nationalgrid

Laura C. Bickel
Senior Counsel

January 20, 2021

VIA ELECTRONIC MAIL

Luly E. Massaro, Commission Clerk
Rhode Island Public Utilities Commission
89 Jefferson Boulevard
Warwick, RI 02888

RE: Docket 5088 – 2021 Renewable Energy Growth Program Tariff and Rule Changes
<u>Responses to PUC Data Requests – Set 2</u>

Dear Ms. Massaro:

On behalf of National Grid,[1] enclosed please find an electronic version[2] of the Company's responses to the Second Set of Data Requests issued by the Rhode Island Public Utilities Commission in the above-referenced docket.

Thank you for your attention to this matter. If you have any questions, please contact me at 781-907-2126.

Very truly yours,

Laura C. Bickel

Enclosures

cc: Docket 5088 Service List
Leo Wold, Esq.
Jon Hagopian, Esq.
John Bell, Division

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[1] The Narragansett Electric Company d/b/a National Grid (National Grid or the Company).

[2] Pursuant to the Rhode Island Public Utilities Commission's guidance concerning the COVID-19 emergency period, National Grid is submitting an electronic version of this filing followed by an original and five hard copies filed with the Clerk within 24 hours of the electronic filing.

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Docket No. 5088– Renewable Energy Growth Program for Year 2021
National Grid & RI Distributed Generation Board
Service List updated 1/4/2021

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PUC 2-1

Request:

The DG Board characterizes the CRDG adder as a pilot. National Grid does not. Is the proposal a pilot or a programmatic change?

Response:

The Narragansett Electric Company d/b/a National Grid (the Company) considers the Low-Income Community Remote Distributed Generation Incentive to be a programmatic change. Like all aspects of the Renewable Energy Growth Program, elements of the program can be changed or rescinded in the future if they prove to be ineffective or otherwise do not meet expected outcomes.

Prepared by or under the supervision of: Ian Springsteel

PUC 2-2

Request:

What is it about the program design that prevents A-60 customers from having "access" to CRDG projects? How does "access" to the programs differ between A-16 customers and A-60 customers? How will the Company's proposed adder address the access issues within the program design? Provide concrete evidence if available.

Response:

The term "access" as it is used in the pre-filed Direct Testimony of Ian Springsteel and Meghan McGuinness refers to the overall ability of customers to know of and act on offers to enroll in a community solar project. With community net metering, the Company has been informed by project owners, and verified by enrollment records, that there is a difference in outreach to and enrollment of income-eligible Rate A-60 customers (i.e., low-income) and Rate A-16 customers, in that income level, credit, and/or bank direct deductions are often needed to enroll with a project, and marketing efforts of developers have focused on higher income, higher credit customers as a result. This forms a base-line of experience with how residential customers are approached for community solar participation. Community Remote Distributed Generation (CRDG) projects allow for the allocation of "net credits" (i.e., credits at no cost to the customer, which create bill savings). Of the two currently operating CRDG facilities, neither has any residential customers enrolled, which the Company also views as indicating an "access" issue. The Company's view is that developers target and enroll customers for CRDG projects who are the easiest to reach and communicate with. To date, those have been non-residential customers. The Low-Income CRDG Incentive will encourage developers to target Rate A-60 customers by offering them slightly more payment for kilowatt-hours that are assigned to such customers. As a result, this would improve access for Rate A-60 customers to Renewable Energy Growth Program benefits.

PUC 2-3

Request:

Under the Company's CRDG adder proposal please explain:

a. What role and tasks the CRDG project owner would need to perform in order to solicit the required number of A-60 customers.

b. How the project owner would determine and confirm which customers solicited are A-60.

c. Whether the Company would be providing A-60 customer lists to CRDG project owners and if so, how this is consistent with customer confidentiality practices.

Response:

a. Community Remote Distributed Generation (CRDG) project owners, or their agents, will need to market the benefits of enrollment, explain the limits on benefits that can be provided based on customer usage, and collect account information from Rate A-60 customers. They will then provide appropriate monthly percentage amounts for credit allocations on a Payment/Credit Transfer form with customer names and account numbers, along with each customer's three-year annual average usage, to the Company to begin transferring credits to such customers.

b. Project owners will ask Rate A-60 customers to self-identify as such when they respond to marketing outreach from the project owner. The project owner can then confirm the customer is on that rate by reviewing a customer bill, or providing the customer details, as discussed in subpart a. above, to the Company, and the Company will confirm the customer is on Rate A-60.

c. The Company will not provide lists of Rate A-60 customers to CRDG project owners. The Company plans to market the opportunity for enrollment generally to Rate A-60 customers and will direct respondents to the community solar referral website run by the Office of Energy Resources. The Company would consider other options for customers to ask for a referral to a project owner if the first approach does not result in a reasonable response and enrollment rate.

Prepared by or under the supervision of: Ian Springsteel

PUC 2-4

Request:

Referring to Schedule NG-6, pages 3 and 4, please provide the source material for the numbers shown for the estimated utility cost savings.

Response:

Please see Attachment PUC 2-4, entitled "Massachusetts Program Administrators: Massachusetts Special and Cross Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation," for a summary of the input values for utility cost savings in Table 2-1, and discussion of these values in more detail in Chapter 4. The Company uses these values as an input in the benefit-cost analysis for its Energy Efficiency programs. The Company adjusted the values to 2020 dollars because the original values were denominated in 2010 dollars.

Prepared by or under the supervision of: Meghan McGuinness

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Massachusetts Program Administrators

Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation

FINAL

August 15, 2011

Prepared by: NMR Group, Inc.

Massachusetts Program Administrators

Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation

FINAL

August 15, 2011

Prepared for: Massachusetts Program Administrators

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List of Acronyms

AESC	Avoided Energy Supply Costs
AWWA	American Water Works Association
CA	Conjoint Analysis
CDC	Centers for Disease Control and Prevention
CFC	Chlorofluorocarbon
CHP	Scottish Central Heating Programme
CO2e	Carbon dioxide equivalent
CV	Contingent Valuation
DHW	Domestic Hot Water
DRIPE	Demand Reduction Induced Price Effect
EPA	Environmental Protection Agency
GPM	Gallons per Minute
GWP	Global warming potential
HCFC	Hydrochlorofluorocarbon
HES	Home Energy Solutions
HWAP	Home Weatherization Assistance Program
IAQ	Indoor air quality
IEQ	Indoor environmental quality
IIFB	Insurance Institute Fact Book
LIHEAP	Low Income Home Energy Assistance Program
LIPPT	Low Income Public Purpose Test (California)
NATCEN	the United Kingdom's National Center for Social Research
NEB	Non-energy benefit
NEI	Non-energy impact
NSWMA	National Solid Wastes Management Association
ORNL	Oak Ridge National Laboratory
PCB	Polychlorinated biphenyls
RAD	Responsible Appliance Disposal
RV	Relative Valuation
T&D	Transmission and distribution
TRC	Total Resource Cost
TRM	Technical Reference Manual
VPP	Venture Partners Pilot
VSL	Value of a statistical life
WAP	Weatherization Assistance Program
WARM	Waste Reduction Model
WHO	World Health Organization
WRAP	Weatherization Residential Assistance Partnership
WTP	Willingness to Pay

1. EXECUTIVE SUMMARY

This report presents the findings of the Massachusetts Cross-Cutting Non-Energy Benefits [NEBs] Evaluation. It incorporates findings from a review of the Non-Energy Impacts (NEI) literature, in-depth interviews, and telephone surveys with program participants. It uses these to quantify non-energy benefits, including NEBs for low-income programs. To account for the fact both positive (benefits) and negative impacts can result from energy efficiency programs, we use the term non-energy impacts (NEIs) in this report.

NEIs are a widely recognized but difficult to quantify affect of energy efficiency programs. The impacts of efficiency programs extend beyond electric demand and electricity, gas, and oil consumption energy savings. NEIs have traditionally been characterized by the perspective of the party a particular NEI accrues to, including utilities, participants, and society. For example, utilities can realize a number of financial savings because program participants often have lower energy bills, which can decrease the likelihood that customers experience difficulties with paying their utility bills. Program participants may benefit through reduced water usage from water saving measures or experience increased comfort after a retrofit. Finally, society may realize environmental benefits and positive economic impacts from energy efficiency programs.

NEIs may also be characterized by ease of estimation. Relatively easy to quantify NEIs have engineering estimates that are fairly well established, such as water savings from an energy-efficient dish washer. Some NEIs can be quantified with more effort and less certainty, while other, less tangible NEIs are difficult to quantify.

This evaluation had several objectives. First and foremost, this evaluation sought to reliably quantify NEIs associated with the Program Administrators' (PAs) programs.[1] Through the literature review, this report classifies NEIs in terms of the perspective of the party a particular NEI accrues to (i.e., utility, participant, society) and specifies whether an NEI applies to low-income households, non-low-income households, or both.[2]

Second, the evaluation assesses the reliability of the NEI values found in the literature and the extent to which they apply to the PAs' low-income and residential programs. Classifying and assessing the reliability of the NEIs found in the literature allowed NMR to recommend NEI quantification methods that include deriving values from the literature, from engineering estimates and algorithms, and from data collection through surveys of program participants.

Third, the evaluation quantifies NEIs that apply to the PAs' residential and low-income programs. When possible, NEIs values were derived from the existing literature or by developing modified algorithms from the literature. For residential and low-income program participants, including owners of low-income rental housing, select NEI values were derived by surveys of program participants.[3] In some cases, the evaluation team does not recommend quantifying an NEI. NEIs were not recommended for quantification for one of several reasons:

- The NEI is too hard to quantify meaningfully
- Quantifying the NEI would amount to double counting as the NEI is already accounted for

[1] It is up to the Program Administrators and regulatory bodies to determine the applicability and use of the NEI values in the cost effectiveness tests used by the relevant jurisdictions.

[2] In some cases, the value of the NEI may vary by type of participant.

[3] The following NEIs were examined in the residential and low-income surveys: thermal comfort, reduced noise, property value, equipment maintenance, durability of the home, lighting life and quality, health impacts. The following NEIs were examined in the surveys of owners and managers of low-income rental housing: marketing, equipment maintenance, tenant complaints, tenant turnover, property value, lighting maintenance, durability of the property.

- There is insufficient evidence in the literature for its existence
- The NEI is too intangible

1.1 NEI QUANTIFICATION IN THE LITERATURE

NEIs have been quantified in the literature for a variety of programs by a variety of methods. However, most monetized NEI values reported have been based on low-income weatherization and retrofit programs. Since many of the NEIs are difficult to measure, quantification of these impacts must balance the minimization of uncertainty with evaluation costs. A key consideration in the quantification of NEIs is to ensure that the impacts do not overlap with other benefits that have already been accounted for elsewhere, in order to avoid double-counting of values. For many of the monetized NEI values found in the literature, the authors have attempted to determine whether or not the quantified benefits are overlapping.

The persistence of NEIs is another key consideration. The persistence of benefits is commonly assumed to be equal to the measure life of the installed efficiency measures.[4] When NEIs are estimated in terms of net present value, the NEI reported are sensitive to the assumed benefit horizon (measure life) and discount rates employed in the calculation.

An issue regarding the quantification of NEI values that is not well-addressed in the literature is the portioning out of NEIs over multiple measures. Most programs studied include multiple measures, with NEIs attributed to the installed measures as a group rather than individually. Therefore, NEIs have generally been examined at the program level rather than at the measure level, with notable exceptions of studies that have examined NEIs associated with appliance programs.[5] While most NEIs are attributable to a program, to the extent possible, NMR has recommended NEI values applicable to individual measures.

Finally, when comparing various values for a give NEI reported in the literature, it is important to recognize the variation in program elements, the type and quantity of measures installed, and geographic/climatic differences amongst the programs from which the values were derived, since these factors can influence the reported NEI values.

1.1.1 Utility-Perspective NEIs

Utilities can realize a number of NEIs from their energy efficiency programs in the form of financial savings. Energy-efficient technologies installed by PA programs often result in reduced energy bills for participants, which can decrease the likelihood that customers experience difficulties with paying their utility bills. In turn, utilities realize financial savings through reduced costs associated with arrearages and late payments, uncollectible bills and bad debt write-offs, service terminations and reconnections, bill-related customer calls, and the bill collections process. In addition, utilities may realize savings from their efficiency programs due to a reduction in safety-related emergency calls and reductions in energy that is eligible for a rate discount. Theoretically, most of these benefits could apply to some extent to all PA programs and customers, but the NEI literature has rarely quantified these benefits for non-low-income customers and programs.

[4] A benefit horizon of ten or 20 years is commonly assumed in the literature (see, for example, Schweitzer and Tonn, 2002; TecMarket Works, SERA and Megdal Associates, 2001; Riggert et al., 1999; and Skumatz and Nordeen, 2002).

[5] Other exceptions would include a study conducted by Smith-McClain, Skumatz and Gardener which examined the impacts of individual weatherization measures on NEI values and found that presence of insulation was the only measure to have a significant impact on NEI values. Other exceptions include several studies that examined NEI values associated with individual appliances (see Fuchs et al., 2005; Skumatz et al, 2005; Stoecklein & Skumatz, 2007)

As utility-perspective NEIs represent tangible benefits in the form of direct monetary savings, they tend to be relatively easy to quantify, compared to Participant- and Societal- perspective NEIs.

1.1.2 Participant-Perspective NEIs – Occupants

Participants can also realize a variety of NEIs from energy efficiency programs. These NEIs are generally considered less tangible and therefore are much more difficult to measure than those from the utility perspective. Some of the participant NEIs are due to subjective, non-material impacts, such as "increased comfort" or "sense of doing good for the environment," while others, though very tangible—such as improved health or increased property value—are difficult to measure and monetize. When measured and monetized, participant NEIs have often been found to be quite valuable, often exceeding the value of energy savings and NEIs from the societal and utility perspectives.

1.1.3 Societal-Perspective NEIs

A number of NEIs from energy efficiency programs may also accrue to society. NEIs from the societal perspective are indirect program effects not realized solely by utilities or by program participants, but rather by society at large. Much of the latest literature on societal-perspective NEIs focuses on environmental and economic impacts; however, these two societal NEIs are not included in this review because the environmental and economic impacts of the PAs' programs have been included in the PAs' three year energy efficiency plans (National Grid et al., 2009; NSTAR et al., 2009). Many of the remaining societal NEIs are sparsely reported and quantified. Examples include equity benefits or reduced societal disparity for the low-income populations, and cost savings to social service agencies resulting from low-income weatherization. When equity benefits associated with low-income programs have been addressed in the literature, improving the economic status of the low-income participants is often the primary program goal. Therefore, these programs tend to emphasize program elements that are not part of the PA programs, such as education, counseling, financial assistance, and job training. Societal NEIs tend to be moderately to very difficult to quantify. Other societal benefits examined by this report include benefits from appliance recycling programs and potential reductions in the costs of medical care due to improved health of program participants.

1.1.4 Participant Perspective NEIs – Owners of Low-Income Housing

A portion of the PAs' program participants consists of property owners of low-income rental housing, particularly within the multifamily programs. Our review of the literature found no mention of non-energy impacts pertaining to participating owners of low-income rental housing. However, interviews with PA staff identified several potential NEIs, including reduced maintenance pertaining to lighting (attributed to the longer life of a CFL, thus reducing labor costs), reduced maintenance associated with heating and cooling systems, improved marketing of rental property (i.e., a more energy-efficient rental unit is easier to market and rent), and reduced tenant turnover.

1.2 SUMMARY OF NEIs

The NEIs we assessed in this study are summarized in Table 1-1. In general, for utility-perspective NEIs, NMR recommends using values in the literature, or algorithms in the literature using inputs of PA-specific data. For some of the participant-perspective NEIs, NMR recommends values derived from the participant surveys. For other participant-perspective NEIs, NMR recommends using engineering estimates, values in the literature, algorithms in the literature, or not valuing a particular NEI. For societal-perspective NEIs, NMR recommends a mixture of not valuing, using new survey data, or using engineering algorithms. If different NEI values are recommended for low-income and non-low-income programs, the values are designated with an LI (low-income) and NLI (non-low-income) in the table.

When estimating NEIs, it is important to note that free-ridership and spillover should be accounted for in all calculations and estimates for NEIs that apply to non-low-income participants. The summary tables, algorithms, and body of the report do not contain free ridership and spillover factors, as it is assumed that these will be applied to each NEI at the program level, from free ridership and spillover factors derived from other evaluations.

In addition, NMR recommends that the duration of the NEI correspond with the expected life of the corresponding measures associated with each NEI, as reported in the current TRM (Massachusetts Electric and Gas Energy Efficiency Program Administrators, 2010). For NEIs that are estimated on a per participant basis and derived from multiple measures, NMR recommends adopting the methodology used in the current TRM for determining the measure life for the gas weatherization program, whereby the measure life is weighted based on the mix of measures installed. (Massachusetts Electric and Gas Energy Efficiency Program Administrators, 2010).

1.2.1 Utility-Perspective NEIs

Nearly all utility-perspective NEIs arise from programs targeted to low-income customers, wherein the programs reduce energy bills for participants. As a result of reduced energy bills, program participants are less likely to experience difficulties with paying their utility bills and the PAs' realize financial savings. In addition, utilities may realize savings due to a reduction in safety-related emergency calls and insurance costs, due to reduced fires and other emergencies. In general, the utility-perspective NEIs are relatively low in value, typically ranging from less than a dollar to nearly $9 per participant. Most of the NEIs found in the literature apply to the PAs' low-income programs and can be monetized relatively easily from the literature or from algorithms using inputs from the PAs.

1.2.2 Participant-Perspective NEIs - Occupants

Participant-perspective NEIs accrue to participants in both low-income and non-low-income programs, although some participant NEIs are specific to low-income participants. Most of the participant-perspective NEIs found in the literature apply to the PAs' programs. In general, the participant-perspective NEIs are relatively high in value, although the ranges of values found in the literature for many of these NEIs vary considerably. Some of these NEIs are quantifiable with some effort, using data from the PAs, secondary data, and algorithms found in the literature. However, most of the participant-perspective NEIs are difficult to quantify and require primary data collection through participant surveys. In this study NMR quantified a number of these less tangible participant-perspective NEIs, though it should be noted that they can be quantified with only limited certainty.

For some of the participant-perspective NEIs, NMR recommends using values derived from the recently completed NEI surveys. For other participant-perspective NEIs, NMR recommends using engineering estimates, values in the literature, algorithms in the literature, or not valuing a particular NEI.

It is important to note that a number of participant perspective NEIs commonly found in the literature and currently included in the TRM report are derived from customer bill savings. These bill savings partially overlap with avoided costs accounted for in the Avoided Energy Supply Costs (AESC) in New England (Hornby et al., 2011) and included in the TRC calculations. The AESC study estimates a number of avoided costs, including avoided costs of electricity to retail customers and avoided costs to natural gas retail customers. Each set of avoided costs is comprised of several individual costs. For example, avoided costs of electricity to retail customers includes avoided energy costs, avoided capacity costs, avoided environmental regulation compliance costs, demand reduction induced price effects, and avoided costs of local transmission and distribution infrastructure (Hornby et al, 2011). While bill savings and avoided costs partially overlap, they typically differ in part because bill savings are based on average retail savings to participants while avoided costs are based on marginal energy supply costs that are avoided because of the PAs' energy efficiency programs. Theoretically, a participant NEI of bill savings, based on the difference between the avoided energy and capacity costs and participant energy bill savings, could be added to the TRC. However, according to traditional TRC calculation methods, including participant bill savings as a benefit would require including a similar cost in the form of lost PA revenues, thus negating the bill savings benefit.[6] Therefore, there is no additional NEI of participant bill savings.

In addition, NMR does not recommend including any NEIs that are derived from participant bill savings because it would amount to double counting of benefits. To count benefits that derive from bill savings would amount to valuing the additional disposable income (i.e., bill savings) and the ways in which the participants spend the disposable income. For example, a participant may spend the bill savings on food or medicine, leading to improved health. Similarly, participants may use their bill savings to pay energy bills, reducing the incidence of service terminations and the costs associated with service termination and reconnection. But to count both the bill savings and the health benefits or the benefit of reduced service terminations that are derived entirely from the way bill savings are spent is to count the same benefit twice. Other examples of NEIs derived from bill savings include reduced bill-related calls and reduced need to move or forced mobility.

1.2.3 Participant-Perspective NEIs - Owners and Managers of Low-income Rental Housing

Participant Perspective NEIs (Owners of Low-income Rental Housing) were derived from the recently completed NEI surveys.

Table 1-1 provides an overview of all NEIs reviewed in this report, including NMR's recommendation to quantify or not quantify the NEI, the method of quantification, and the recommended value of the NEI (if available). NEI values are reported on a per-housing unit basis. More detailed presentations of the NEI values, including reasons for not quantifying an NEI, can be found in the body of the report.

1.2.4 Societal-Perspective NEIs

The societal-perspective NEIs of interest to the PAs for this literature review (i.e. the non-economic and non-environmental societal NEIs) generally arise from programs targeted to low-income customers. Little work has been done in the area of quantifying these NEIs, and quantification methods are not well-established in the literature. Societal NEIs are generally quantifiable with some effort using secondary data, but the values are of limited certainty.

1.2.5 Non-Resource Benefits

NMR has developed several values for non-resource benefits that pertain to waste reduction attributable to the PAs' Appliance Turn-in Program.

Table 1-1. Summary of Recommended NEI Values

NEI	Quantify (Yes/No)	Method of Quantification	Recommended Value[7]	Duration
UTILITY PERSPECTIVE				
Arrearages	Yes	Literature	$2.61	Annual
Bad debt write-offs	Yes	Literature	$3.74	Annual

[6] As defined in the *California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects,* the TRC takes into consideration program benefits and costs in terms of the participants and the ratepayers: "In a sense, it is the summation of the benefit and cost terms in the Participant and the Ratepayer Impact Measure tests, where the revenue (bill) change and the incentive terms intuitively cancel (CPUC, 2001, p. 18)."

