programmatic data indicating the extent to which participants actually experienced the NEIs addressed in the conjoint questions.

In the 2007 NYSERDA NEI study, researchers applied findings from a literature review and combined the strengths of the available methods for estimating NEI values. This yielded results that are within a reasonable range of those from prior NEI studies conducted by NYSERDA, while increasing the amount of descriptive data provided by the study, as well as the level of confidence in the precision of the results. The CA results are recommended for use in NYSERDA's future cost-benefit analysis because they are thought to be more precise and conservative than the DQ results. However, both the DQ and CA survey components warrant application in future NYSERDA NEI studies. Assumptions used in designing the conjoint study and applying conjoint results at the program-level should be reviewed by others so that the application of this method can gain greater acceptance for uses in which it is well-suited.

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