[7] Recommended values derived from the literature represent the median of the values reported in the recent NEI literature. Values were adjusted to 2010 dollars using an inflation rate of 2.5 percent per year, the same inflation rate used in the PAs' three-year plans.

NEI	Quantify (Yes/No)	Method of Quantification	Recommended Value[7]	Duration
Terminations and reconnections	Yes	Literature	$0.43	Annual
Rate discounts	Yes	Algorithm & PA data	Algorithm	Annual
Complaints and payment plans	No	None for now	None	—
Customer calls	Yes	Literature	$0.58	Annual
Collections notices	Yes	Literature	$0.34	Annual
Safety-related emergency calls	Yes	Literature	$8.43	Annual
Increased electricity system reliability	No	Quantified Elsewhere	None	—
Transmission and distribution savings	No	Quantified Elsewhere	None	—
Insurance savings	Yes	Literature	National WAP Evaluation (2011)	—
PARTICIPANT PESPECTIVE (OCCUPANT)				
Higher comfort levels	Yes	Survey	$125 (NLI retrofits); $77 (NLI new construction) / $101 (LI)	Annual
Improved sense of environmental responsibility	No	Quantified Elsewhere	None	Annual
Quieter interior environment	Yes	Survey	$31 (NLI retrofits); $40 (NLI new construction) / $30 (LI)	Annual
Reduced noise (dishwashers)	No	None for now	None	Annual
Lighting quality & lifetime	Yes	TRM Report	$3.50/CFL fixture; $3.00 per CFL bulb	One time
Increased housing property value	Yes	Survey	$1,998 (NLI retrofits); $72 (NLI RNC/$949 (LI)	One time (Annual for NLI RNC)
Buffers energy price increase	No	Quantified Elsewhere	None	—
Reducing energy expenses, making more money available for other uses, such as health care	No	Quantified Elsewhere	None	—
Reduced need to move and costs of moving, including homelessness	No	Quantified Elsewhere	None	—
Reduced detergent usage (dishwashers)	No	None	None	Annual

NEI	Quantify (Yes/No)	Method of Quantification	Recommended Value[7]	Duration
Reduced water usage and sewer costs (dishwashers)	Yes	Algorithm from literature	$3.70	Annual
Reduced water usage and sewer costs (tankless water heaters)	No	None	—	—
Reduced water usage and sewer costs (faucet aerators)	Yes	Algorithm from literature	Algorithm	Annual
Reduced water usage and sewer costs (low flow showerheads)	Yes	Algorithm from literature	Algorithm	Annual
More durable home and less maintenance	Yes	Survey	$149 (NLI retrofits)/$35 (LI)	Annual
Equipment and appliance maintenance requirements	Yes	Survey	$124 (NLI retrofits)/$54 (LI)	Annual
Health related NEIs	Yes	Survey	$4 (NLI retrofits)/$19 (LI)	Annual
Improved safety (heating system, ventilation, carbon monoxide, fires)	Yes	Algorithm & PA data	$37.40 (avoided fire deaths); $0.03 (avoided fire injuries); $1.24 (avoided fire property damage); $6.38 (avoided CO poisonings; all LI	Annual
Improved safety (lighting)	No	None for now	None	—
Heat (or lack thereof) generated	No	None	None	—
Warm up delay	No	None for now	None	—
Product lifetime	No	None	None	—
Availability of hot water	No	None for now	None	—
Product performance	No	None for now	None	—
Window AC NEIs	Yes	Literature	$49.50	Annual
Bill-related calls	No	Quantified Elsewhere	None	—
Termination and reconnection	No	Quantified Elsewhere	None	—
Reduced transaction costs	No	None	None	—
Education	No	None	None	—
SOCIETAL PERSPECTIVE				

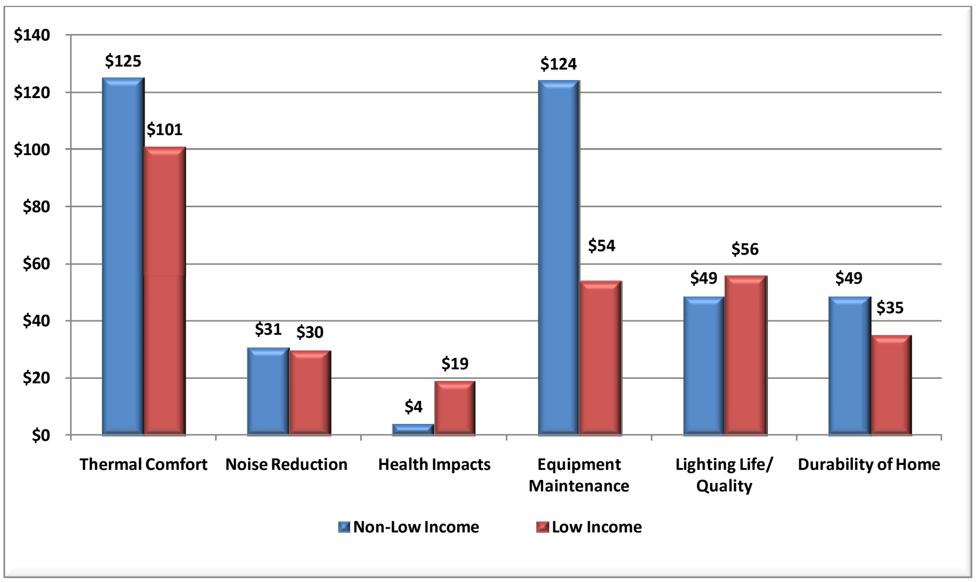
NEI	Quantify (Yes/No)	Method of Quantification	Recommended Value[7]	Duration
Weatherization by utility programs saves costs of inspections and upgrades by other agencies	No	None for now	None	—
Equity and Hardship	No	None	None	—
Improved Health	No	None for now	None	—
Improved Safety	No	None for now	None	—
Water	No	None for now	None	—
National Security	Yes	Algorithm from literature	Algorithm	Annual
PARTICIPANT PERSPECTIVE (OWNERS OF LOW-INCOME RENTAL HOUSING), PER HOUSING UNIT				
Marketability/ease of finding renters	Yes	Survey	$0.96	Annual
Reduced tenant turnover	Yes	Survey	$0	Annual
Property value	Yes	Survey	$17.03	One time
Equipment maintenance (heating and cooling systems)	Yes	Survey	$3.91	Annual
Reduced maintenance (lighting)	Yes	Survey	$66.73	Annual
Durability of property	Yes	Survey	$36.85	Annual
Tenant complaints	Yes	Survey	$19.61	Annual
NON-RESOURCE BENEFITS				
Appliance Recycling – Avoided landfill space	Yes	Algorithm from literature	$1.06	One time
Appliance Recycling – Reduced emissions due to recycling plastic and glass, reduced emissions	Yes	Algorithm from literature	$1.25	One time
Appliance Recycling – Reduced emissions due to incineration of insulating foam	Yes	Algorithm from literature	$170.22	One time

1.3 NEIS QUANTIFIED THROUGH PARTICIPANT SURVEYS

NMR estimated the value of several NEIs through surveys of program participants, using a *Relative Valuation* method, by which respondents were asked to assign a monetary value to various NEIs, compared to the amount of energy savings yielded by the measures they had installed. To correct for the common finding that the sum of individual NEI values exceeds the overall value reported by participants of the NEIs together, NMR included a question about overall NEI values, then took the conservative approach of scaling the individual NEI values to the overall value.

The survey results for non-low-income and low-income respondents are summarized in Figure 1-1. The values shown for each NEI are the per participant annual averages of each NEI. In general, non-low-income (NLI) respondents placed a higher value than did the low-income (LI) respondents on the NEIs that provide annual benefits (i.e., all the NEIs except increase in property value), except for health impacts and lighting life and quality. NLI respondents valued thermal comfort and equipment maintenance the most ($125 and $124 per year, respectively), while LI respondents valued thermal comfort, lighting life and quality, and equipment maintenance the most ($101, $56, and $54, respectively).

Figure 1-1. Valuation of Annual NEIs per Participant Non-low-income and Low-income Respondents

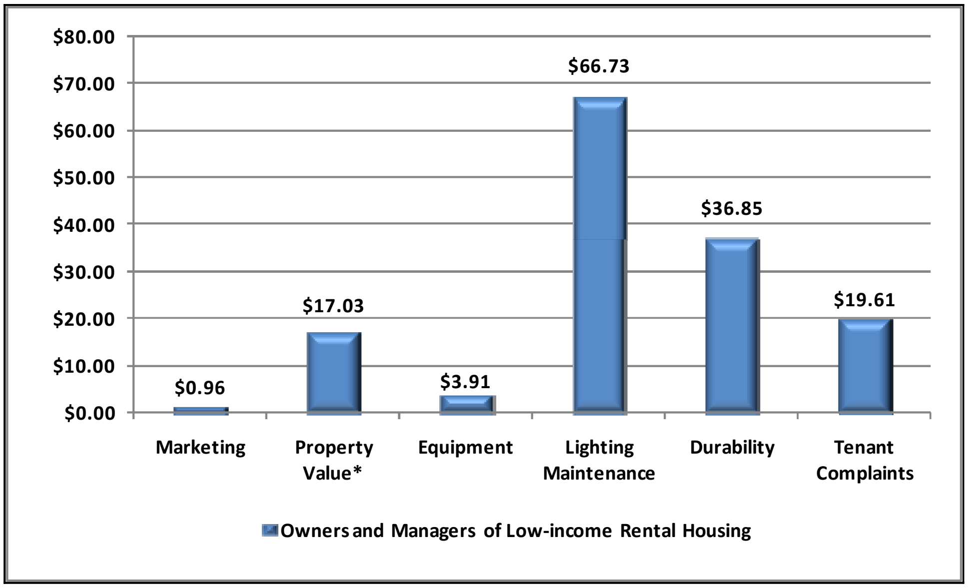


Non-low-income respondents also estimated a substantially higher one-time property value increase attributable to the energy efficiency retrofits than did low-income respondents ($1,998 and $949, respectively).

In addition to the NEIs assessed through the relative valuation method, this survey included questions related to participant perspective health benefits—via reductions in sick days attributed to the energy efficiency retrofits—as well as societal benefits via reduced medical costs due to reductions in incidences of heat stress, hypothermia and asthma. Because of the extremely small number of respondents reporting program induced changes in health, NMR does not recommend using results from this method. Findings are reported in Section 9.5. However, health benefits are also being examined in the current evaluation of the national WAP; values might be derived from these findings once the study is complete (Ternes et al., 2007)

Survey results for owners and managers of low-income rental housing are summarized in Figure 1-2. The most highly valued NEI was reduced costs associated with lighting maintenance, with a mean annual value of $66.73 per housing unit, followed by increased durability of the building or property, with a mean annual value of $36.85 per housing unit. Improved marketing, reduced equipment maintenance, expected increase in property value (one-time benefit), and reduced tenant complaints were all valued at $20 a year or less per housing unit. One NEI, reduced tenant turnover, was valued at $0 for all respondents.

Figure 1-2. Valuation of NEIs per Housing Unit
Owners and Managers of Low-income Rental Housing



*Property Value is a one-time benefit while the remaining NEIs are annual benefits.

2. INTRODUCTION AND OVERVIEW OF NEI VALUES

This report presents the findings of the Massachusetts Cross-Cutting Non-Energy Benefits Evaluation. It incorporates findings from a review of the NEI literature, in-depth interviews, and telephone surveys with program participants, and uses these to quantify non-energy benefits, including NEBs for low-income programs. To account for the fact both positive and negative impacts can result from energy efficiency programs, we use the term non-energy impacts (NEIs) in this report.

Overall, more than 125 reports and academic papers were reviewed for this report. As a complement to the literature review, NMR conducted 13 interviews with Project Administrator (PA) staff members responsible for residential retrofit programs, low-income retrofit programs, and residential new construction programs. Nine in-depth interviews were also conducted with administrators of low-income and residential retrofit energy efficiency programs in other states, health and safety experts, and social service providers familiar with low-income weatherization programs.

NEI values were derived in several ways. When possible, NEIs values were derived from the existing literature or by developing modified algorithms from the literature. For residential and low-income program participants, including owners of low-income rental housing, select NEIs values were estimated with surveys of program participants. NEIs estimated from surveys relied on the following three sources:

- A survey of 213 low-income households whose homes were retrofitted by the PAs programs between July 1, 2009 and June 30, 2010
- A survey of 209 non-low-income households whose homes were retrofitted by the PAs programs between July 1, 2009 and June 30, 2010
- A survey of 21 owners and managers of low-income rental housing

The following participant NEIs were addressed via the surveys:

- Thermal comfort in terms of temperature and draftiness
- Noise levels in terms of the amount of outdoor noise the home's occupants can hear inside the house
- Health in terms of the frequency or intensity of colds, flus or other illnesses, such as asthma
- Expected increase in property value (homeowners only)
- Reliability and maintenance requirements of heating and cooling equipment
- Lighting quality combined with longer lighting life, given the use of CFLs and fluorescent fixtures
- Durability of home and need for repairs
- In addition, the surveys examined in more detail a number of health related NEIs that may accrue to the participant and to society. These include changes in the number of sick days experienced by program participants, with the resulting impacts on societal costs for medical care, as measured by the number of times medical care was sought for heat exposure, hypothermia and asthma or other chronic conditions.

Lastly, the surveys addressed the following NEIs that may be experienced by the owners and managers of retrofitted low-income rental housing:

- Marketability and ease of finding renters
- Reduced maintenance of heating and cooling equipment

- Reduced maintenance for lighting
- Reduced tenant turnover
- Reduced tenant complaints
- Expected increase in property value
- Improved durability of property

Table 2-1(Utility-perspective), Table 2-2 (Participant-perspective – Occupants), Table 2-3 (Societal-perspective), and Table 2-5 (Participant-perspective – Owners of Low-income Rental Housing) provide details for each NEI. In the tables, for each NEI, we present the following:

- The range of values reported in the recent literature (and indicate if no values have been reported in the literature)
- Recommendation for quantification
- Method of quantification
- The recommended value of the NEI, the recommended algorithm for quantifying the NEI, or the justification for not quantifying the NEI.
- The basis of the NEI (per participant or per measure)
- The time frame of the NEI (annual benefit or one-time benefit)
- The relevant PA programs

When estimating NEIs, it is important to note that free-ridership and spillover should be accounted for in all calculations and estimates for NEIs that apply to non-low-income participants. The summary tables, algorithms, and body of the report do not contain free ridership and spillover factors, as it is assumed that these will be applied to each NEI at the program level, from free ridership and spillover factors derived from impact evaluations.

In addition, NMR recommends that the duration of the NEI correspond with the expected life of the corresponding measures associated with each NEI as reported in the current TRM (Massachusetts Electric and Gas Energy Efficiency Program Administrators, 2010). For NEIs that are estimated on a per participant basis and derived from multiple measures, NMR recommends adopting the methodology used in the current TRM for determining the measure life for the gas weatherization program, whereby the measure life is weighted based on the mix of measures installed. (Massachusetts Electric and Gas Energy Efficiency Program Administrators, 2010).

Utility-perspective NEIs are summarized below in Table 2-1 Nearly all utility-perspective NEIs arise from programs targeted to low-income customers, wherein the programs reduce energy bills for participants. As a result, program participants are less likely to experience difficulties with paying their utility bills and the PAs realize financial savings. In addition, utilities may realize savings due to a reduction in safety-related emergency calls and insurance costs, due to reduced fires and other emergencies. In general, the utility-perspective NEIs are relatively low in value, typically ranging from less than a dollar to nearly $9 per participant. Most of the NEIs found in the literature apply to the PAs' low-income programs and can be monetized relatively easily from the literature or from algorithms using inputs from the PAs. An overview of the studies used to estimate utility-perspective NEI values is provided in Appendix D.[8]

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[8] Values were derived from the literature published since 1997 and were adjusted into 2010 dollars using an inflation rate of 2.5 percent per year, the same inflation rate used in the PAs' three-year plans (see National Grid et al., 2009; NSTAR et al., 2009).

In addition, NMR estimated NEI values at the measure level (Table 2-6, Table 2-7, and Table 2-8). To do so, NMR assigned a portion of a given NEI value to an individual measure based on the average energy bill savings for which the measure is responsible. This method has also been used for the *2001 California Low Income Public Purpose Test (LIPPT) report for the Reporting Requirements Manual (RRM) Working Group Cost Effectiveness Committee* (TecMarket Works, SERA and Megdal Associates, 2001).

Table 2-1. Summary of Utility-Perspective NEI Values

NEI	Range of Reported Values ($)[9]	Quantify	Method of Quantification	Recommended Value, Algorithm, or Justification for not quantifying[10]	Basis	Duration	Relevant PA Programs[11]
Arrearages	0.50–7.50[12]	Yes	Literature	$2.61	Per participant	Annual	1,2
Bad debt write-offs	0.48–7.00	Yes	Literature	$3.74	Per participant	Annual	1,2
Terminations and reconnections	0.02–7.00	Yes	Literature	$0.43	Per participant	Annual	1,2
Rate discounts	2.61–23.57	Yes	Algorithm & PA data	Estimated energy savings per installed measure * [(full rate per unit energy ($) – discounted rate per unit energy ($)][13]	Per measure	Annual	1,2
Complaints and payment plans	No monetized values reported	No	None for now	Insufficient data in the literature to derive a reliable value	—	—	—
Customer Calls	0.00–1.58	Yes	Literature	$0.58	Per participant	Annual	1,2

[9] Values in the table reported as per participant, per year

[10] Recommended values derived from the literature represent the median of the values reported in the recent NEI literature. Values were adjusted to 2010 dollars using an inflation rate of 2.5 percent per year, the same inflation rate used in the PAs' three-year plans.

[11] The following numbers correspond to the following PA Programs: 1 Low-income retrofit programs; 2 = Low-income new construction programs; 3 = Residential new construction; 4 = Residential cooling and heating; 5 = Residential heating and hot water; 6 = Non-low-income retrofit programs (i.e., MassSAVE, multi-family retrofit programs); 7 = ENERGY STAR lighting; 8= ENEGY STAR appliances

[12] A previous draft reported a maximum value of $32 reported in the NEI literature. The $32 value was an annual value reported in the 1993 evaluation of the national WAP program (Brown et al., 1993). This same benefit was estimated to have an net present value (NPV) of $57 (or roughly $3.90 annual value) in the 2002 evaluation of the same program (Schweitzer and Tonn, 2002), so we relied on the more recent value to report the range of values.

[13] Alternatively, the NEI of rate discounts could also be estimated at the participant level rather than at the measure level The rate discount benefit can be calculated either by individual PAs, according to their individual PA rate discount, or it can be calculated statewide using the population weighted rate discounts of $0.0424 per kWh and $0.2663 per therm.

NEI	Range of Reported Values ($)[9]	Quantify	Method of Quantification	Recommended Value, Algorithm, or Justification for not quantifying[10]	Basis	Duration	Relevant PA Programs[11]
Collections notices	0.00–1.49	Yes	Literature	$0.34	Per participant	Annual	1,2
Safety-related emergency calls	0.07–15.58[14]	Yes	Literature	$8.43	Per participant	Annual	1[15]
Increased electricity system reliability	No monetized values reported	No	Quantified Elsewhere	The PAs currently receive credit for contributing to increased system reliability due to the load reductions attributable to energy efficiency measures (Hornby et al., 2011).	—	—	—
Transmission and distribution savings	0.13–4.33	No	Quantified Elsewhere	Avoided transmission and distribution losses are already accounted for in the Total Resource Cost (TRC) test	—	—	—
Insurance savings	0.00–0.15	Yes	Literature	Derive value from National WAP Evaluation (2011)	—	—	1

[14] A previous draft reported a maximum value of $22.67 reported in the NEI literature The $22.57 was reported in a study by Magouirk (1995) as first-year savings value attributable to the 1993 Colorado Public Service's energy savings partners program (a low-income weatherization program). It was an overall safety value comprised of several individual safety NEIs: $15.58 (emergency calls excluding flex connectors); $1.98 (for gas flex connectors), & $5.01 (incremental cost of having the flex connector replaced by emergency services instead of weatherization agency). Because gas flex connectors were not included in the PAs' programs, we removed the benefits associated with the flex connectors and report the value of $15.58 (emergency calls excluding flex connectors).

[15] This NEI only applies to participants with replaced or repaired space and water heating equipment, gas appliances, and gas connectors

Participant-perspective NEIs are summarized below in Table 2-2. Participant-perspective NEIs accrue to participants in both low-income and non-low-income programs, although some participant NEIs are specific to low-income participants. Most of the participant-perspective NEIs found in the literature apply to the PAs' programs. In general, the participant-perspective NEIs are relatively high in value, although the ranges of values found in the literature for many of these NEIs are large. Some of these NEIs are quantifiable with some effort: with data from the PAs, secondary data and algorithms found in the literature. However, most of the participant-perspective NEIs are difficult to quantify and require primary data collection through participant surveys. Due to the less tangible nature of many participant-perspective NEIs, they can be quantified with only limited certainty.

For some of the participant-perspective NEIs, NMR recommends using values derived from the recently completed NEI surveys. For other participant-perspective NEIs, NMR recommends using engineering estimates, values in the literature, algorithms in the literature, or not valuing a particular NEI

For the PAs' residential new construction program, NMR recommends scaling the values of individual NEIs to 100% of estimated bill savings.[16] Because the NMR survey did not include a question asking respondents to estimate the overall value of the NEIs combined, this would represent a more conservative valuation of these NEIs.

It is important to note that a number of participant perspective NEIs commonly found in the literature and currently included in the TRM report are derived from customer bill savings. These bill savings partially overlap with avoided costs accounted for in the Avoided Energy Supply Costs (AESC) in New England (Hornby et al., 2011) and included in the TRC calculations. The AESC study estimates a number of avoided costs, including avoided costs of electricity to retail customers and avoided costs to natural gas retail customers. Each set of avoided costs is comprised of several individual costs. For example, avoided costs of electricity to retail customers includes avoided energy costs, avoided capacity costs, avoided environmental regulation compliance costs, demand reduction induced price effects, and avoided costs of local transmission and distribution infrastructure (Hornby et al, 2011). While bill savings and avoided costs partially overlap, they typically differ in part because bill savings are based on average retail savings to participants while avoided costs are based on marginal energy supply costs that are avoided because of the PAs' energy efficiency programs. Theoretically, a participant NEI of bill savings, based on the difference between the avoided energy and capacity costs and participant energy bill savings, could be added to the TRC. However, according to traditional TRC calculation methods, including participant bill savings as a benefit would require including a similar cost in the form of lost PA revenues, thus negating the bill savings benefit.[17] Therefore, there is no additional NEI of participant bill savings.

In addition, NMR does not recommend including any NEIs that are derived from participant bill savings because it would amount to double counting of benefits. To count benefits that derive from bill savings would amount to valuing the additional disposable income (i.e., bill savings) and the ways in which the participants spend the disposable income. For example, a participant may spend the bill savings on food or medicine, leading to improved health.Similarly, participants may use their bill savings to pay energy bills, reducing the incidence of service terminations and the costs associated with service termination and

[16] Our recommendation of scaling to 100% of bill savings represents a higher percentage of bill savings than the average non-low-income respondent from this study (total NEIs were, on average, 77% of bill savings for non-low-income respondents). However, we believe that 100% of bill savings is reasonable because the NEIs for a new home may be different than a retrofit. Further, the sum of the individual NEIs for the residential new construction program were substantially higher than the retrofit NEIs found in this study, both in dollar value and as a percentage of savings (NMR and Conant, 2009). For the ENERGY STAR homes evaluation, the sum of the individual NEIs ($1,445) was a much higher percentage of bill savings (361% of bill savings, based on estimate of $400 annual bill savings) than the non-low-income respondents from this study (the sum of the individual NEIs was equal to 132% of bill savings).

[17] As defined in the *California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects,* the TRC takes into consideration program benefits and costs in terms of the participants and the ratepayers: "In a sense, it is the summation of the benefit and cost terms in the Participant and the Ratepayer Impact Measure tests, where the revenue (bill) change and the incentive terms intuitively cancel (CPUC, 2001, p. 18)."

reconnection. But to count both the bill savings and the health benefits or the benefit of reduced service terminations that are derived entirely from the way bill savings are spent is to count the same benefit twice. Other examples of NEIs derived from bill savings include reduced bill-related calls and reduced need to move or forced mobility.

Table 2-2. Summary of Participant-Perspective (Occupants) NEI Values

NEI	Range of Reported Values ($)[18]	Quantify	Method of Quantification	Recommended Value, Algorithm, or Justification for not quantifying	Basis	Duration	Relevant PA Programs[19]
Higher comfort levels	27.13–279.00	Yes	Survey	$125 (NLI) / $101 (LI)	Per participant	Annual	1,2,4,5,6[20]
			Survey	$77	Per participant	Annual	3
Improved sense of environmental responsibility	4.00–220.00	No	Quantified Elsewhere	Environmental benefits have already been estimated in the *Avoided Energy Supply Costs in New England: 2011 Report* (AESC 2011) and included in PA's 3-year energy efficiency plans and the benefit is too intangible to quantify	Per participant	Annual	—
Quieter interior environment	13.00–252.00	Yes	Survey	$31 (NLI) / $30 (LI)	Per participant	Annual	1,2,4 5,6 [20]
			Survey	$40	Per participant	Annual	3
Reduced noise (dishwashers)	No monetized values reported	No	None for now	Insufficient data in the literature to derive a reliable value	—	—	—
Lighting quality	19.00–25.00[21]	Yes	TRM Report	$3.50 / CFL fixture; $3.00 per CFL bulb; combined value for lighting lifetime and quality.	Per fixture / bulb	One time	1,2, 3,6,7 (lighting measures only)
Longer lighting life	1.80		TRM Report				

[18] Values in the table reported as per participant, per year

[19] The following numbers correspond to the following PA Programs: 1 Low-income retrofit programs; 2 = Low-income new construction programs; 3 = Residential new construction; 4 = Residential cooling and heating; 5 = Residential heating and hot water; 6 = Non-low-income retrofit programs (i.e., MassSAVE, multi-family retrofit programs); 7 = ENERGY STAR lighting; 8= ENEGY STAR appliances

[20] This NEI only applies to participants that installed shell measures &/or HVAC equipment

[21] This range excludes the value of $144 estimated for the MA ENERGY STAR Homes program by NMR and Conant (2009) which was based on lighting quality combined with longer lighting life for all CFLs and fluorescent fixtures in the home.

NEI	Range of Reported Values ($)[18]	Quantify	Method of Quantification	Recommended Value, Algorithm, or Justification for not quantifying	Basis	Duration	Relevant PA Programs[19]
Increased housing property value	2.57 – 22.00	Yes	Survey	$1,998 (NLI) / $949 (LI)	Per participant	One time	1,2,4,5,6 [20]
Anticipated ease of selling or leasing home	170.00 – 348.00		Survey	$72 for combined increased property value/anticipated ease of selling or leasing home	Per participant	Annual	3
Buffers energy price increase	161.00 – 611.00	No	Quantified Elsewhere	The value of Demand Reduction Induced Price Effect (DRIPE) has been estimated in AESC 2011 report and included in the TRC test	—	—	—
Reducing energy expenses, making more money available for other uses	No monetized values reported	No	Quantified Elsewhere	Benefit derived entirely from energy savings, which are already included in the TRC test	—	—	—
Reduced need to move and costs of moving, including homelessness	0.65 – 100.00	No	Quantified Elsewhere	Benefit derived entirely from energy savings, which are already included in the TRC test	—	—	—
Reduced detergent usage (dishwashers)	No monetized values reported	No	None	Insufficient data in the literature to derive a reliable value	—	—	—
Reduced water usage and sewer costs (dishwashers)	1.65	Yes	Algorithm from literature	$3.70	Per measure	Annual	3 (dishwashers)
Reduced water usage and sewer costs (tankless water heaters)	No monetized values reported	No	None	Insufficient data in the literature to derive a reliable value	—	—	—

NEI	Range of Reported Values ($)[18]	Quantify	Method of Quantification	Recommended Value, Algorithm, or Justification for not quantifying	Basis	Duration	Relevant PA Programs[19]
Reduced water usage and sewer costs (low flow showerheads)	4.89 – 13.38	Yes	Algorithm from literature	(3696 gallons water saved per low flow showerhead per year) * √average number of showerheads installed per site * [$0.0036 (average cost of water per gallon) + $0.0050 (average cost of sewerage per gallon)]	Per participant	Annual	1, 2,6 [22]
Reduced water usage and sewer costs (faucet aerators)		Yes	Algorithm from literature	(332 gallons water saved per faucet aerator per year * √average number of faucet aerator installed per site * [$0.0036 (average cost of water per gallon) + $0.0050 (average cost of sewerage per gallon)]	Per participant	Annual	1,2,6 [22]
More durable home and less maintenance	90.00 – 202.00	Yes	Survey	$149 (NLI retrofits) / $35 (LI)	Per participant	Annual	1,2,4,5,6 [20]
Equipment & appliance maintenance	17.00 – 150.00	Yes	Survey	$124 (NLI retrofits) / $54 (LI)	Per participant	Annual	1,2,4,5,6 [20]
Health related NEIs	1.00 – 330.00	Yes	Survey	$4 (NLI retrofits) / $19 (LI)	Per participant	Annual	1,2,4,5,6 [20]
Improved safety (heating system, ventilation, carbon monoxide, fires)	0.00 – 105.00	Yes	Algorithm & PA data	Avoided fire deaths: $37.40	Per measure	Annual	1 [23]
			Algorithm & PA data	Avoided fire-related injuries: $0.03	Per measure	Annual	
			Algorithm & PA data	Avoided fire-related property damage: $1.24	Per measure	Annual	
			Algorithm & PA data	Avoided deaths attributable to CO poisonings: $6.38	Per measure	Annual	
Improved safety (lighting)	No monetized values reported	No	None for now	Insufficient data in the literature to derive a reliable value	—	—	—

[22] This NEI only applies to participants that installed low flow showerheads and faucet aerators

[23] This NEI only applies to replaced and/or repaired heating systems.

NEI	Range of Reported Values ($)[18]	Quantify	Method of Quantification	Recommended Value, Algorithm, or Justification for not quantifying	Basis	Duration	Relevant PA Programs[19]
Heat (or lack thereof) generated	0.92	No	None	Energy-related impact	—	—	—
Warm up delay	0.29 – 0.77	No	None for now	Insufficient data in the literature to derive a reliable value	—	—	—
Product lifetime	No monetized values reported	No	None	Insufficient data in the literature to derive a reliable value	—	—	—
Availability of hot water	No monetized values reported	No	None for now	Insufficient data in the literature to derive a reliable value	—	—	—
Product performance	14.00 – 18.00	No	None for now	Insufficient data in the literature to derive a reliable value	—	—	—
Window AC NEIs	$109	Yes	Literature	$49.50	Per participant	Annual	1
Bill-related calls	0.18 – 8.00	No	Quantified Elsewhere	Benefit derived entirely from energy savings, which are already included in the TRC test	—	—	—
Termination and reconnection	0.03 – 86.93	No	Quantified Elsewhere	Benefit derived entirely from energy savings, which are already included in the TRC test	—	—	—
Reduced transaction costs	0.00 – 5.00	No	None	Insufficient data in the literature to derive a reliable value	—	—	—
Education	No monetized values reported	No	None	Insufficient data in the literature to derive a reliable value	—	—	—

Societal-perspective NEIs are summarized below in Table 2-3. The societal-perspective NEIs of interest to the PAs for this literature review (i.e. the non-economic and non-environmental societal NEIs) generally arise from programs targeted to low-income customers. Little work has been done in the area of quantifying these NEIs, and quantification methods are not well-established in the literature. Societal NEIs are generally difficult to quantify or quantifiable with some effort, but limited certainty, using secondary data.

Table 2-3. Summary of Societal-Perspective NEI Values

NEI	Range of Reported Values ($)[24]	Quantify	Method of Quantification	Recommended Value, Algorithm, or Justification for not quantifying	Basis	Time Frame	Relevant PA Programs[25]
Weatherization by utility programs saves costs of inspections and upgrades by other agencies	No monetized values reported	No	None for now	Insufficient data in the literature to derive a reliable value	—	—	—
Equity and Hardship	No monetized values reported	No	None	Insufficient data in the literature to derive a reliable value	—	—	—
Improved Health	No monetized values reported	No	None for now	Heat Stress: Insufficient data from surveys; Algorithm if data can be derived from National WAP Evaluation (2011) [(Reductions in visits to hospital, emergency room, or urgent care facilities for heat stress (participant surveys) * $1,469.79 (Cost of general injury emergency room visit, adjusted for inflation)) / Total number of participants]	Per participant	Annual	1,4,5 6[26]
			None for now	Cold exposure: Insufficient data from surveys; Algorithm if data can be derived from National WAP Evaluation (2011 [(Reductions in visits to hospital, emergency room, or urgent care facilities for cold exposure (participant surveys) * $1,469.79 (Cost of general injury emergency room visit, adjusted for inflation)) / Total number of participants]	Per participant	Annual	

24 Values in the table reported as per participant, per year

25 The following numbers correspond to the following PA Programs: 1 Low-income retrofit programs; 2 = Low-income new construction programs; 3 = Residential new construction; 4 = Residential cooling and heating; 5 = Residential heating and hot water; 6 = Non-low-income retrofit programs (i.e., MassSAVE, multi-family retrofit programs); 7 = ENERGY STAR lighting; 8= ENEGY STAR appliances

26 This NEI only applies to participants that installed shell measures &/or HVAC equipment

NEI	Range of Reported Values ($)[24]	Quantify	Method of Quantification	Recommended Value, Algorithm, or Justification for not quantifying	Basis	Time Frame	Relevant PA Programs[25]
			None for now	Asthma: Insufficient data from surveys; Algorithm if data can be derived from National WAP Evaluation (2011 [(Reductions in visits to hospital, emergency room, or urgent care facilities for asthma (participant surveys) * $737.74 (Cost of treating asthma at emergency room, adjusted for inflation)) / Total number of participants]	Per participant	Annual	
Improved Safety	0.00 – 0.29	No	None for now	Insufficient data in the literature to derive a reliable value	—	—	—
Water	0.00	No	None for now	Insufficient data in the literature to derive a reliable value	—	—	—
National Security	$202	Yes	Algorithm from literature	[(Estimated annual savings in fuel oil and kerosene, MMBtu, per measure * $1.83 (10% adder for cost of relying on imported oil or kerosene, per MMBtu) * number of homes that use fuel oil or kerosene as the primary heating fuel)] / all program participants	Per measure	Annual	1,5,6 (heating related measures only)

Table 2-4 presents the non-resource benefits that pertain to waste reduction attributable to the PAs' Appliance Turn-in Program.

Table 2-4. Summary of Non-Resource Benefits

NEI	Range of Reported Values ($)	Quantify	Method of Quantification	Recommended Value, Algorithm, or Justification for not quantifying	Basis	Time Frame	Relevant PA Programs
NEIs derived from refrigerator/freezer turn-in programs	No monetized values reported	Yes	Algorithm from literature	Avoided landfill space: $1.06 per unit, one-time benefit	Per measure	One time	Massachusetts Appliance Turn-in Program
				Recycling of plastics and glass: $1.25 per unit, one-time benefit	Per measure	One time	
				Incineration insulating foam: $170.22 per unit, one-time benefit	Per measure	One time	

Participant Perspective NEIs (Owners of Low-income Rental Housing) are summarized below in Table 2-5. Our review of the literature found no mention of non-energy impacts pertaining to participating owners of low-income rental housing. However, interviews with PA staff identified several potential NEIs, including reduced maintenance pertaining to lighting (attributed to the longer life of a CFL, thus reducing labor costs), improved sense of environmental responsibility, improved marketing of rental property (i.e., a more energy-efficient rental unit is easier to market and rent), and reduced tenant turnover. All values for the NEIs were derived from surveys of owners and managers of low-income rental housing and estimated on a per housing unit basis.

Table 2-5. Summary of Participant-Perspective NEI Values (Owners of Low-income Rental Housing)

NEI	Range of Reported Values ($)	Quantify	Method of Quantification	Recommended Value, Algorithm, or Justification for not quantifying	Basis	Time Frame	Relevant PA Programs
Marketability/ease of finding renters	No monetized values reported	Yes	Survey	$0.96	Per housing unit	Annual	MF Low-income retrofit programs
Reduced tenant turnover	No monetized values reported	Yes	Survey	$0	Per housing unit	Annual	MF Low-income retrofit programs
Property value	No monetized values reported	Yes	Survey	$17.03	Per housing unit	One time	MF Low-income retrofit programs
Equipment maintenance (heating and cooling systems)	No monetized values reported	Yes	Survey	$3.91	Per housing unit	Annual	MF Low-income retrofit programs[27]
Reduced maintenance (lighting)	No monetized values reported	Yes	Survey	$66.73	Per housing unit	Annual	MF Low-income retrofit programs[28]
Durability of property	No monetized values reported	Yes	Survey	$36.85	Per housing unit	Annual	MF Low-income retrofit programs
Tenant complaints	No monetized values reported	Yes	Survey	$19.61	Per housing unit	Annual	MF Low-income retrofit programs

[27] This NEI only applies to participants that installed programmable thermostats.
[28] This NEI only applies to participants that installed energy efficient lighting.

In addition, NMR estimated NEI values at the measure level (Table 2-6, Table 2-7, and Table 2-8). To do so, NMR assigned a portion of a given NEI value to an individual measure based on the average energy bill savings for which the measure is responsible. This method has also been used for the *2001 California Low Income Public Purpose Test (LIPPT) report for the Reporting Requirements Manual (RRM) Working Group Cost Effectiveness Committee* (TecMarket Works, SERA and Megdal Associates, 2001).

Computation of dollar values for a specific NEI begins with calculating the average portion of bill savings attributed to each measure for an individual NEI. As a first step, the NMR team made a determination whether a measure reasonably contributes to an individual NEI. For example, air sealing, cooling equipment, door, insulation, window, and weatherization measures contribute to changes in outside noise heard inside the home. [29] Next, the team calculated the average percentage of bill savings for each measure that contributes to an NEI. For example, for the NLI sample air sealing represents, on average, 8% of the bill savings of measures that contribute to Thermal Comfort, while heating systems represent 39% of those bill savings; combined, all of the measures sum to 100% of the bill savings associated with each NEI. Last, the team multiplied the average percentage of bill savings by the average NEI value to estimate an NEI value for each measure (Table 2-6).

As illustrated in Table 2-6 and Table 2-7, the attribution of NEI values to measures by non- and low-income participants reveals that several measures typically account for the bulk of dollar benefits for a particular NEI: heating systems, insulation, weatherization measures,[30] and air sealing. Heating systems, air sealing, insulation, and various weatherization programs have the greatest impact, a benefit to the thermal comfort NEI in both samples. Heating system measures provide the greatest benefit in the equipment maintenance NEI.

The low-income sample exhibits a similar distribution of NEI benefits with some notable exceptions (Table 2-7). For example, air sealing measures generally represent the highest percentage of bill savings, followed by insulation measures. Air sealing represents the largest percentage of bill savings for noise reduction at 55% of the NEI or valued at $16 annually. Another marked difference from non-low-income participants is the contribution of the lighting measure to the property value NEI. Lighting accounts for 24% of the total property value NEI and $226 one-time benefit for the low-income sample while the non-low-income sample only derives 5% of total benefit from lighting (or $97 in dollar terms).

Compared to the occupant sample, the sample of owners and managers of multi-family rental housing had fewer types of measures installed: refrigerators and freezers, hot water systems and other water saving measures, lighting, programmable thermostats, and air sealing. Not surprisingly, with fewer types of measures installed, the total value of NEIs to owners and managers was a much smaller percentage of bill savings (36%) than for occupants – 62% for low-income and 57% for others. As illustrated in the tables, energy efficient lighting has the greatest percentage contribution to the NEIs for owners and managers, at 46% of estimated energy savings and in turn 46% of each individual NEI (except for reduced lighting maintenance). Refrigerators and freezers provide the second largest percentage contribution to multi-family owner NEIs, at 35% of estimated bill savings.

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[29] For the NLI sample, the following measures were not included in this analysis: doors, heating controls, pipe wrap, hot water tank wrap, pool timer and faucet aerators. For the LI sample, the following measures were not included in the analysis: cooling systems, heating and cooling systems, heating and hot water systems, heating controls, AC system sizing, pool timer, and hot water tank wrap. While these measures reasonably contribute to several NEIs, such as comfort or property value, the measures were either not installed in any homes included in this study or savings data at the measure level were not available.

[30] The 'Weatherization' measure represents the program level savings for National Grid and Berkshire Gas customers; savings data for the individual measures installed were not available for these programs

Table 2-6. Attribution of NEI Values to Energy Efficiency Measures, Non-low-income Participants, Dollars per Measure[31]
(Weighted mean value of all respondents)

	Thermal Comfort		Noise Reduction		Health Impacts		Property Value		Equipment Maintenance		Lighting Quality		Durability of Home	
	% bill savings	$[32]	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$
Sample size, by NEI[33]	*209*	*180*	*147*	*187*	*209*	*190*	*209*	*171*	*139*	*125*	*47*	*41*	*209*	*188*
Air sealing	8%	$10.13	16%	$4.88	8%	$0.32	7%	$135.83	-	-	-	-	8%	$3.95
Appliance (refrigerators and freezers)	-	-	-	-	-	-	<1%	$1.44	-	-	-	-	-	-
Cooling systems	3%	$3.92	9%	$2.83	3%	$0.13	3%	$62.65	6%	$7.54	-	-	3%	$1.54
Duct sealing	<1%	$0.16	-	-	<1%	$0.01	<1%	$2.51	-	-	-	-	<1%	$0.06
Heating & cooling syst.	4%	$5.05	-	-	4%	$0.16	4%	$80.69	8%	$9.42	-	-	4%	$1.98
Heating & hot water sys.	1%	$1.83	-	-	1%	$0.06	1%	$29.17	3%	$3.41	-	-	1%	$0.72
Heating system	39%	$48.63	-	-	39%	$1.56	34%	$678.52	83%	$102.40	-	-	36%	$17.42
Hot water system	-	-	-	-	-	-	4%	$82.56	-	-	-	-	4%	$2.13
Insulation	20%	$25.15	37%	$11.54	20%	$0.80	19%	$378.05	-	-	-	-	20%	$9.82
Lighting	-	-	-	-	-	-	5%	$96.61	-	-	100%	$49.00	-	-
Service to heating or cooling system	<1%	$0.47	-	-	<1%	$0.01	<1%	$7.44	1%	$0.87	-	-	<1%	$0.18
Low flow showerhead	-	-	-	-	-	-	<1%	$0.03	-	-	-	-	-	-
AC system sizing	<1%	$0.19	-	-	<1%	$0.01	<1%	$3.01	<1%	$0.37	-	-	<1%	$0.07
Programmable thermo.	3%	$3.99	-	-	3%	$0.13	3%	$51.49	-	-	-	-	3%	$1.33
Window	1%	$0.68	2%	$0.54	1%	$0.02	<1%	$6.72	-	-	-	-	<1%	$0.21
Weatherization[34]	20%	$25.00	36%	$11.22	20%	$0.79	19%	$381.28	-	-	-	-	19%	$9.57
Total Value	100%	$125	100%	$31	100%	$4	100%	$1,998	100%	$124	100%	$49	100%	$49

[31] For the purpose of attributing NEI values to individual measure, the evaluation team only included measures that reasonably have an impact on an individual NEI. For example, heating, cooling and shell measures are included in the NEI for thermal comfort. A cell with a '-' indicates that the measure does not reasonably impact the individual NEI. The following measures were not included in this analysis: doors, heating controls and pipe wrap. While these measures reasonably contribute to several NEIs, such as comfort or property value, the measures were either not installed or savings data at the measure level were not available for the respondents in this sample.

[32] The values in the table are reported as dollars per measure.

[33] The sample size for each individual NEI varies because analysis is limited to those respondents who had specific measures installed.

[34] The 'Weatherization' measure represents the program level savings for National Grid and Berkshire Gas customers; savings data for the individual measures installed were not available for these programs.

Table 2-7. Attribution of NEI Values to Energy Efficiency Measures, Low-income Participants, Dollars per Measure[35]

(Weighted mean value of all respondents)

	Thermal Comfort		Noise Reduction		Health Impacts		Property Value		Equipment Maintenance		Lighting Quality		Durability of Home	
	% bill savings	$[36]	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$
Sample size, by NEI[37]	*211*	*177*	*141*	*191*	*211*	*199*	*213*	*147*	*140*	*122*	*108*	*89*	*212*	*189*
Aerator	-	-	-	-	-	-	3%	$26.61	-	-	-	-	-	-
Air sealing	30%	$30.23	55%	$16.39	30%	$5.69	15%	$144.93	-	-	-	-	30%	$10.61
Appliance (refrigerators and freezers)	-	-	-	-	-	-	3%	$26.61	-	-	-	-	-	-
Door	<1%	$0.01	<1%	$0.01	<1%	$0.01	<1%	$0.04	-	-	-	-	<1%	$0.01
Duct sealing	1%	$0.68	-	-	1%	$0.13	1%	$5.11	-	-	-	-	1%	$0.23
Heating system	28%	$28.01	-	-	28%	$5.27	26%	$249.20	51%	$27.43	-	-	28%	$9.72
Hot water system	-	-	-	-	-	-	<1%	$1.65	-	-	-	-	1%	$0.20
Insulation	25%	$25.38	45%	$13.56	25%	$4.77	24%	$223.63	-	-	-	-	25%	$8.76
Lighting	-	-	-	-	-	-	24%	$226.31	-	-	100%	$56.00	-	-
Pipe wrap	6%	$5.56	-	-	6%	$1.05	1%	$5.00	-	-	-	-	-	-
Service to heating or cooling system	6%	$6.18	-	-	6%	$1.16	<1%	$3.52	49%	$26.57	-	-	11%	$3.77
Low flow showerhead	-	-	-	-	-	-	<1%	$1.72	-	-	-	-	-	-
Programmable thermostat	5%	$4.87	-	-	5%	$0.92	4%	$34.47	-	-	-	-	5%	$1.68
Window	<1%	$0.08	<1%	$0.04	<1%	$0.01	<1%	$0.19	-	-	-	-	<1%	$0.03
Total Value	100%	$101	100%	$30	100%	$19	100%	$949	100%	$54	100%	$56	100%	$35

[35] For the purpose of attributing NEI values to individual measure, the evaluation team only included measures that reasonably have an impact on an individual NEI. For example, heating, cooling and shell measures are included in the NEI for thermal comfort. A cell with a '-' indicates that the measure does not reasonably impact the individual NEI. The following measures were not included in the analysis: cooling systems, heating and cooling systems, heating controls, AC system sizing, and pool timer. While these measures reasonably contribute to several NEIs, such as comfort or property value, the measures were either not installed or savings data at the measure level were not available. for the respondents in this sample

[36] The values in the table are reported as dollars per measure.

[37] The sample size for each individual NEI varies because analysis is limited to those respondents having specific measures installed.

Table 2-8. Attribution of NEI Values to Energy Efficiency Measures, Multi Family Owners, Per Housing Unit

	Marketing		Reduced Tenant Turnover		Increased Property Value		Equipment Maintenance and Reliability		Reduced Lighting Maintenance		Durability		Tenant Complaints	
	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$
Sample size	*27*	*21*	*27*	*25*	*27*	*22*	*0*	*4*	*19*	*12*	*27*	*22*	*27*	*20*
Refrigerators or Freezers	35%	$0.34	35%	$0	35%	$5.96	-	-	-	-	35%	$12.90	35%	$6.86
Hot Water System or Water Saving Measures	1%	$0.01	1%	$0	1%	$0.17	-	-	-	-	1%	$0.37	1%	$0.20
Energy Efficient Lighting	46%	$0.44	46%	$0	46%	$7.83	-	-	100%	$66.73	46%	$16.95	46%	$9.02
Thermostats	11%	$0.11	11%	$0	11%	$1.87	100%	$3.91	-	-	11%	$4.05	11%	$2.16
Air Sealing	7%	$0.07	7%	$0	7%	$1.19	-	-	-	-	7%	$2.58	7%	$1.37
Total Value	100%	$0.96	100%	$0	100%	$17.03	100%	$3.91	100%	$66.73	100%	$36.85	100%	$19.61

3. METHODOLOGY

This report presents the findings of the Massachusetts Cross-Cutting Non-Energy Benefits Evaluation and incorporates findings from a review of the NEI literature, in-depth interviews, and telephone surveys with program participants. To account for the fact both positive and negative impacts can result from energy efficiency programs, we use the term non-energy impacts (NEIs) in this report.

3.1 LITERATURE REVIEW

NMR conducted an extensive review of the non-energy benefits (NEBs) literature, in order to identify and review methods used to quantify non-energy benefits, particularly NEBs for low-income programs. Overall, more than 125 reports and academic papers were reviewed for this report

3.2 IN-DEPTH INTERVIEWS

As a complement to the literature review, NMR conducted 13 interviews with Project Administrator (PA) staff members responsible for residential retrofit programs, low-income retrofit programs, and residential new construction programs. Nine in-depth interviews were also conducted with administrators of low-income and residential retrofit energy efficiency programs in other states, health and safety experts, and social service providers familiar with low-income weatherization programs.

During September and October of 2010, NMR conducted in-depth interviews with PA staff members responsible for residential retrofit programs, low-income retrofit programs, and residential new construction programs. The 13 PA program implementers that were interviewed represented the following programs: Mass Save, Multifamily Retrofit, Low Income Multifamily Retrofit, Low Income 1- to 4-Family Retrofit, Weatherization, Residential New Construction, Low Income Residential New Construction, and Residential Heating and Cooling. During the interviews PA staff members were asked to review NEIs found in the literature to be associated with the programs and provide suggestions for additional NEIs not identified in the literature. Findings specific to individual NEIs resulting from these interviews have been included in the discussion of the corresponding NEIs within the body of this report. When asked about the NEIs associated with their programs and the program measures, many interviewees expressed two common viewpoints: that bill savings and increased comfort were the most important benefits of their programs, and that their programs take a whole-house approach wherein the individual measures can have synergistic effects, so that estimating NEIs for individual measures was difficult.[38]

Administrators of low-income and residential retrofit energy efficiency programs in other states were also targeted for in-depth interviews. The purpose of these interviews was to understand how NEIs are considered and treated in other states. Five out-of-state interviewees were targeted. However, due to a low response rate, only two out-of-state interviews could be completed. Relevant findings resulting from these interviews have been included in the discussion of the body of this report were appropriate.

NMR targeted two additional groups for in-depth interviews: health and safety experts and social service providers. The goal was to complete four interviews each for these two groups. NMR was able to complete four in-depth interviews with health and safety experts, and three in-depth interviews with social service providers. These interviewees provided NMR with research studies and reports outside of the evaluation literature that are relevant to particular NEIs, such as health and safety. Findings specific to

[38] The "whole-house approach" concept arose during interviews with PA Staff responsible for the following programs: residential new construction, MassSAVE, low-income multi-family and low-income one to four family. PA staff emphasized that their programs consider the whole house as a system and attempt to address energy efficiency at the house level rather than at the measure level. For example, one PA staff summarized their approach as follows: "When we go through this process we look at the house as a whole. We don't look at it as measure by measure, but what does the measure have an affect on the house as a whole,"

certain NEIs resulting from these interviews have been included in the discussion of the corresponding NEIs within the body of this report.

3.3 SURVEYS OF PROGRAM PARTICIPANTS

The study relied on two different surveys. First, we conducted an occupant survey of households that had taken part in various PA programs. Second, we performed surveys with owners and managers of low-income rental housing that had received PA program services. We discuss each method below.

3.3.1 Occupant Surveys

We surveyed 213 low-income households and 209 non-low-income households via computer-assisted telephone interviewing (CATI) from April 11, 2011 through May 10, 2011. The sample was developed from data provided by the PAs for the following programs:

- Low-income retrofit programs (single and multi-family programs)
- Residential cooling and heating program
- Residential heating and hot water program
- Non-low-income retrofit programs (i.e., Mass Save, weatherization, multi-family retrofit programs)

In order to examine potential differences in participant NEI values due to the types of measures installed, the NMR team stratified the residential and low-income residential samples according to the measures installed in their homes, with the three strata representing homes retrofitted with shell measures, or with heating and cooling measures, or with shell plus heating and cooling measures.[39]

Classifying participants into one of the strata required several steps. First, because of the large number of measure types installed by the programs, individual measures were categorized into broader groups of similar measures. For example, we grouped furnaces and boilers together as heating systems and the variety of CFL bulbs and fixtures installed through the programs as lighting, and so on. These efforts yielded the following measure categories:

- Air sealing
- Appliance (refrigerators and freezers)
- Cooling systems
- Door
- Duct sealing
- Faucet Aerator
- Heating and cooling system
- Heating and hot water system
- Heating system

[39] To be included in the shell stratum, a respondent had to have air sealing or insulation installed. To be included in the heating and cooling stratum, a respondent had to have a heating system, such as furnaces or boilers, or an air conditioning system installed. To be included in the shell plus heating and cooling stratum, a respondent had to have at least one shell measure and one heating and cooling measure installed. Installed measures that were neither shell nor heating and cooling did not affect classification of respondents into strata.

- Heating controls[40]
- Hot water system
- Insulation
- Lighting
- Pipe wrap
- Service to heating or cooling system[41]
- Low flow showerhead
- AC system sizing
- Programmable thermostat
- Pool timer
- Hot water tank wrap
- Window
- Weatherization[42]

The measure categories were further grouped into three broader groups of measures: 1) Shell measures, 2) Heating and cooling measures, and 3) Other measures (Table 3-1). The three strata into which participants were classified (i.e., Shell, Heating and Cooling, and Shell plus Heating and Cooling) were derived from these categories. As all participants had at least one shell or heating and cooling measure installed, any measures participants may have installed that are in the *Other Measures* group did not affect respondents' classification into the strata.

[40] The following types of measures were defined as heating controls: boiler reset controls, heat recovery ventilator, weather responsive control, ECM motor.

[41] The following types of measures were defined as service to heating and cooling systems: HVAC service, AC digital tune-up, AC QIV, CoolSmart AC Digital check-up / tune-up.

[42] The 'Weatherization' measure represents the program level savings for National Grid and Berkshire Gas customers; savings data for the individual measures installed were not available for these programs.

Table 3-1. Measure Categories and Strata

Shell Measures	Heating and Cooling Measures	Other Measures
Air sealing	Heating and cooling system	Appliance (refrigerators and freezers)
Insulation	Heating and hot water system	Door
Weatherization[43]	Heating system	Duct sealing
		Heating controls[44]
		Hot water system
		Lighting
		Pipe wrap
		Service to heating or cooling system[45]
		Low flow showerhead
		AC system sizing
		Programmable thermostat
		Pool timer
		Hot water tank wrap
		Window

Second, because program participants can participate in multiple programs with the same PA or across multiple PAs, we developed a unique ID in order to identify participants across programs and PAs.[46] Using the unique ID, NMR aggregated all measures installed in a participant's home by the PAs' programs, plus the energy savings associated with the measures.

Third, using PA data of the estimated energy savings associated with each efficiency measure installed, NMR estimated annual bill savings for the sample. Bill savings were estimated by using a population weighted average of gas and electric rates reported on the Web site of the Executive Office of Energy and Environmental Affairs of Massachusetts.[47] Table 3-2 displays the estimated average annual energy bill savings for the survey respondents, by population and strata. Overall, low-income respondents are expected to save $473 annually and non-low-income respondents are expected to save $673 annually. For the low-income respondents, the shell stratum has the highest average annual energy savings ($583)

43 The 'Weatherization' measure represents the program level savings for National Grid and Berkshire Gas customers; savings data for the individual measures installed were not available for these programs.

44 The following types of measures were defined as heating controls: boiler reset controls, heat recovery ventilator, weather responsive control, ECM motor.

45 The following types of measures were defined as service to heating and cooling systems: HVAC service, AC digital tune-up, AC QIV, CoolSMart AC Digital check-up / tune-up.

46 A participant who receives gas service from one PA and electric service from a different PA can participate in programs from both PAs. In addition, participants may enroll in multiple programs within the same PA.

47 http://www.mass.gov/?pageID=eoeeaterminal&L=5&L0=Home&L1=Energy%2c+Utilities+%26+Clean+Technologies&L2=Electric+Power&L3=Electric+Market+Information&L4=Basic%26%2347%3bDefault+Service&sid=Eoeea&b=terminalcontent&f=dpu_restruct_default_service_fixed_defaul

while for the non-low-income respondents the shell plus heating and cooling stratum has the highest average annual energy savings ($1,275).[48]

Table 3-2. Estimated Average Annual Energy Bill Savings

Strata	Low-income	Non-low-income
Sample size	**213**	**209**
Shell	$583	$380
Heating and Cooling	$392	$347
Shell plus Heating and Cooling	$445	$1,275
Overall Population	$473	$673

Fourth, we classified participants into strata according to the program measures installed in their homes. To be included in the shell stratum, a respondent had to have air sealing or insulation installed. To be included in the heating and cooling stratum, a respondent had to have a heating system, such as furnaces or boilers, or an air conditioning system installed. To be included in the shell plus heating and cooling stratum, a respondent had to have at least one shell measure and one heating and cooling measure installed. Other measures installed by participants did not affect classification. Next, we removed from the sample all program participants who had been included in the sample frame for other surveys recently conducted for the residential retrofit evaluations (i.e., Mass Save and low-income retrofit programs) to avoid burdening program participants with multiple survey requests.

Table 3-3 shows the final sample population, sample sizes, and associated expected error margin at the 90% confidence level, assuming a 50/50 break in responses. In addition, because program participants who received both shell measures and heating and cooling measures were oversampled, we developed weights so that results could be extrapolated to the population of program participants that met at least one of the strata criteria[49].

[48] Estimated annual bill savings ranged from a low of $13.93 to a high of $4,910.74 for non-low-income respondents and from a low of $3.15 to a high of $2,150.81 for low-income respondents.

[49] The shell plus heating and cooling strata had a wider range of measures installed in their homes, which may result in different levels of NEIs for these participants. Weights were applied so that results could generalized to all program participants who installed shell measures or heating and cooling measures.

Table 3-3. Sample Size, Sampling Error, and Weight: Occupants

		Population (households)	Sample Size	Sampling Error at 90% Confidence Interval	Weight*
Non-low-income	Heating & Cooling	13,313	68	±10.0%	1.53
	Shell	12,574	70	±9.9%	1.40
	Shell plus Heating & Cooling	944	71	±9.5%	0.10
	Total	26,831	209	±9.9%	-
Low-income	Heating & Cooling	1,087	72	±9.4%	1.22
	Shell	869	72	±9.3%	0.98
	Shell plus Heating & Cooling	672	69	±9.4%	0.79
	Total	2,628	213	±9.4%	-

*Weights were calculated as follows: (strata population / total population) * (total sample size / class sample size)

The occupant survey addressed the following issues:

- Whether the participant believed their home, because of the energy efficiency improvements, provides a particular NEI
- Annual value placed on each NEI in relation to energy bill savings. Values could be expressed in dollars or as a percentage of bill savings.
- Total value of the NEIs
- Changes in household health since the energy efficiency improvements were installed
- Demographic and housing characteristics

A copy of the survey instrument is found in Appendix F: NEI Survey: Low-income and Non-low-income Retrofits.

3.3.2 Owners and Managers of Low-income Rental Housing Survey

Twenty-one owners and managers of low-income rental housing were surveyed about 27 low-income rental facilities via computer-assisted telephone interviewing (CATI) from April 26, 2011 through May 10, 2011.

The sample was developed from multi-family retrofit program data provided by the PAs. As with the occupant survey sample, we took several steps to prepare the program data for the sample, including categorizing measures, aggregating installed measures and related energy savings by owner or manager and by facility, and estimating bill savings for each facility. All of the sample processing procedures used for the occupant survey sample were followed except for the step of classifying by strata.

Table 3-4 shows the final sample population, sample sizes, and the associated error margin at the 90% confidence level, assuming a 50/50 break in responses.

Table 3-4. Sample Size, Sampling Error, and Weight: Owners and Managers of Low-income Rental Housing

	Population (Buildings/Facilities)	Sample Size	Sampling Error at 90% Confidence Interval
Owners & Managers of Low-income Rental Housing	196	27	+15.0%

4. UTILITY-PERSPECTIVE NEIs—LITERATURE REVIEW

Utilities can realize a number of non-energy impacts (NEIs) from their energy efficiency programs in the form of financial savings. Energy-efficient technologies installed by Project Administrators' (PA) programs often result in reduced energy bills for participants, which can decrease the likelihood that customers experience difficulties with paying their utility bills. In turn, utilities realize financial savings through reduced costs associated with arrearages and late payments, uncollectible bills and bad debt write-offs, service terminations and reconnections, bill-related customer calls, and the bill collections process. In addition, utilities may realize savings from their efficiency programs due to a reduction in safety-related emergency calls and reductions in the costs of energy that receives a rate discount. Program induced energy savings among low-income participants reduces the amount of energy receiving a rate discount. These financial savings are generally passed on to ratepayers, and therefore are sometimes referred to as ratepayer benefits in the literature. Theoretically, these benefits could apply to some extent to all PA programs and customers, but the NEI literature has rarely quantified this benefit for non-low-income customers and programs. Therefore, NMR recommends limiting the utility-perspective NEIs to low-income programs.

The majority of early NEI literature focused on utility-perspective NEIs arising from programs targeted to low-income customers. A wide range of positive impacts to utilities were reported, based on a variety of programs. The variability in the magnitude of impacts reported in the literature is due to several reasons. First, the programs on which the analyses are based incorporated different approaches. While some low-income programs provided only weatherization measures to participants, others included or relied entirely upon education or cash assistance components. For programs that included energy efficiency measures, the type and quantity of measures varied between programs and often are not specified in the analyses. Secondly, utility data on participant characteristics and certain collection-related costs are often nonexistent or extremely expensive to collect. Absent accurate data, various assumptions have been made in the estimation of utility perspective NEIs. Lastly, the calculation of many utility-perspective NEIs includes marginal costs to the utility such as the cost per customer call, late payment notice, or service termination. It is apparent from the literature that these costs vary among utilities, due to differences in utility cost structures and policies. Table 4-1 provides an overview of recent NEI evaluations of low-income programs, illustrating the range of program elements and efficiency measures installed by the programs as well as the estimated bill savings realized by the programs.

Table 4-1. Recent NEI Studies of Low-Income Programs

Year of Study	Author	Location	Program Type	Measures Installed[50]	Estimated Annual Energy Bill Savings, per Participant[51]
1997	Skumatz & Dickerson	California	Low-income Weatherization & Education Pilot Program	Outreach; on-site audit & education; weatherization[52]; & follow-up education visit	$85
1999	Skumatz & Dickerson	California	Low-income Weatherization Program	Attic insulation, water heater blankets, efficient showerheads, door weather-stripping, caulking, minor home repairs that affect infiltration, refrigerators, & education	$44
1999	Riggert et al.	Vermont	Low-income Weatherization Program	Water heater wrap, water conservation devices, pipe insulation, CFLs, water bed insulation covers, insulation, windows, air sealing, weather-stripping, heating system replacement or repair	$276
2002	Skumatz & Nordeen	Connecticut	Low-income Weatherization Program	CFLs, lighting fixtures, water heater wraps, low flow showerheads & faucet aerators, waterbed insulated covers, door sweeps, thermostats, caulking &insulation, energy efficient refrigerators & freezers, minor repairs, burner & furnace replacement	$67
2005	Skumatz & Gardner	Wisconsin	Low-income Weatherization Program	CFLs, air sealing, CO detectors, attic insulation, insulation of hot water heater pipes, smoke detectors	$220

Table 4-2 provides a summary of the utility-perspective NEIs for which NMR recommends deriving values from the literature, including reductions in arrearage carrying costs, bad debt write-offs, terminations and reconnections, customer calls, notices, and safety-related emergency calls. NMR's review of the literature found eight reports containing utility-perspective NEI values based on programs comparable to the PAs' programs with respect to program components[53], energy efficient measures[54], and target populations.[55] [56]

[50] Most programs installed wide variety of measures. This list includes the most commonly installed measures as reported in the literature.

[51] Dollar values have not been adjusted for inflation.

[52] Specific weatherization measures were not defined in the study.

[53] The low-income energy efficiency programs in the literature incorporated different program elements, including different combinations of energy efficiency measures, educational and counseling components, and in some cases payment assistance. NMR considered programs comparable to the PAs' programs to be those relying primarily on energy efficiency measures. Programs relying primarily or entirely on education, counseling, or payment assistance components were not considered comparable to the PAs' programs.

[54] In determining whether an NEI value from the literature was applicable to the PAs' programs, NMR reviewed the measures implemented by the programs in each study. Next, NMR compared the measures in the literature to measures implemented through the PAs' programs (the PAs provided lists of measures implemented through their programs). With the exception of low-income programs relying primarily on education, counseling, or payment assistance components, the majority of low-income weatherization and retrofit programs in the NEI literature offer similar measures as the PAs' low-income programs, such as insulation, air sealing, heating system repairs/replacements, lighting, and DHW measures.

[55] NMR considers low-income programs that are open to all low-income customers to be comparable to the PAs' low-income programs. Studies of programs that targeted only a subset of low-income customers, such as high-arrearage low-income customers, were not considered comparable to the PAs' programs.

The table does not include NEI values from evaluations of programs that were not comparable to the PAs' programs. For example, the 2008 evaluations of the Oregon HEAT and REACH Programs (Drakos et al., 2008) and the 2005 evaluation of the Utah HELP program (Khawaja and Wiley, 2005) were excluded because these programs relied heavily or entirely on payment assistance, counseling, and educational components, program elements not included in the PAs' low-income programs.

Table 4-2. Reported NEI Values (Dollars per Participant per Year) from Recent NEI Studies of Low-Income Programs

Study	Reported NEI Value, $/year/participant					
	Carrying Cost on Arrearages	Bad Debt Write-Offs	Terminations and Reconnections	Customer Calls	Notices	Safety-Related Emergency Calls
WI Low-income Weatherization (Skumatz and Gardner, 2005)	1.37	--	0.13	0.43	0.30	--
National Low-income Weatherization NEBs Study (Schweitzer and Tonn, 2002)	--	6.09	0.55	--	--	6.91
MA Low-income Weatherization (Skumatz Economic Research) Associates, 2002)	1.71	3.62	--	0.59	--	0.40
CT Low-income Weatherization (Skumatz and Nordeen, 2002)	2.03	2.24	0.10	0.55	1.16	0.21
CA Low-income Public Purpose Test (TecMarket Works, Skumatz Economic Research Inc, and Megdal Associates, 2001)	3.76	0.48	0.07	1.58	1.49	0.07
VT Low-income Weatherization (Riggert et al., 1999)	--	--	7.00	--	--	15.58
CA Low-income Weatherization (Skumatz and Dickerson, 1999)	2.09	2.34	0.33	0.07	0.04	7.91
Venture Partners Pilot Program (Skumatz and Dickerson, 1997)	4.00	4.50	0.63	0.13	0.08	15.00

4.1 ARREARAGES

Arrearages accumulate when customers are unable to pay their bills on time. The carrying cost associated with arrearages is borne by the utilities. The magnitude of arrearage carrying cost is dependent on the dollar value of arrears, the utility's interest rate for carrying short-term debt,[57] and the duration that arrears are outstanding.

The value of the NEI of reduced arrearage carrying costs ranges from $0.50 to $7.50 per participant per year in recent studies.

Energy efficiency programs that reduce customers' energy consumption also reduce customers' energy bills, making it easier for low-income customers to pay their bills and therefore less likely to be in arrears.

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[56] An empty cell in Table 4-1 signifies one of two things: either an NEI value was not estimated for a particular study, or the NEI value reported was based on an NEI from another report included in the table. An example of the latter scenario is the NEI of reduced carrying cost on arrearages reported for the national low-income WAP (Schweitzer and Tonn, 2002), in which the NEI value was estimated by taking the midpoint of the values reported for the Venture Partners Pilot and CA low-income weatherization programs (Skumatz and Dickerson, 1997 and 1999).

[57] The interest rate for carrying short-term debt refers to the interest expense associated with arrears. Accounts in arrear represent a lost opportunity to the utility to earn a return on customer's bill payment. The relevant time period for a dollar in late payments is the amount of time that that dollar is late and not earning a return for the utility.

The NEI value to utilities from reduced arrearages can be calculated by multiplying the program-induced reduction in arrearages by the utility's interest rate for carrying short-term debt. Studies measuring the impact on arrearages of energy efficiency programs date back to the early 1990's. A review of the literature indicates that programs targeting high-arrearage or payment-troubled customers tend to have a larger impact in arrears than those that do not. The most rigorous arrearage studies in the literature employ a quasi-experimental design, with one year each of pre- and post-program billing data for both a treatment and a comparison group. More recent studies quantifying arrearage NEIs often substitute pre/post treatment/control measured impacts with assumed percentage arrearage reductions taken from previous studies.

Howat and Oppenheim (1999) summarized much of the earlier arrearage literature. Many of the arrearage estimates reported in the early literature were not reported in conjunction with pre-program arrearage balances. Therefore, while they demonstrate that energy efficiency programs affect arrearages, they do not demonstrate the magnitude of program impacts. A 1995 study conducted for the Boston Edison Settlement Board by the Tellus Institute found an arrearage reduction of $0 to $469 per household (Biewald et al., 1995), and a 1998 study by Skumatz and Dickerson reported a reduction of $4 to $63 per household. The Oak Ridge National Laboratory (ORNL) reported the average reduction in arrearages for the year following weatherization to be $32 in its 1993 evaluation of the national Weatherization Assistance Program (WAP) (Brown et al., 1993), though a follow-up study of the national WAP study estimated a smaller benefit of $3.90 per year (Schweitzer and Tonn, 2002).

One complication in comparing arrearage impact estimates across different reports is that the literature does not consistently report program design elements and the energy efficiency measures employed, both of which vary across programs. The national 1993 WAP evaluation published by ORNL, however, did specify commonly employed measures, which included caulking and weather stripping around doors and windows, sealing unnecessary openings to reduce air infiltration, installing attic, wall, and floor insulation, and wrapping water heaters and pipes with insulating material. Another report that identified installed measures, thereby allowing for the meaningful comparison of arrearage impacts across programs, is Blasnik's 1997 evaluation of Ohio's low-income Home Weatherization Assistance Program (HWAP). The HWAP measures included dense-pack cellulose wall insulation, attic insulation, blower-door guided air sealing, duct sealing, energy-related home repairs, energy education, and heating and water heating system safety testing, minor tune-ups and occasional replacements. Additionally, it was noted in the 1997 HWAP evaluation report that the gas savings for HWAP participants were 70% larger than the average national WAP gas savings (Blasnik, 1997). The HWAP analysis reported both average arrearage reductions and original arrearage balances, allowing program impacts to be interpreted in percentage terms. The HWAP arrearage impact evaluation employed a pre/post treatment/comparison approach and found that average payment shortfalls declined by 63% after HWAP, while the comparison group's shortfall actually increased by 7%.

Program-induced arrearage reductions are generally estimated as an annual benefit with the annual program-induced arrearage reductions multiplied by a utility's interest rate associated with short-term debt in order to estimate the benefit to the utility in the form of reduced carrying costs.

Skumatz and Dickerson (1997)

Skumatz and Dickerson (1997) estimated a range of $0.50-$7.50 in reduced arrearage carrying costs per participant, based on the Venture Partners Pilot (VPP) Program, a low-income weatherization and education program in California. The VPP estimate was based on an assumed reduction in arrearages of 26%, taken from Magouirk (1995), and utility data on the percentage of customers in arrears and arrearage balances for customers eligible to participate in the program.

Skumatz and Dickerson (1999)

A different low-income weatherization program in California evaluated by Skumatz and Dickerson (1999) yielded a smaller benefit range of $0.26-$3.91. Weatherization measures for the VPP program were not reported, but they were for the 1999 California weatherization program and included energy education services, energy-efficient refrigerators, attic insulation, water heater blankets, energy-efficient showerheads, door weather-stripping, caulking, and minor home repairs affecting infiltration. A key differentiating factor between the two California programs is that the average bill savings per participant from the VPP program were approximately twice as much as the average bill savings from the weatherization program.

Skumatz and Nordeen (2002)

A 2002 report evaluating the NEIs associated with the Connecticut Weatherization Residential Assistance Partnership (WRAP) program reported a reduction in arrearage balances of 32%, resulting in carrying cost savings to the utility of $2.03 per participant (Skumatz and Nordeen, 2002). WRAP measures included weather stripping, caulking, CFLs, low-flow showerheads, faucet aerators, refrigerators, furnaces, thermostats, and on-site energy discussion and education. Identifying eligible nonparticipants for a control group in the WRAP evaluation proved challenging, because the utility's database was not designed to differentiate between low-income and non-low-income customers. As cited in Skumatz, Khawaja, and Krop (2010), Skumatz has been involved in the estimation of several other arrearage-carrying-cost NEI values, including $1.37 per household per year for a Wisconsin low-income program and $1.71 per household per year for a Massachusetts program.

Riggert et al. (1999)

Many of the more recent NEI valuations of reduced arrearage carrying costs are based partially or entirely on values published in the literature estimated for other programs. A comprehensive summary of arrearage analyses in the literature is provided in Riggert et al.'s 1999 Evaluation of the Energy and Non-energy impacts of Vermont's Weatherization Assistance. Rather than calculating an NEI value for the benefit from reduced carrying cost of arrearages based on Vermont WAP data, Riggert et al. selected an NEI value of $4.00 per household per year from their literature review. Assuming a 20-year benefit duration, a net present value of $57.25 per household in reduced arrearage carrying costs was estimated for the 1999 Vermont WAP evaluation.

TecMarket Works, SERA, and Megdal Associates (2001)

A literature review was also conducted for the 2001 California Low-income Public Purpose Test (LIPPT) report for the Reporting Requirements Manual (RRM) Working Group Cost Effectiveness Committee (TecMarket Works, SERA, and Megdal Associates, 2001). This literature review identified over 30 arrearage estimates, most of which employed a pre/post treatment/comparison methodology. The range of arrearage reductions, excluding studies which targeted customers with bill payment difficulties, was 0%-90%. The LIPPT estimated an NEI value of $3.76 per participant per year based on the average percentage reduction in arrearages from the literature review of 28%. This NEI valuation assumes a ten-year benefit duration and a utility interest rate of 8.15%. The magnitude of the arrearage benefit relative to other utility NEIs is illustrated in the LIPPT report, which found reduced arrearage carrying costs to represent 36% of the total utility perspective NEIs quantified in the report.

4.1.1 Assessment of the NEI Literature

Out of all of the NEIs that have been recognized in relation to energy efficiency programs, arrearage impacts are the most studied. The literature on arrearage impacts of low-income programs extends back two decades. The impact evaluations in the earlier literature were frequently performed using a rigorous evaluation design, which included pre- and post-program billing data for both a treatment and a comparison group. The majority of recent NEI valuations for the utility benefit of reduced arrearage carrying costs borrow arrearage reduction percentages from previous studies, rather than conducting a pre/post treatment/comparison arrearage impact evaluation in order to calculate the relevant program-induced impact on arrearages. NEI valuations estimated in this way avoid the costs associated with collecting primary data, which can be expensive and, particularly when it is necessary to distinguish between low-income and non-low-income participants, extremely difficult to collect. Energy efficiency programs targeting customers with bill payment difficulties have resulted in higher arrearage reductions, though even when these results are ignored, the range of arrearage reduction percentages from the literature is 0%-90%. Caution should be used when making generalizations based on the literature, because the programs studied incorporated different program elements, including different combinations of measures, educational and counseling components, and in some cases payment assistance[58] and because the relative impact of each program element on arrearage reductions is not examined in the literature.[59]. Arrearage impact estimates found in the literature are sensitive to underlying assumptions, including the duration of savings to the utility, the discount rate used to calculate annual benefits, the utility interest rate used to calculate the carrying cost savings, and substitute values that have been used when data is unavailable.

4.1.2 Relevant PA Programs

All of the arrearage estimates in the literature have been based on information from low-income programs, the majority of which were weatherization programs. Therefore, NMR recommends applying this NEI to participants in the PAs' low-income programs.

4.1.3 Recommendations

Based on our review of the literature, NMR recommends a value of $2.61 per participant per year, based on the median of the values reported in the literature.[60] An overview of the studies used to estimate this value is provided in Appendix D.[61]

Because PA data were not available for average arrearage balances for eligible low-income customers before and after program participation, it is not possible to derive an estimated value from PA data. If such data becomes available, an alternative method of quantifying the annual cost savings to utilities from reduced arrearage carrying costs is as follows:

- Average arrearage balance per eligible low-income customer before program (PA data) * 28% (average reduction in arrearages, derived from the literature[62]) * utility interest rate associated with short-term debt (PA data).

Greater precision would require the collection of primary data on pre- and post-program arrearages of program participants. However, because of the relatively low value of this NEI, NMR does not recommend primary data collection at this time.

4.2 BAD DEBT WRITE-OFFS

Utilities incur the cost of bad debt write-offs (or uncollectables) when customers fail to pay their bills and utilities are unable to collect unpaid balances. Bad debt write-offs are accounted for separately from arrearages by utilities and represent a different cost from the carrying costs of arrearages. Low-income energy efficiency programs can reduce this utility cost by making energy bills more affordable to customers. The NEI value to utilities from reduced bad debt write-offs is a simple calculation, equal to the difference between pre-program bad debt write-offs and post-program bad debt write-offs. A couple of

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58 It is NMRs understanding that none of the PA programs include cash assistance. Therefore, we excluded all analyses based on cash assistance programs. It is possible, however, that program impact values that are based on point estimates from literature reviews did not exclude cash assistance programs.

59 In other words, if the educational and counseling component of a program in the literature review is responsible for a significant amount of the total arrearage reduction and the PAs' programs do not include an educational and counseling component, than deriving an average program-induced reduction in arrearages from the literature would result in an inflated estimate of arrearage reductions

60 The current TRM reports a one-time arrearage benefit of $70 per household (Massachusetts Electric and Gas Energy Efficiency Program Administrators, 2010). Because the evaluation team was not provided the study used to estimate and justify this value, we relied on the existing literature to estimate a value.

61 Values were derived from the literature published since 1997 and were adjusted into 2010 dollars using an inflation rate of 2.5 percent per year, the same inflation rate used in the PAs' three-year plans (see National Grid et al., 2009; NSTAR et al., 2009).

62 Data source for average reduction in arrearages: TecMarket Works, SERA and Megdal Associates, 2001.

studies in the literature examined the impact of low-income energy efficiency programs on bad debt write-offs, using a pre/post impact evaluation design. However, most bad debt write-off NEI valuations found in the literature are based on assumed rates of program-induced decreases in bad debt write-offs, as opposed to rates calculated based on program billing data.

The NEI value of reduced bad debt write-offs ranges from $0.48 to $7.00 per participant per year in the literature.

Magouirk (1995)

One of the pre/post impact evaluations of bad debt write-offs frequently cited in the literature is that of a low-income weatherization program in Colorado by Magouirk (1995), which found that write-offs dropped 18% at weatherized homes during the year following weatherization.

Skumatz and Dickerson (1997 and 1999)

Skumatz and Dickerson (1997 and 1999) applied the 18% reduction reported by Magouirk in the calculation of the value of avoided bad debt write-offs for the VPP and low-income weatherization programs in California.

TecMarket Works, SERA, and Megdal Associates (2001)

In a review of the literature, the 2001 California LIPPT found that the average reduction in write-offs associated with energy efficiency programs ranged from 8% to 36%, based on a variety of low-income programs. The average percentage reduction of bad debt write-offs found in the literature was multiplied by the average bad debt per low-income customer for four California utilities, in order to calculate the per participant NEI value of $0.48[63] for the LIPPT report (TecMarket Works, SERA and Megdal Associates, 2001). Bad debt write-offs were estimated to represent 5% of total utility NEIs in the LIPPT report.

Skumatz and Nordeen (2002)

The percentage reduction in arrearages was employed as a proxy for percentage reduction in bad debt write-offs in the bad debt write-off NEI estimation for Connecticut's WRAP program (Skumatz and Nordeen, 2002).

[63] Assumes ten-year benefit duration and 8.15% interest rate.

Skumatz, Khawaja, and Krop (2010)

Based on a review of the literature, Skumatz, Khawaja and Krop (2010) noted that the impact values for reduced bad-debt range from 20-35%, that few studies have specifically examined program impacts on bad debt, and that the values for this NEI are approximately $2 when averaged across participants.

4.2.1 Assessment of the Literature

While the literature for bad debt write-off impacts is less extensive than that for arrearages, estimation methods and impact results are similar for these two NEIs. Many of the recent studies have applied assumed rates of decrease in bad debt write-offs, such as the percent decrease in arrearages or a point estimate taken from the literature, as opposed to embarking on a pre/post bad debt write-offs impact analysis. There is moderate variability in the range of estimates of the NEI for bad debt write-offs; however, the magnitude of this NEI is small relative to other NEIs.

4.2.2 Relevant PA Programs

All of the bad debt write-off estimates in the literature have been based in information from low-income programs, the majority of which were weatherization programs. Therefore, NMR recommends applying this NEI to participants in the PAs' low-income programs.

4.2.3 Recommendations

Based on our review of the literature, NMR recommends a value of $3.74 per participant per year, based on the median value reported in the literature.[64]

Because PA data were not available for average bad debt write-offs for eligible low-income customers before and after program participation, it is not possible to derive an estimated value from PA data. If such data becomes available, an alternative method of quantifying the annual cost savings to utilities from reduced bad debt write-offs is as follows:

- Average amount of bad debt per eligible low-income customer before program (PA data) * 20.7% (average reduction in bad debt write-offs, derived from the literature[65]).

Greater precision would require primary data collection on pre- and post-program bad debt write-offs of program participants. However, because of the relatively low value of this NEI, NMR does not recommend primary data collection at this time.

4.3 TERMINATIONS AND RECONNECTIONS

Energy efficiency programs that make energy bills more affordable for low-income customers can decrease the likelihood of service termination due to non-payment. Terminations and subsequent reconnections represent a cost to utilities. The NEI value to utilities from avoided termination costs can be estimated by multiplying the number of avoided terminations times the marginal cost per termination. The NEI value for avoided reconnections is calculated in a similar manner.

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[64] Values were derived from the literature published since 1997 and were adjusted into 2010 dollars using an inflation rate of 2.5 percent per year, the same inflation rate used in the PAs' three-year plans (see National Grid et al., 2009; NSTAR et al., 2009). For more details, see Appendix D.

[65] Data source for average reduction in bad debt write-offs: TecMarket Works, SERA and Megdal Associates, 2001.

The NEI value of decreased terminations and reconnections ranges from $0.02 to $7.00 per participant per year in the literature.

Termination and reconnection costs vary between utilities. Howat and Oppenheim (1999) cited costs from Colton (1994) to Columbia Gas Company, including $21.92 per termination and $43.84 per reconnection. The 2007 Low Income Arrearage Study found a wide range in disconnection and reconnection service fees in PacifiCorp's service territory, ranging from $19.75 to $112.15. The study authors noted that fees varied by state for a variety of reasons, including the personnel assigned, the associated time, and hourly rates (Khawaja et al., 2007).

Blasnik (1997 & 1999)

The ideal way to measure the impact of energy efficiency programs on frequency of terminations and reconnections is to conduct a pre/post treatment/comparison impact evaluation. Using the pre/post treatment/comparison method, Blasnik (1997) found that the service disconnection rate for HWAP participants declined 39.3%, from 3.7% to 2.3% of the participating population, while the comparison group experienced an increase of 28.5% over the same period. Blasnik reported a net reduction of 67.8% in service disconnections resulting from the HWAP program. As cited in the 2001 California LIPPT report, Blasnik's 1999 study of Ohio's WAP found a reduction in service terminations of 5.4%, and his 1999 evaluation of Louisville Gas and Electric reported a reduction of 23% (TecMarket Works, SERA and Megdal Associates, 2001)

Skumatz and Nordeen (2002)

A reduction in service terminations of 16% was reported for the 2002 Connecticut WRAP program analysis (Skumatz and Nordeen, 2002).

TecMarket Works, SERA, and Megdal Associates (2001)

A literature review for the 2001 California LIPPT report revealed a range of 1% to 84% reduction in service terminations resulting from low-income weatherization programs, some of which included education components. The authors selected the value of 23% from Blasnik's 1999 evaluation of Louisville Gas and Electric in estimating the NEI value for the LIPPT report. The assumed 23% impact was multiplied by the average shutoff per low-income customer per year (0.0279) and the utility's marginal cost per shutoff ($8.29) to derive an NEI value of $0.05 per participant. The value of decreased reconnections was calculated similarly in the LIPPT report: average reconnects per low-income customer were estimated to be 0.0192 and marginal cost per reconnect was found to be $22.70, yielding an NEI value of $0.02 per participant. The value of reduced terminations and reconnections represented only 1% of total utility NEIs considered in this report (TecMarket Works, SERA, and Megdal Associates, 2001).

4.3.1 Assessment of the Literature

A few early studies of program impacts on terminations and reconnections employed pre/post treatment/comparison methods. These early studies examined impacts on service terminations, but did not quantify impacts on reconnections. In addition, some of the literature assumes that customers who experience a service termination will likely have service reconnected; thus the cost to the utility per termination incident includes the cost per termination plus the cost per reconnection. Most of the recent literature that monetizes program-induced utility cost savings does not directly measure program impacts, but instead assumes an impact percentage reduction in terminations and reconnections based on findings from past research. Termination and reconnection costs represent a minor portion of utility avoided costs associated with energy efficiency programs.

4.3.2 Relevant PA Programs

The literature on service terminations and reconnections is based entirely on low-income customers. Therefore, NMR recommends applying this NEI to participants in the PAs' low-income programs.

4.3.3 Recommendations

Based on our review of the literature, NMR recommends a value of $0.43 per participant per year, based on the median value reported in the literature.[66]

Because PA data were not available for PA costs of terminations and reconnections, it is not possible to derive an estimated value from PA data. If such data becomes available, an alternative method of quantifying the annual cost savings to utilities from reduced terminations and reconnections is as follows:

- Average number of terminations per eligible low-income customer before program (PA data) * 23% (conservative reduction in terminations, derived from the literature[67]) * marginal cost per termination (PA data).
- Average number of reconnections per eligible low-income customer before program (PA data) * 23% (conservative reduction in reconnections, derived from the literature[68]) * marginal cost per reconnection (PA data).

Greater precision would require the collection of primary data on pre- and post-program terminations and reconnections of program participants. However, because of the relatively low value of this NEI, NMR does not recommend primary data collection at this time.

4.4 RATE DISCOUNTS

Rate discounts are offered to low-income customers and are subsidized by utilities and ratepayers. Energy efficiency programs that reduce the amount of energy consumed by low-income customers can decrease the quantity of energy sold at the discounted rate. Utilities realize financial savings because a smaller portion of energy is sold at the discounted rate. The financial savings to utilities is equal to the expected energy savings of low-income participants times the difference between the full residential rate and the discounted rate for eligible low-income participants.

The NEI value of rate discounts ranges from $2.61 to $23.57 per participant per year in the literature.

Skumatz and Dickerson (1997 & 1999)

One of the earlier estimates of rate discount NEIs was by Skumatz and Dickerson (1997), who estimated the utility benefit from avoided rate subsidies attributable to the VPP program to be $5-$32 annually per participant. This NEI value was calculated based on the annual subsidy per-participant and the expected percentage energy savings from the program. The same authors estimated a benefit range of $2.61-$16.68 for a California low-income weatherization program (1999).

Skumatz, Khawaja, and Krop (2010)

The annual per participant NEI value estimated in the 2001 California LIPPT report was $2.77, which was calculated by multiplying the following: 1) average annual bill savings per participant; 2) rate subsidy percentage; 3) percent of participants paying the subsidized rate. Intuitively, average bill savings is dependent on average energy savings. The LIPPT report authors found a range of 4% to 22% for average energy savings in the literature, noting that programs that included an education component tended to produce greater energy savings. Skumatz, Khawaja, and Krop (2010) reported a range from the

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66 Values were derived from the literature published since 1997 and were adjusted into 2010 dollars using an inflation rate of 2.5 percent per year, the same inflation rate used in the PAs' three-year plans (see National Grid et al., 2009; NSTAR et al., 2009). For more details, see Appendix D.

67 Data source for reduction in terminations: TecMarket Works, SERA and Megdal Associates, 2001.

68 Data source for reduction in reconnections: TecMarket Works, SERA and Megdal Associates, 2001.

literature of $3.32-$23.57 for this NEI, noting that the value is directly related to energy savings and the utility's discount rate.

4.4.1 Assessment of the Literature

The calculation of the NEI associated with rate discounts is relatively straightforward. Estimation methods in the literature are consistent, although it is not always clear from the literature whether the energy savings input has been calculated based on actual program data, or whether energy savings have been assumed based on previous study results. The cost savings to a utility from avoided rate discounts is particularly sensitive to individual rate discount percentages and the level of program-induced energy savings.

4.4.2 Relevant PA Programs

NMR recommends applying this NEI to programs in which low-income participants pay discounted rates.

4.4.3 Recommendations

Based on our review of the literature, NMR recommends quantifying the cost savings to utilities from reduced rate discounts as follows:

- Estimated energy savings per installed measure (PA data) * Number of measures installed * [(full rate per unit energy ($) – discounted rate per unit energy ($)]

Alternatively, this could also be estimated at the participant level rather than at the measure level using the following formula:

- Average program energy savings per low-income eligible customer (PA data) * [(full rate per unit energy ($) – discounted rate per unit energy ($)]

The rate discount benefit can be calculated either by individual PAs, according to their individual PA rate discount, or it can be calculated statewide using the following population weighted rate discounts of $0.0424 per kWh and $0.2663 per therm.[69]

4.5 CUSTOMER CALLS AND COLLECTIONS ACTIVITIES

Timely customer bill payments can result in fewer customer calls, late payment notices, shut-off notices, and other collection activities. The PAs realize savings in staff time and materials. As with all other payment-related utility NEIs addressed in the literature, customer calls and collection activities have been examined only within the context of low-income programs. Oftentimes the data required to estimate program impacts for low-income customers are extremely difficult or impossible to collect; utilities do not usually track whether individual telephone calls, notices, and other collection-related activities involve low-income or non-low-income customers. Therefore, program-induced changes in incidence rates of these activities involve assumptions in the proportion of activities involving low-income customers. Some studies examining collection-related NEIs investigate each cost individually, while others examine various combinations. In this section we review each collection-related avoided cost separately.

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[69] The population weighted average rate discount was estimated using data reported on the Web site of the Executive Office of Energy and Environmental Affairs of Massachusetts: (http://www.mass.gov/?pageID=eoeeaterminal&L=5&L0=Home&L1=Energy%2c+Utilities+%26+Clean+Technologies&L2=Electric+Power&L3=Electric+Market+Information&L4=Basic%26%2347%3bDefault+Service&sid=Eoeea&b=terminalcontent&f=dpu_restruct_default_service_fixed_default)

4.5.1 Customer Calls

Reduced incidence of customer calls is widely recognized as a non-energy benefit to utilities. Bill-related calls from customers represent a cost to utilities, as do calls made by utilities in order to collect on delinquent accounts. The general approach to quantifying the average per-participant savings due to reduced customer calls is easy to calculate, and is done so by multiplying the percentage reduction in calls as a result of the program by the utility's marginal cost for calls. Quantifications in the literature of the value of this NEI have not been based on pre/post program changes in customer calls, but instead employ substitute impact values, such as the percentage decrease in arrears or bad debt. Because utility costs are a component of the calculation, this NEI is inherently sensitive to each individual utility's costs.

The NEI value of reduced incidence of customer calls ranges from $0.00 to $1.58 per participant per year in recent studies.

Skumatz and Dickerson (1997 and 1999)

Some of the first estimates of the utility NEI from reduced customer calls were reported by Skumatz and Dickerson, who estimated a value range for reduced customer calls of $0.00-$0.25 per participant per year for the VPP program (1997) and $0.00-$0.13 for the California weatherization program (1999). These ranges were calculated by multiplying the reduction in write-offs and arrearages by utility data on cost of customer calls. A key assumption in the estimation of these benefit ranges is that low-income customers are more likely to call the utility regarding late payments and notices than other customers. The authors noted that the actual percentage of customer calls from eligible customers was unavailable from the utility data; therefore, the estimated benefit ranges were based on an assumed proportion of calls from low-income customers.

TecMarket Works, SERA, and Megdal Associates (2001)

The authors of the California LIPPT report suggested that the preferred calculation method for the NEI associated with decreased customer calls is to multiply the average number of pre-program bill-related calls from eligible low-income customers by the percent reduction in participant bill-related calls, by the utility marginal cost per bill-related call (TecMarket Works, SERA, and Megdal Associates, 2001). They also recognized that the literature did not contain any studies with estimates of reductions in customer calls. The proxy value used in quantifying the NEI value for the LIPPT report, in place of percent reduction in customer calls, was a point estimate based on an assortment of bill payment behavior and collection activity impact studies. The NEI value of $1.58 per participant per year was calculated by multiplying the average customer calls per year (1.865) by the proxy value (24.7%) and the utility's marginal cost per call ($3.42). Reduced customer calls represented 15% of total utility NEIs quantified in the LIPPT report.

Skumatz and Gardner (2005)

An NEI value of $0.43 per participant per year was estimated for a 2005 report on Wisconsin's low-income weatherization program (Skumatz and Gardner, 2005). This calculation was not based on any of Wisconsin's program data, but instead employed estimates from the literature for average calls per low-income customer pre-program, average program-induced reduction in calls, and utility marginal cost per call.

Skumatz, Khawaja, and Krop (2010)

In a review of the literature that includes the California LIPPT report, Wisconsin low-income weatherization, and Skumatz and Dickerson estimates above, Skumatz, Khawaja and Krop (2010) report that values for the NEI of reduced customer calls are on the order of $0.50 annually per participant.

4.5.2 Assessment of the Literature

Standard practice in the literature is to assume that energy efficiency programs reduce telephone calls involving low-income customers, in proportion to low-income bill payment improvement. Where data on the proportion of calls that are bill-related calls from low-income customers have been unavailable, NEI calculations have relied on data for all customer calls. All of the quantifications of the value to utilities of reduced customer calls are based on assumed impact values for payment-related behavior from the literature, rather than on data about program-induced changes in customer calls. Therefore, by relying on decreases in arrears or bad debt as a proxy value for reduced customer calls, previous studies have assumed that the decrease in customer calls from the program is exactly the same as the decrease in arrears or bad debt. The accuracy of this assumption is not addressed in the literature. Another, more overarching assumption that is not addressed in the literature is that energy efficiency programs will lead to a reduction the number of customer calls to utilities.

4.5.3 Relevant PA Programs

All of the estimates of customer call NEIs have been based on low-income programs. Therefore, NMR recommends applying this NEI to participants in the PAs' low-income programs.

4.5.4 Recommendations

Based on our review of the literature, NMR recommends a value of $0.58 per participant per year, based on the median value reported in the literature.[70]

Because PA data were not available for PA costs of fielding customer calls, it is not possible to derive an estimated value from PA data. If such data becomes available, an alternative method of quantifying the annual cost savings to utilities from reduced incidence of customer calls is as follows:

- Average number of bill-related calls per low-income customer before program (PA data) * the percentage decrease in bill-related calls from low-income customers (PA data) * marginal cost per call (PA data).[71]

4.6 NOTICES

A reduction in late payment and termination notices is widely recognized as a non-energy benefit to utilities. Utilities realize savings in the form of reduced paper, ink, and postage. These savings are realized for reductions in past due, collection, and termination notices, which are sent separately from ordinary billing statements. The value of these savings is easy to calculate, provided that the necessary data is available. Quantifying the value of reduced notices involves multiplying the program-induced reduction in notices by the marginal cost per notice. Few studies have actually measured the program-induced impact on notices;[72] thus most estimates of this NEI value are based on assumed impact values. Because utility costs are a component of the calculation, this NEI is inherently sensitive to each individual utility's costs.

The value of the NEI of reduced late payment and termination notices ranges from $0.00 to $1.49 per participant per year in recent studies.

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[70] Values were derived from the literature published since 1997 and were adjusted into 2010 dollars using an inflation rate of 2.5 percent per year, the same inflation rate used in the PAs' three-year plans (see National Grid et al., 2009; NSTAR et al., 2009). For more details, see Appendix D.

[71] Alternatively, if PA data on the marginal cost of a bill-related low-income customer call are available, an NEI value could be derived from the following formula: average number of low-income customer calls (PA data) * 25% (average reduction in bad debt and arrearages, derived from the literature) * marginal cost per call (PA data). The assumed 25% reduction in calls is from \TecMarket Works, SERA and Megdal Associates, 2001.

[72] Skumatz (2002) is an exception and the authors measured the impact on reminder notices associated with Connecticut's WRAP program. However, rather than finding a reduction in notices the authors found a 20% increase in notices for the participant group (Skumatz, 2002).

Skumatz and Dickerson (1999) & Skumatz and Gardner (2005)

In place of the percentage reduction in late payment notices, Skumatz and Dickerson used the reduction in write-offs and arrearages to estimate a value range for fewer late payment notices of $0.00-$0.15 per participant per year for the VPP program, and $0.00-$0.08 for the California weatherization program (1999). An NEI value of $0.30 per participant per year was estimated for the 2005 report on Wisconsin's low-income WAP program, based on an assumed percent reduction in late payment notices taken from the literature (Skumatz and Gardner, 2005).

TecMarket Works, SERA, and Megdal Associates (2001)

The cost savings resulting from reduced notices is estimated in the California LIPPT report in the same manner as reduced customer calls. In place of an actual program-induced impact value for reduced notices, a point estimate, based on an assortment of bill payment behavior and collection activity impact studies, is employed. The NEI value of $1.49 per participant per year was calculated by multiplying the average notices per customer per year (1.1) by the proxy value (24.7%) and the utility's marginal cost per notice ($5.50). The LIPPT report found reduced notices to represent 15% of total utility NEIs quantified (TecMarket Works, SERA, and Megdal Associates, 2001).[73]

4.6.1 Assessment of the Literature

Standard practice in the literature is to assume that energy efficiency programs reduce the number of past due, collection, and termination notices in proportion to low-income bill payment improvement. This is a reasonable assumption, considering the relationship between bill payment and notices. When data on the proportion of notices sent to low-income customers have been unavailable, NEI calculations have relied on data for all customer notices.

4.6.2 Relevant PA Programs

All of the estimates of reduced notice NEIs have been based on low-income programs. Therefore, NMR recommends applying this NEI to participants in the PAs' low-income programs.

4.6.3 Recommendations

Based on our review of the literature, NMR recommends a value of $0.34 per participant per year, based on the median value reported in the literature.[74]

Because PA data were not available for PA costs of customer notices, it is not possible to derive an estimated value from PA data. If such data becomes available, an alternative method of quantifying the annual cost savings to utilities from reduced late payment and termination notices is as follows:

- Average number of notices per low-income customer before program (PA data) * 25% (average reduction in bad debt and arrearages, derived from the literature[75]) * marginal cost per notice (PA data).[76]

[73] Some studies have combined reduced notices with avoided credit and collection expenses associated with unpaid utility bills, and it is therefore difficult to make a reliable estimate of the individual components of the NEI, and to compare these estimates with estimated values of reduced notices alone (see Colton, 1994; Riggert et al., 1999; Schweitzer and Tonn, 2002; Tellus, 1995).

[74] Values were derived from the literature published since 1997 and were adjusted into 2010 dollars using an inflation rate of 2.5 percent per year, the same inflation rate used in the PAs' three-year plans (see National Grid et al., 2009; NSTAR et al., 2009). For more details, see Appendix D.

[75] Data source for average reduction in bad debt and arrearages: TecMarket Works, SERA and Megdal Associates, 2001.

[76] If the marginal cost for late payment notices differs from the cost for termination notices, then NMR recommends quantifying these values separately.

4.7 OTHER COLLECTION ACTIVITIES

Improved participant payment behavior can lead to additional reductions in collections-related costs, such as establishing payment plans or contracting with collections agencies. These costs have rarely been quantified, though they are worth reviewing briefly, in case the PAs wish to capture these potential benefits through primary data collection.

For example, Colton (1994) quantified an additional benefit due to the decreases in negotiating payment plans with customers. Colton (1994) estimated a value of $14.64 for each individual payment plan negotiation avoided. Riggert et al. (1999) cite a 1995 study by the Tellus Institute that estimates the benefit of reduced credit and collection expenses between $65 and $85 per participant.

However, without further primary data collection, NMR does not recommend including this as an NEI.

4.8 SAFETY RELATED EMERGENCY CALLS

The NEI of reductions in safety related emergency calls has been limited to natural gas programs in the literature. Low-income households are more prone than other customers to have old or damaged space and water heating systems, and therefore are more likely to experience fires from gas leaks. Energy efficiency programs that repair space and water heating appliances can potentially reduce the likelihood of an emergency call to the gas utility. NEI estimates in the literature vary, due to differences in assumptions regarding incidence of emergencies, portion of emergencies obviated by programs, and gas utility costs per emergency. Because utility costs are a component of the calculation, this NEI is inherently sensitive to each individual utility's costs.

The value of the NEI of reduced safety related emergency calls ranges from $0.07 to $15.58 per participant per year in recent studies.

Skumatz and Dickerson (1997 & 1999)

Skumatz and Dickerson (1997) quantified three components of savings to gas utilities arising from a reduction in emergency situations: 1) fewer emergency gas calls, valued at $10-$20 per participant per year; 2) flex connector replacements, valued one time at $0-$5; and 3) fewer emergency calls from replaced flex connectors, valued at $0-$2 per participant per year. The VPP program checked and replaced gas appliances and gas connectors on appliances as needed. The NEI value range for reduced emergency gas calls was based on the utility's cost per emergency gas call, and an assumed percent reduction of 20% in emergency calls, taken from Magouirk's 1995 analysis of a low-income weatherization program in Colorado. The flex connector value ranges were also taken from Magouirk (1995), although they did not apply directly to the VPP program. Skumatz and Dickerson reported a value range of $5.27-$10.54 for reduced emergency gas calls, for the California weatherization program in their 1999 report.

Riggert et al. (1999)

The 1999 Vermont WAP evaluation applied the dollar savings estimated by Magouirk (1995) of $22.57 per home, representing the summed estimated savings from reduced emergency calls ($15.58), gas flex connector replacements ($1.98), and the incremental avoided cost of having a gas flex connector replaced by an emergency crew ($5.01), as opposed to during weatherization (Riggert et al., 1999).

Schweitzer and Tonn (2002)

Reduction in emergency gas service calls was quantified by Schweitzer and Tonn (2002) for the national WAP, by selecting a midpoint from the range of estimates presented in the literature (including those listed above), and then adjusting the value down in order to accurately reflect the proportion of U.S. households fueled by natural gas (50.9% at the time the report was published).

Ternes et al., (2007)

In the upcoming evaluation of the national WAP, ORNL intends to monetize the value of reduced emergency gas service calls via the following formula (Ternes et al., 2007):

Number of households weatherized	*	Average reduction in number of emergency service calls made per weatherized household	*	Average cost to utility per service call

TecMarket Works, SERA, and Megdal Associates (2001)

Quantification of the non-energy benefit associated with reduced emergency calls for the California LIPPT report required estimation of several variables, including the proportion of total participants who have gas checks or gas appliances in place, the percentage of those needing appliance repairs or maintenance, the total potential emergencies avoided, and the marginal cost per emergency call (TecMarket Works, SERA and Megdal Associates, 2001). Impact values for the percentage of participants needing appliance repairs or maintenance, and the total potential emergencies avoided, were selected from the literature review. An annualized NEI value of $0.07 per participant was calculated from the following formula:

10% Participants Receiving Gas Services	*	23% Eligible Customers Needing Gas Appliances Fixed	*	25.9% Emergencies Avoided Through Program Activities[77]	*	$76.08 Marginal Cost Per Emergency Call Avoided	*	0.15 Adjustment Factor (horizon and discount assumptions)[78]

The non-energy benefit associated with fewer emergency gas calls was found to represent 1% of total utility NEIs considered in the LIPPT report.

4.8.1 Assessment of the Literature

Weatherization programs that identify and repair potential gas leaks undoubtedly prevent some quantity of emergency calls to gas utilities. Few studies have measured actual program impacts on the frequency of emergency gas calls, which is dependent on the fuel source of a given home, the condition of the heating system, and the safety-related measures included in the program. The majority of estimates for the value of this NEI are based on assumed impact values taken from the literature. The value to gas utilities of reduced emergency calls is relatively low, compared to the value of other utility NEIs.

4.8.2 Relevant PA Programs

The NEI derived from avoided safety-related emergency calls should be limited to the PAs' low-income programs that repair or replace space and water heating appliances, gas appliances, and gas connectors.

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[77] The California LIPPT applied the 25.9% reduction in emergency calls reported by Magourik (1995) (TecMarket Works, SERA and Megdal Associates, 2001).

[78] Assumes a ten year benefit stream and applies a 8.15% discount rate (TecMarket Works, SERA and Megdal Associates, 2001).

4.8.3 Recommendations

Based on our review of the literature, NMR recommends a value of $8.43 per participant per year, based on the median value reported in the literature.[79]

Because PA data were not available for the marginal cost of a safety-related emergency call and for decreases in emergency calls among program participants, it is not possible to derive an estimated value from PA data. If such data becomes available, an alternative method of quantifying the savings to the PAs from reduced emergency gas calls is as follows:

- Average number of safety-related emergency calls per customer before program (PA data) * the percentage decrease in emergency calls per customers (PA data) * marginal cost per emergency (PA data). [80]

4.9 INCREASED ELECTRICITY SYSTEM RELIABILITY

The nation's electricity system has a maximum limit of electricity it can supply at any given point in time, based on installed capacity and infrastructure. Blackouts can occur when electric demand in a particular geographic region exceeds the maximum capacity of the system in that region. By reducing the demand for electricity, energy efficiency programs can potentially increase the reliability of the system, by preventing demand from exceeding maximum capacity when it otherwise would have, thereby preventing a blackout from occurring. Total electricity demand is expected to grow at a rate of 1% annually through 2035.[81] Therefore, by reducing electricity consumption (and consequently slowing demand growth), energy efficiency programs can, to some extent, prolong the need to build additional infrastructure to meet growing demand. Financial savings are realized when expenses are pushed further into the future, due to the time value of money. Theoretically, the financial savings derived from delaying investments in electricity system infrastructure represent the non-energy impact of energy efficiency programs on the electricity system.

According to the *Avoided Energy Supply Costs in New England: 2011 Report* the PAs currently receive credit for contributing to increased system reliability due to the load reductions attributable to energy efficiency measures (Hornby et al., 2011).

Interestingly, NMR's review of the NEI literature did not uncover any valuation of increased electricity system reliability as an NEI associated with energy efficiency programs. Skumatz, Khawaja, and Krop (2010) identify "power quality/reliability" as a potential utility-perspective NEI arising from low-income programs, but state that no studies quantifying its value have been performed to date.

4.9.1 Recommendation

Because the PAs currently receive credit for contributing to increased system reliability due to the load reductions attributable to energy efficiency measures, NMR does not recommend attempting to quantify an NEI value above and beyond what has already been accounted for in *Avoided Energy Supply Costs in New England: 2011 Report* (Hornby et al., 2011).

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[79] Values were derived from the literature published since 1997 and were adjusted into 2010 dollars using an inflation rate of 2.5 percent per year, the same inflation rate used in the PAs' three-year plans (see National Grid et al., 2009; NSTAR et al., 2009). For more details, see Appendix D.

[80] Data source for the percentage decrease in emergency calls: Magouirk (1995) as cited in Skumatz and Dickerson (1997).

[81] http://www.eia.doe.gov/oiaf/aeo/electricity.html

4.10 ADDITIONAL UTILITY NEIS FOUND IN THE LITERATURE

NMR's review of the literature found additional utility-perspective NEIs commonly mentioned in the literature, but not identified in the work plan or during the kick-off meeting. These additional NEIs include insurance savings and transmission and distribution savings.

4.10.1 Transmission and Distribution Savings

Transmission and distribution (T&D) line loss reduction is often recognized as a non-energy benefit in the NEI literature. By reducing the use of electricity, energy efficiency programs eliminate the line losses, which would have occurred during transmission and distribution of the electricity which would have been generated absent the programs.

Because the PAs currently receive credit for avoided transmission and distribution losses, NMR does not recommend attempting to quantify an NEI value above and beyond what has already been accounted for in *Avoided Energy Supply Costs in New England: 2011 Report* (Hornby et al., 2011) and applied to the Total Resource Cost (TRC) test for the PAs' electric energy efficiency plan (National Grid et al., 2009; NSTAR et al., 2009).[82]

4.10.2 Insurance Savings

Energy efficiency programs that fix gas leaks and replace faulty equipment can reduce the risk of explosions and fires in participants' homes, which in turn can lead to lower insurance costs for utilities. The NEI of insurance savings is primarily applicable to gas utilities, due to the higher risk of fires from gas equipment. The most accurate way to quantify the NEI of insurance savings is to perform a pre/post impact evaluation to assess the reduction in explosions and fires resulting from the program, in order to determine the impact on the utility's insurance costs, which depends on whether a utility self-insures or buys coverage from an insurer. Insurance savings to utilities has been identified as an NEI associated with energy efficiency programs several times in the literature, but has rarely been quantified. When NEI values have been quantified for utility insurance savings, they have not been based on actual program impact data, but rather proxy values for reduced risk of explosions and fires.

The value of the NEI of insurance savings ranges from $0.00 to $0.15 per participant per year in recent studies.

Schweitzer and Tonn (2002); Ternes et al. (2007)

Insurance savings are recognized as a non-energy benefit to utilities by the evaluators of the national WAP program at the Oak Ridge National Laboratory (ORNL). According to the 2002 non-energy benefit report prepared for the national WAP, reduced risk of fires and explosions is expected to lower utility insurance costs, regardless of whether the utility self-insures or buys coverage from an insurer (Schweitzer and Tonn, 2002). In the current national WAP evaluation, the evaluators at ORNL plan to calculate a monetized value of insurance savings to utilities, by multiplying the number of weatherized households by the average reduction in utility's cost for insurance to cover household fires and explosions per weatherized household. Relative to all other NEIs that these evaluators plan to measure in the upcoming WAP evaluation, both the magnitude and uncertainty surrounding the monetized value are expected to be medium, on a scale of low, medium and high (Ternes et al., 2007).

Skumatz and Dickerson (1997 and 1999)

Estimates of the non-energy benefit of insurance savings to utilities are provided by Skumatz and Dickerson (1997, 1999). The authors estimated a NEI range of zero to fifteen cents annually per

[82] A brief review of other studies that have estimated a value for transmission and distribution savings is presented in Appendix A.

participant, based on two low-income weatherization programs. The NEI estimates were calculated based on insurance claims per household for an average year and an assumed reduction in risk from the program. Because the actual reduction in risk was unknown, the authors used the reduction in gas emergency calls of 75% from Magouirk (1995) as a proxy for the actual reduction in risk. The authors noted that the NEI of utility insurance savings applies primarily to gas utilities and that the quantified NEI values reported were applicable only to self-insuring utilities.

a. Assessment of the Literature

Although insurance savings are recognized as a non-energy benefit, the impact of energy efficiency programs on utility insurance costs has rarely been investigated. The few values that have been reported in the literature are not based on actual program impacts, but instead rely on proxy measures such as reductions in emergency calls. Additionally, they are extremely low in value, indicating that the value of this NEI compared to other utility NEIs is relatively insignificant.

b. Relevant PA Programs

The utility-perspective NEI of insurance savings potentially applies to all PA programs that reduce the risk of fires and explosions by repairing or replacing faulty gas equipment.

c. Recommendation

Due to the scarcity of studies examining the impact of energy efficiency programs on utility insurance costs in the literature, NMR does not recommend quantifying a value for insurance savings at this time.

Upon completion of the national WAP evaluation in 2011, an estimate of insurance savings could be derived from the national evaluation and applied to the PAs' low-income programs.

5. PARTICIPANT-PERSPECTIVE NEIs—LITERATURE REVIEW

Participants can also realize a number of non-energy impacts. When measured and monetized, participant NEIs have been found to be quite substantial, often exceeding the value of energy savings and NEIs from the societal and utility perspectives. However, participant NEIs are generally much more difficult to measure than NEIs from the utility perspective and some are considered less tangible. For example, some of the less tangible participant NEIs include “increased comfort” or “sense of doing good for the environment,” while others, though very tangible—such as improved health or increased property value—are difficult to measure and monetize.

It is important to note that a number of participant perspective NEIs commonly found in the literature and currently included in the TRM report are derived from customer bill savings. These bill savings partially overlap with avoided costs accounted for in the Avoided Energy Supply Costs (AESC) in New England (Hornby et al., 2011) and included in the TRC calculations. The AESC study estimates a number of avoided costs, including avoided costs of electricity to retail customers and avoided costs to natural gas retail customers. Each set of avoided costs is comprised of several individual costs. For example, avoided costs of electricity to retail customers includes avoided energy costs, avoided capacity costs, avoided environmental regulation compliance costs, demand reduction induced price effects, and avoided costs of local transmission and distribution infrastructure (Hornby et al, 2011). While bill savings and avoided costs partially overlap, they typically differ in part because bill savings are based on average retail savings to participants while avoided costs are based on marginal energy supply costs that are avoided because of the PAs’ energy efficiency programs. Theoretically, a participant NEI of bill savings, based on the difference between the avoided energy and capacity costs and participant energy bill savings, could be added to the TRC. However, according to traditional TRC calculation methods, including participant bill savings as a benefit would require including a similar cost in the form of lost PA revenues, thus negating the bill savings benefit.[83] Therefore, there is no additional NEI of participant bill savings.

In addition, NMR does not recommend including any NEIs that are derived from participant bill savings because it would amount to double counting of benefits. To count benefits that derive from bill savings would amount to valuing the additional disposable income (i.e., bill savings) and the ways in which the participants spend the disposable income. For example, a participant may spend the bill savings on food or medicine, leading to improved health.Similarly, participants may use their bill savings to pay energy bills, reducing the incidence of service terminations and the costs associated with service termination and reconnection. But to count both the bill savings and the health benefits or the benefit of reduced service terminations that are derived entirely from the way bill savings are spent is to count the same benefit twice. Other examples of NEIs derived from bill savings include reduced bill-related calls and reduced need to move or forced mobility.

Table 5-1 below provides a summary of recent studies that have measured and monetized a number of participant perspective NEIs, especially the less tangible NEIs such as higher comfort levels and quieter interior environments. The studies have used a variety of survey methods, including relative valuation methods and conjoint analysis (described in more details in section 5.1. Methods Used to Measure Participant NEIs). Several NEIs, such as higher comfort levels, quieter interior environment and health impacts, are frequently valued highly by program participants. However, there is also wide variation in the values reported by survey respondents, either in dollars or as a percentage of bill savings. For example, higher comfort levels have been estimated to range from $44 to $280 per participant per year and from 2% of bill savings to 70% of bill savings.

[83] As defined in the *California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects,* the TRC takes into consideration program benefits and costs in terms of the participants and the ratepayers: “In a sense, it is the summation of the benefit and cost terms in the Participant and the Ratepayer Impact Measure tests, where the revenue (bill) change and the incentive terms intuitively cancel (CPUC, 2001, p. 18).”

Table 5-1. Summary of the Value of Participant NEIs Reported in the Literature

NEI	Savings	Studies: MA ES Homes (NMR & Conant, 2009)	NYSERDA ES Homes, Relative Valuation (Barkett et al., 2006)	NYSERDA ES Homes and CFLs, Conjoint Analysis (Barkett et al., 2006)	Various MF Retrofit Programs (Myers & Skumatz, 2006)	LI MF Retrofit Program (Myers & Skumatz, 2006)	Wisconsin LI Weatherization (Skumatz &Gardner, 2005)	NYSERDA ES CFLs, Relative Valuation (Barkett et al., 2006)	Various ENERGY STAR Programs84 (Fuchs et al., 2004)
Higher Comfort Levels	% Bill Savings	70%	42%	—	2-4%	3%	20-25%	—	2-7%
	$	$280	$252	$191	—	—	$44-56	—	—
Improved Sense of Environmental Responsibility	% Bill Savings	—	—	—	7-18%	29%	2-3%	70%	15-18%
	$	—	—	—	—	—	$4-6	$10	—
Quieter Interior Environment	% Bill Savings	37%	42%	—	0%	9%	7-9%	—	1-11%
	$	$146	$252	$72	—	—	$14-19	—	—
Reduced Noise Dishwashers	% Bill Savings	—	—	—	—	—	—	—	6%
	$	—	—	—	—	—	—	—	—
Longer Lighting Life	% Bill Savings	36%[85]	—	—	—	—	—	55%	12%[86]
	$	$144	—	$1.80[87]	—	—	—	$8	—
Anticipated Ease of	% Bill Savings	65%	62%	—	4-11%	18%	—	—	3-5%

[84] NEI values reported for the following ENERGY STAR products: refrigerators, dishwashers, room air conditioners, CFLs, and lighting fixtures.

[85] The NEI value for Massachusetts represents the combined value of lighting life and lighting quality.

[86] Applies to CFLs only.

[87] One-time benefit for bulb lifetime.

NEI	Savings	Studies: MA ES Homes (NMR & Conant, 2009)	NYSERDA ES Homes, Relative Valuation (Barkett et al., 2006)	NYSERDA ES Homes and CFLs, Conjoint Analysis (Barkett et al., 2006)	Various MF Retrofit Programs (Myers & Skumatz, 2006)	LI MF Retrofit Program (Myers & Skumatz, 2006)	Wisconsin LI Weatherization (Skumatz &Gardner, 2005)	NYSERDA ES CFLs, Relative Valuation (Barkett et al., 2006)	Various ENERGY STAR Programs84 (Fuchs et al., 2004)
Selling or Leasing Home	$	$259	$372	—	—	—	—	—	—
Buffers Energy Price Increase	% Bill Savings	97%	—	—	—	—	—	—	—
	$	$386	—	—	—	—	—	—	—
Reduced Need to Move	% Bill Savings	—	—	—	—	5%	<1%	—	1-6%
	$	—	—	—	—	—	$1	—	—
More Durable Home	% Bill Savings	—	15%	—	—	—	—	—	—
	$	—	$90	$202	—	—	—	—	—
Equipment and Appliance Maintenance	% Bill Savings	—	25%	—	4-9%	-14%	9-11%	—	2-7%
	$	—	$150	—	—	—	$19-24	—	—
Health Impacts[88]	% Bill Savings	32%	55%	—	—	—	0-5%	—	—
	$	$126	$330	$156	—	—	$1-12	—	—
Improved Safety	% Bill Savings	26%	35%	—	1-3%	5%	10-12%	—	1-6%
	$	$105	$210	$181	—	—	$20-$26	—	—
Warm up Delay	% Bill Savings	—	—	—	—	—	—	-15-0%	—

[88] The NEI values reported for the Massachusetts and New York ENERGY STAR Homes programs represent participant valuation of perceived improved indoor air quality. The NEI values reported for the Wisconsin Low Income Weatherization program represent the range of valuations for numerous health-related impacts measured in the participant survey, including frequency or intensity of chronic conditions such as asthma, frequency or intensity of other illnesses, headaches, doctor or hospital visits and related costs, and medication costs.

NEI	Savings	Studies							
		MA ES Homes (NMR & Conant, 2009)	NYSERDA ES Homes, Relative Valuation (Barkett et al., 2006)	NYSERDA ES Homes and CFLs, Conjoint Analysis (Barkett et al., 2006)	Various MF Retrofit Programs (Myers & Skumatz, 2006)	LI MF Retrofit Program (Myers & Skumatz, 2006)	Wisconsin LI Weatherization (Skumatz &Gardner, 2005)	NYSERDA ES CFLs, Relative Valuation (Barkett et al., 2006)	Various ENERGY STAR Programs84 (Fuchs et al., 2004)
	$	—	—	-$0.29	—	—	—	-$2	—
Product Lifetime	% Bill Savings	—	—	—	—	3%	—	—	2-6%[89]
	$	—	—	—	—	—	—	—	—
Product Performance	% Bill Savings	—	—	—	2-4%	15%	6-8%	—	4-9%
	$	—	—	—	—	—	$14-$18	—	—
Total NEIs[90]	% Bill Savings	—	47%	—	44-110%	108%	122-156%	60%	29-90%[91]

[89] Applies to ENERGY STAR refrigerators, dishwashers, room air conditioners, and lighting fixtures (excludes CFLs).

[90] Total NEIs reflect participant valuation of all NEIs experienced as a percentage of energy bill savings. Participants were asked to value all NEIs experienced in relation to bill savings as a separate question from the valuation of individual NEIs, so that the sum of participant reported individual NEI valuations could be compared with participant reports of total NEIs experienced.

[91] 29% of energy bill savings for refrigerators, 65% of energy bill savings for dishwashers, 71% of energy bill savings for room air conditioners, 90% of energy bill savings for CFLs, and 30% of energy bill savings for lighting fixtures.

5.1 METHODS USED TO MEASURE PARTICIPANT NEIS

Much of the research on participant NEIs has relied on participant self-reports garnered from surveys. For many participant NEIs, self-report is the only possible source of data, as their values are based on the participants' own perceptions. These perceptual, less tangible, NEIs represent the extent to which participants experience a particular intangible impact of a program, such as "increased comfort" or "sense of doing good for the environment," as well as how important that impact is to them.

On the other hand, there are many participant NEIs, such as "increased property value" and "fewer colds and viruses" that could be estimated using non-survey data (e.g., by tracking sales data, interviewing real estate experts, checking employers' office data for participants' sick days before and after the program, etc.), but are often addressed in surveys for practical reasons, such as the lack of available data and the relative ease and low cost of including questions on surveys that are already being used to measure the perceptually-based NEIs.

In some cases, values for these more tangible NEIs are derived entirely from a participant survey, while in other cases data collected from the participant survey is combined with secondary data to estimate a value for the NEI. For example, in some studies, improved health has been measured by combining survey data—in this case reductions in the number of sick days—and multiplying that value by an assumed wage rate for the participant from secondary data.

In addition, some participant NEIs are derived entirely from secondary sources and computations. For example, increases in property values from low-income weatherization programs have been estimated by using program expenditures on repairs made to homes before weatherization measures are installed.

5.1.1 Survey Methods

Several different types of survey methods have been used since researchers began monetizing participant NEIs as part of program evaluations in the 1990's. These methods are loosely based on methods used in behavioral economic research that were developed in order to gauge the value of non-market goods (i.e., goods or attributes of goods that are not ordinarily directly exchanged for money, such as the value of the existence of a wilderness area or the value of the preservation of endangered species). Lisa Skumatz has been a central figure in the adapting these methods to NEI research from the late 1990's to the present. Her work is cited throughout this literature review.

In this section, we briefly review the survey methods most frequently used in NEI evaluations, by describing each method and discussing its advantages and disadvantages. The terminology of the methods is somewhat confusing, because different researchers tend to use different terms for the same method and, in some cases, the same term for different concepts, when describing the methods. We attempt to clarify the terminology by specifying the various terms used for each method and labeling them consistently throughout this report. Following that we discuss other aspects of survey methods that are important to consider and make recommendations regarding developing surveys used for evaluating the PAs' programs.

a. Contingent Valuation (Willingness to Pay)

One of the most direct methods of monetizing an NEI is *Willingness to Pay (WTP)*, by which respondents are asked how much they would pay to obtain an NEI or a group of NEIs. For example, to quantify the value of *reduced noise in the home*, respondents who reported that a program resulted in reduced noise would be asked, "How much would you be willing to pay to go from the previous noise level in your home to the present noise level, if everything else were the same?"[92] A variant on this method is to ask respondents how much they would pay to get a group of NEIs back if they disappeared.

The advantage of this method is its directness. However, although a question asking what someone would be willing to pay for something is relatively easy to understand, it has proven to be quite difficult for people to answer accurately and consistently. This method tends to result in high non-response rates, wildly divergent values across respondents, and much higher values than are typically obtained by other methods. For example, a survey used in an evaluation of the Northeast Utilities Weatherization Residential Assistance Partnership (Skumatz and Nordeen, 2002) asked respondents to value overall NEIs using *WTP* and two other types of questions, allowing the results from the different methods to be compared directly. Only 39% of respondents answered the *WTP* question, and the average value obtained through the *WTP* questions was roughly ten times that obtained through the other methods. Across respondents, *WTP* values ranged from $0 to $70,000. For these reasons, this method is rarely used in current evaluations of NEIs.

b. Relative Valuation

The *Relative Valuation* (*RV)* method involves asking respondents the value of the NEI relative to the bill savings from a program, either in terms of a verbally labeled scale (*Labeled Magnitude Scaling)* or in percentage or dollar terms (*direct scaling* or *self-reported percentages)*. For example, an *RV* survey might ask respondents whether they have experienced changes in the noise level in their home as a result of the program, whether these changes are positive or negative, and whether the value of these changes is higher than, lower than, or about the same as the bill savings from the program (or, for negative changes, how much the value detracts from the bill savings). A follow-up question would ask *how much* more or less than the bill savings, expressed either as a percentage of bill savings (i.e., *self-reported percentages*) or as "somewhat" or "very much" more or less than bill savings (i.e., *labeled magnitude scaling*). Respondents answer *labeled magnitude scaling* questions more quickly than the *self-reported percentage*, but analyzing the data requires an extra step of translating the verbal labels into values using standard equivalence equations. When both methods have been used in a single survey, the results have been similar.

Respondents generally find *RV* questions easier to answer than *WTP* questions. The results tend to be more consistent within and across studies (although the ranges of values obtained by this method are still quite wide both within and across studies and programs). A disadvantage is that, across programs, NEI values tend to be correlated with the value of bill savings, which might reflect the fact that higher "anchors" in such survey questions tend to result in higher values, a robust finding in recent survey research (Kahneman and Sugden, 2005). Thus, it is not clear whether higher bill savings results in higher NEI values or whether instead the effect of bill savings on NEI values is an artifact of the survey method, and not reliable evidence that programs with higher bill savings tend to result in more valuable NEIs. Also, when studies have asked respondents to value NEIs relative to bill savings without telling them the average savings amount for the program, results have been less consistent across participants, possibly because different respondents were assuming different levels of bill savings, thus using different values as an anchor with which to decide the value of NEIs. Nevertheless, because this method yields higher response rates and more consistent results than the other methods that have been used, *Relative Valuation* is the most frequently used method in NEI research.

[92] In WTP surveys, respondents are generally asked to estimate how much they would pay for a good or service, without reference to any other price, good or service.

c. Conjoint Analysis

The *Conjoint Analysis (CA)* survey method, commonly used in marketing research, essentially involves assessing the value of various hypothetical attributes of a product, through multiple questions asking respondents to choose between two hypothetical products, or scenarios with different combinations of the attributes in question. In some of these pairs, a monetary value replaces one of the attribute bundles. These preferences are then analyzed to obtain the monetary value of each of the attributes.[93]

The *CA* approach occasionally has been used in NEI research. For example, Summit Blue's evaluation of the NYSERDA ENERGY STAR Homes programs included *CA* questions in addition to *RV* questions (Barkett et al., 2006). To illustrate, one question asked respondents to choose between two different homes. Home 1 was described as having very little noise, standard ventilation (worse air quality), and best installation and construction practices (more durable); home 2 had some noise (less quiet), improved ventilation (better air quality) and standard installation and construction practices (less durable).

The main advantage of *CA* is that it does not require respondents to directly place a value on each of the NEIs. Rather, this method simply asks respondents about their preferences, which arguably is closer to how people evaluate intangibles in their everyday lives. The primary disadvantage of this method for NEI research is that the results reflect the value of NEIs under hypothetical, idealized circumstances, as opposed to value of the NEIs as actually experienced. Another disadvantage of the *CA* method is that it requires a more lengthy and complex set of survey questions, reducing the number of NEIs that can be evaluated. In addition, the values obtained tend to be substantially higher than those using *RV* methods. The evaluation of NYSERDA ES Homes (Barkett et al., 2006) found that the average value of overall NEIs from the *CV* questions was about $300 (50% of bill savings), whereas the value from the *CA* questions was about $800 (over 130% of bill savings).

d. Overall versus Individual NEI Values

Recent NEI research has found that if participants are asked to estimate the value of individual NEIs (i.e., thermal comfort, sense of environmental responsibility, etc.) and then asked to estimate the overall value of all of the individual NEIs together, the sum of the individual values often exceeds the overall value of the NEIs substantially. For example, in Summit Blue's evaluation of NYSERDA ES Homes program (Barkett et al., 2006), the sum of the individual NEI values is about 250% of bill savings, five times the average value obtained from the question about the overall value of all the NEIs (roughly 50% of bill savings).

Some reports have corrected for this divergence between the sum of the NEI values and the overall NEI value by presenting NEI values that are scaled down proportionately, so that they sum to the overall NEI value (e.g., Skumatz and Gardner, 2005). This correction is meant to adjust for potential overlap and overestimation of NEIs. Potential overlap and overestimation can be conceptualized in two ways. First, when asking respondents to valuate non-market goods with multiple parts or components, the stated value of the whole is often less than the value of the sum of the parts. This is often referred to as 'part-whole bias' when the values of the individual parts are not adjusted for the value of the whole (Bateman et al., 1996; Brown and Duffield, 1995). Second, when valuating several related things, the stated value of the total is often less than that of the sum of the individual items, often referred to as an "embedding effect" (Baron and Greene, 1996; Brown et al, 1995). There could be any number of explanations for this, but in the case of NEIs it is likely that there is "overlap" among the various NEIs asked about, such that respondents do not conceptualize the individual NEIs as being completely distinct and therefore their values are not additive.

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[93] For a thorough review of *Conjoint Analysis* see Wobus, et al. (2009).

Overlap could be occurring among NEIs in a few different possible ways. One way is if there is an implied causal relationship in the respondent's mind between two NEIs, so that it would be redundant to "pay for" each separately. For example, if a respondent thinks that fewer drafts lead to fewer colds and viruses, the respondent might think that both NEIs are valuable, but when combined, the NEIs are less valuable in total because when the respondent 'pays' for fewer drafts the respondent also benefits from fewer colds/viruses. Alternatively, two or more NEIs could be conceptually or experientially similar, so that they share at least some of their perceived meaning. For example, a respondent might perceive comfort, fewer illnesses, and reduced noise as all being different but somewhat overlapping aspects of an overall sense of "well-being," such that the various aspects, when taken separately, add up to more than the overall sense. Finally, one NEI can be considered a subset of another NEI, such that the value of one "contains" the value of another. For example, longer lighting life and even durable home could be perceived as part of "reduced equipment maintenance," such that the value of equipment maintenance includes the value of the other two.

5.2 IMPLICATIONS AND RECOMMENDATIONS FOR SURVEY METHODS

NMR recommends that surveys used in evaluating the PAs' programs use a *Relative Valuation* method, with *self-reported percentages*. To limit survey length and reduce respondent burden and fatigue, surveys should include fewer than eight NEIs (NMR and Conant, 2009). To correct for the commonly found disparity between the sum of individual NEI values and the overall value of the NEIs together, we recommend including a question about overall NEI values, then taking the conservative approach of scaling the individual NEI values to the overall value.

As noted earlier, several of the non-energy impacts of energy efficiency programs are intangible effects on participants' subjective quality of life. As such, they can only be measured through the reports of the participants themselves. They include increased thermal comfort, sense of environmental responsibility, lighting quality, and perceived reduction in noise levels. Although these NEIs are often highly valued by participants, because of methodological and theoretical difficulties with their measurement, they are often either not measured or their estimated values are reported separately from those of the other NEIs, instead of being incorporated into total NEI values for a program. Values for "soft" NEIs have been used primarily for marketing, designing, and targeting programs. They currently are rarely used for regulatory purposes.

Among the several published studies measuring soft NEIs, resulting values have varied by orders of magnitude, depending on survey method and other factors, including the type and comprehensiveness of the program, number of NEIs asked about in the survey, geographical area of the program, whether participants give an estimate of the sum of NEIs to which individual NEI values are scaled, and the value of energy savings for the program. For these reasons, it is not possible to come up with a reliable point estimate for any of these intangible NEIs based on values derived from these past studies. Collecting primary data from program participants through telephone surveys is far more reliable, as doing so controls for the variation among programs, participant sectors, and geographical area.

In addition, many of these intangible NEIs tend to be most relevant to whole-house programs, particularly those that include weatherization or other HVAC measures, rather than those with only one or two measures such as appliance rebate programs. Previous studies indicate that these NEIs tend to be equally important to low-income and general populations, and are relevant to both retrofit and new construction programs.

If the PAs wish to apply point estimates for the NEI values from the Evaluation of the Massachusetts New Homes with ENERGY STAR Program (NMR and Conant, 2009) to similar new construction programs, NMR recommends scaling the values of individual NEIs to 100% of estimated bill savings. Because the NMR survey did not include a question asking respondents to estimate the overall value of the NEIs combined, this would represent a more conservative valuation of these NEIs. This would be consistent with values found in a similar study conducted for NYSERDA's ENERGY STAR Homes program, which found participants valued all NEIs at 47% of estimated bill savings (Barkett et al., 2006).

In the following sections we indicate whether an NEI is being estimated via surveys of program participants.

5.2.1 Higher Comfort Levels

Participants in energy efficiency programs that include HVAC components and weatherization measures commonly experience greater perceived comfort, due to fewer drafts and more even temperatures throughout the home. The literature provides strong evidence that participants experience increased thermal comfort as a result of programs that affect the heating and cooling of the home, and that they consider these increased comfort levels to be a very important program benefit, both in general terms and in relation to other perception-based NEIs.

5.2.2 Non-low-income Programs

Myers and Skumatz (2006)

Several studies show that participants in non-low-income retrofit and new construction programs highly value thermal comfort relative to bill savings as well as relative to other NEIs, although some of the reported monetary valuations are probably overestimates because of methodological issues (as discussed in more detail throughout this section). For example, Myers and Skumatz (2006) performed an analysis of NEIs from multi-family retrofit programs, estimating the value of various NEIs across studies. The resulting estimated average value for comfort was 4% of the value for all NEIs combined. It should be noted, however, that this value reflects not only how much participant's value comfort, but also the frequency with which the various surveys include questions about comfort. The individual studies included in the analysis varied widely in the number and combination of NEIs assessed, and for surveys that did not include a particular NEI, the value was estimated to be 0%.

Barkett et al. (2006)

An assessment of NEIs from a New York ENERGY STAR Homes program using a *Relative Valuation* survey method (Barkett et al., 2006) found that 92% of participants reported positive changes in thermal comfort relative to their previous homes, compared to 67% of non-participants who had purchased non-ES (standard efficiency) new homes. Participants valued comfort at 42% of energy savings for the program. However, this result is difficult to interpret in terms of attributing the impact to the program, as non-participants valued increased comfort relative to their previous homes at an even higher rate, at 55% of bill savings. Further, participants estimated the value of all the NEIs combined (asked in the same way as the individual NEIs) at 47% of bill savings, which was just slightly higher than the average value of the individual NEI of comfort. Scaling the values for comfort and the other NEIs relative to the total NEI value would have resulted in far lower estimates. It should also be noted that the value of 42% of energy savings for thermal comfort derived from Summit Blue's survey was calculated from the nine participants who reported positive changes in that attribute (Barkett et al., 2006). The three participants who said either "same (no impact)" or "don't know" were not included in calculating the average valuation. If these participants had been included in the analysis and assigned a value of zero and averaged with the positive valuations, as was done in many other studies, including NMR's evaluation of MA ES Homes, the value of comfort would have been lower (NMR and Conant, 2009). Therefore, the value of 42% of energy savings is somewhat higher than the average value per participant.

The same New York ENERGY STAR Homes survey also assessed the NEIs using *Conjoint Analysis* questions, which yielded a comfort value of $191 annually per participating household, or 32% of estimated annual bill savings (Barkett et al., 2006).

NMR and Conant (2009)

Another *RV* survey evaluating NEIs from a similar ENERGY STAR program in MA (NMR and Conant, 2009) found that 86% of participants said that their homes provided more thermal comfort than they thought a non-ENERGY STAR new home would provide, and valued comfort at 70% of their bill savings, or $280. Again, although this value is not scaled relative to participants' estimates of the total value of all the NEIs in the survey, it does provide further evidence that thermal comfort is quite valuable to participants of energy efficiency programs.

5.2.3 Low-income Programs

Participants of low-income programs also experience increased thermal comfort and perceive it to be a particularly important benefit. In 1999, Skumatz and Dickerson conducted a study evaluating NEIs across several low-income weatherization programs. Participants from each program were asked to rate the importance of several NEIs. For programs with insulation, thermal comfort (phrased as "less drafty" in the survey) received the highest average importance rating, and for programs with caulking and weather-stripping, comfort and lower bills were judged to be equally important. Also, 52% of respondents in a survey evaluating NEIs from the CT Weatherization Residential Assistance Program said the thermal comfort in their homes was "better" or "much better" than before the program, while 34% of these participants said comfort was of greater value than their bill savings (Skumatz and Nordeen, 2002).

5.2.4 Assessment of the Literature

The literature provides strong evidence that participants experience increased thermal comfort as a result of programs that affect the heating and cooling of the home, and that they consider these increased comfort levels to be a very important program benefit, both in general terms and in relation to other perception-based NEIs. As illustrated above, due to methodological issues and the wide range of values obtained for increased thermal comfort across studies, the literature does not allow for a reliable estimate of increased comfort value for any of the PA programs, either in terms of dollars per participant or percent of energy savings. Instead, *increased* thermal comfort should be measured through surveys of program participants for programs that affect the heating and cooling of the home.

5.2.5 Relevant PA Programs

Based on the findings from the literature, increased thermal comfort is likely to be experienced and considered important by participants of a number of the PAs' programs that install weatherization measures, shell measures, and heating and cooling equipment, including low-income programs, retrofit and new construction programs, residential new construction and retrofit programs, as well as residential heating and hot water and residential cooling and heating programs.

5.2.6 Recommendations

Based on the surveys of program participants, NMR recommends an annual value of $125 for NLI participants and $101 for LI participants who installed shell and weatherization measures or heating and cooling equipment. The NEI applies to the PAs' low income-retrofit programs, low-income new construction programs, residential cooling and heating programs, residential heating and hot water programs, and non-low-income retrofit programs (i.e., Mass Save, multi-family retrofit programs).

For the PAs' residential new construction programs (non-low-income), NMR recommends using a value of $77 per participant, the scaled value from the Evaluation of the Massachusetts New Homes with ENERGY STAR Program (NMR and Conant, 2009).[94]

[94] Thermal comfort was estimated to be equal to $279 per participant, or 19% of the $1,445 in total NEI benefits from the Evaluation of the Massachusetts New Homes with ENERGY STAR Program (NMR and Conant, 2009). Energy savings from a new ENERGY STAR rated home

5.3 IMPROVED SENSE OF ENVIRONMENTAL RESPONSIBILITY

Participants are generally aware that reducing their own energy consumption has a positive effect on the environment, and programs that increase the energy efficiency of their homes can result in a sense of satisfaction from being environmentally responsible. When *sense of environmental responsibility* (or, as expressed in some surveys, participants' perceptions of the value of the "environmental impact" of their participation in the program) is included in NEI studies, it tends to be one of the most highly valued participant NEIs for both all-income and low-income whole-house programs, possibly second only to comfort (for example, Myers and Skumatz, 2006; NMR and Conant, 2009; Skumatz and Dickerson, 1999; Skumatz and Nordeen, 2001; for a review of these studies, see Appendix A).

While sense of environmental responsibility has been shown to be commonly experienced and considered important by participants of a variety of program types, the environmental benefits of the PAs' programs have been estimated in the *Avoided Energy Supply Costs in New England: 2011 Report* (Hornby et al, 2011) and included in the PAs' three year energy efficiency plans (National Grid et al., 2009; NSTAR et al., 2009). Therefore, NMR does not recommend including the NEI of sense of environmental responsibility, as this would amount to double counting of the same benefit.

5.3.1 Recommendations

NMR does not recommend including the NEI of sense of environmental responsibility for two reasons. First, because the environmental benefits of the PAs' programs have been estimated in the *Avoided Energy Supply Costs in New England: 2011 Report* (Hornby et al, 2011) and included in the PAs' three year energy efficiency plans (National Grid et al., 2009; NSTAR et al., 2009), this would potentially amount to double counting of the same benefit. In other words, this would count both the material environmental benefit and the psychic benefit of how program participants feel about the material environmental benefit. Second, because sense of environmental benefit is so intangible, NMR does not recommend counting this benefit. ,

5.4 QUIETER INTERIOR ENVIRONMENT

Energy efficiency programs can reduce the noise in participants' homes by installing insulation and sealing doors and windows, thus reducing the extent to which outside noise can be heard inside the home. Also, some of the measures installed such as furnaces, can themselves be quieter than the standard, often older, equipment that was replaced. This NEI is sometimes included in evaluations of whole-house programs. It is perceived by participants of both all-income and low-income programs to be of moderate to high value, relative to other participant NEIs.

5.4.1 Non-low-income Programs

Barkett et al. (2006)

In the evaluation of the NY ENERGY STAR Homes program described earlier (Barkett et al., 2006), 75% of participants surveyed reported a positive change in noise levels in their home relative to their previous home, compared to 67% of non-participants (who had recently purchased a non-ENERGY STAR home). Participants and non-participants both valued reduced noise levels at 42% of energy savings, a value equal to that of thermal comfort. Again, although the NEI values were not scaled proportionately to the overall value, and the equivalence of the participants' and non-participant results is difficult to interpret, it is notable that such a large proportion of participants experienced reduced noise levels and that the value was as high as that of thermal comfort. The C*onjoint Analysis* questions in the survey, which measure the

were estimated to be $400 per home per year. Scaling thermal comfort to 100% of the estimated bill savings results in an NEI estimate of $77 per participant (i.e., 19% * $400=$77). NMR recommends considering adjusting the scaling of the residential new construction NEI values upon completion of the analysis of the current NEI surveys of participants in the PAs' residential retrofit programs.

value to participants of noise level and other attributes in the abstract (as opposed to actually experienced), yielded an annual value of $72 per participant household. Although this is far lower than the $191 obtained for comfort, it is still high relative to the other NEIs, showing that participants prefer lower noise levels and (at least in hypothetical scenarios) would be willing to exchange a substantial amount of money for a reduction in noise.

NMR and Conant (2009)

NMR's Massachusetts New Homes ENERGY STAR program evaluation (NMR and Conant, 2009) found that 67% of participants perceived that their homes were quieter than they thought an equivalent non-ENERGY STAR home would be, and they valuated this NEI at 37% of bill savings, or $146. Although this value should be interpreted in light of the fact that it was not scaled to an overall NEI value, the study provides further evidence that reduced noise is clearly experienced and valued by many program participants.

5.4.2 Low-income Programs

The literature suggests that participants in low-income programs also consider reduced noise levels to be of moderate to high importance relative to other participant NEIs, but the evidence that such programs result in a significant reduction in noise levels is somewhat mixed. Skumatz and Dickerson's study on NEIs from various low-income weatherization programs (1999) found that, for the programs with caulking/weather-stripping, reduced noise was rated as the second most important NEI (after "less drafty"), equivalent in importance to "lower bills." However, fewer than 10% of participants in the CT WRAP program said that the noise level in their house was "better" or "much better" than before the program (Skumatz and Nordeen, 2002), indicating that not all programs are successful in reducing noise levels to a noticeable degree. Nevertheless, on the whole it appears that low-income programs do have a net positive impact on noise levels; in a recent review of NEIs from hundreds of different low-income programs, Skumatz, Khawaja, and Krop (2010) estimates that reduced noise values for such programs are $13 to $20 annually per participant household.

5.4.3 Assessment of the Literature

Quieter interior environment NEI is sometimes included in evaluations of whole-house programs and is perceived by participants of both all-income and low-income programs to be of moderate to high value relative to other participant NEIs. NMR does not consider the range of values reported by Skumatz, Khawaja and Krop (2010)—$13 to $20 annually—to be readily applicable to the PAs' programs, as the values in the review vary widely by type of program, measures installed, survey method, geographical region, and other factors.

5.4.4 Relevant PA Programs

Quieter interior environment is often found to be a moderate- to low-value participant NEI and it is potentially applicable to all-income and low-income programs that include insulation and other weatherization and shell measures.

5.4.5 Recommendations

Based on the surveys of program participants, NMR recommends an annual value of $31 for NLI participants and $30 for LI participants who installed shell and weatherization measures or heating and cooling equipment. The NEI applies to the PAs' low income-retrofit programs, low-income new construction programs, residential cooling and heating programs, residential heating and hot water programs, and non-low-income retrofit programs (i.e., Mass Save, multi-family retrofit programs).

For the PAs' residential new construction program (non-low-income), NMR recommends using a value of $40 per participant, the scaled value from the Evaluation of the Massachusetts New Homes with ENERGY STAR Program (NMR and Conant, 2009).[95]

5.5 REDUCED NOISE (DISHWASHERS)

A potential non-energy impact associated with ENERGY STAR dishwashers is reduced noise.[96] Some dishwashers, particularly older models, can be loud. The NEI of reduced noise from dishwashers has rarely been measured in the literature. In fact, NMR's review of the literature identified only one study quantifying this benefit. A survey conducted for the New York Energy $mart programs found that respondents valued the NEI of "noise levels" for dishwashers at 9% of total NEIs (Fuchs et al., 2004). This survey employed the relative valuation method, in which respondents were asked if the appliance had a positive, negative, or no impact with regards to each of 13 NEIs. When respondents indicated that there was an impact (positive or negative), they were then asked for the relative value of the impact. Monetized NEI values were not computed in this report.

5.5.1 Assessment of the Literature

The literature on participant valuation of reduced noise from dishwashers is virtually nonexistent.

5.5.2 Relevant PA Programs

The NEI of reduced noise from dishwashers is relevant to PA programs that implement ENERGY STAR dishwashers. These programs include the RNC programs.

5.5.3 Recommendation

Due to the lack of research on reduced noise from dishwashers and its relative low and non-monetized value in the single study in which it was measured, NMR does not recommend quantifying the value of this NEI at this time.[97]

5.6 LIGHTING QUALITY

Our review of the literature found few studies assessing participants' perceptions of the lighting quality of CFLs. When it has been examined, it has sometimes been combined with lifespan of CFLs provided through the program. However, the results are mixed and difficult to interpret. Lighting lifespan is discussed in more detail in Section 5.7.

In a study evaluating NEIs from several NY Energy $mart programs, ten participants of a CFL marketing program (CFL users) and ten non-participants (CFL non-users) were asked a series of questions about their experiences or perceptions of CFL bulbs compared to incandescent bulbs (Barkett et al., 2006). While the majority (72%) of respondents perceived the longer lifetime of CFLs to be positive, more respondents perceived the lighting quality of CFLs to be worse than incandescents (about 35%) than perceived it to be better (less than 30%). Combining quality and lifetime in a single question, NMR's

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[95] Noise reduction was estimated to be equal to $146 per participant, or 10% of the $1,445 in total NEI benefits from the Evaluation of the Massachusetts New Homes with ENERGY STAR Program (NMR and Conant, 2009). Energy savings from a new ENERGY STAR rated home were estimated to be $400 per home per year. Scaling noise reduction to 100% of the estimated bill savings results in an NEI estimate of $40 per participant (i.e., 10% * $400 = $40). NMR recommends considering adjusting the scaling of the residential new construction NEI values upon completion of the analysis of the current NEI surveys of participants in the PAs' residential retrofit programs.

[96] Reduced noise may also apply to energy efficient clothes washers.

[97] Reduced noise from dishwashers could be quantified through the surveys of the PAs' program participants, but priority was placed on NEIs that derive from shell, heating and cooling measures rather than appliances.

survey evaluating NEIs from the MA ENERGY STAR Homes program found that 61% of participants considered the combination to be positive overall, compared to what they thought they would experience in a new standard-efficiency home, whereas 20% said it was overall negative (NMR and Conant, 2009).

5.6.1 Assessment of the Literature

Few studies have assessed participants' perceptions of the lighting quality of CFLs and when it has been examined, it has sometimes been combined with lifespan of CFLs provided through the program. Results from the literature are mixed and difficult to interpret.

5.6.2 Relevant PA Programs

Lighting quality applies to PA programs that install CFLs and LEDs, including the RNC programs, Mass Save, ENERGY STAR Lighting, the Multifamily Retrofit programs, and the Low-Income retrofit programs.

5.6.3 Recommendations

We recommend a single benefit for both lighting quality and lifetime and recommends using the one-time operation and maintenance (O&M) benefit presented in the Massachusetts Statewide Technical Reference Manual (TRM) for Estimating Savings from Energy Efficiency Measures for the 2011 program year, provided by the Massachusetts Department of Energy Resources (Massachusetts Electric and Gas Energy Efficiency Program Administrators, 2010). The one-time benefit per CFL bulb or CFL fixture installed through programs that ranges from $3.00 to $3.50 per CFL bulb or fixture, depending on the type of bulb or fixture. This applies to all of the PAs' programs that install energy efficient lighting (i.e., RNC programs, Mass Save, ENERGY STAR Lighting, the Multifamily Retrofit programs, Low-Income retrofit programs, and low-income new construction programs)

While the surveys of program participants found that respondents assign a positive value to the lighting quality and lifetime of program sponsored energy efficient lighting ($49 for NLI participants and $56 for LI participants), the O&M benefit is a more reliable and straightforward estimate of lighting NEIs.

5.7 LONGER LIGHTING LIFETIME

Energy-efficient lighting technologies such as CFLs and LEDs have longer lifetimes than incandescent lighting. ENERGY STAR CFL bulbs last up to ten times longer than incandescent bulbs, while LED bulbs last at least 15 times longer than incandescent bulbs.[98] In addition to energy bill savings, participants realize financial savings from CFLs in the form of fewer bulb purchases due to their longer lighting life. Additionally, participants benefit because they need to spend less time changing light bulbs. The value of financial savings to participants in the form of fewer bulb purchases and maintenance can be derived via an engineering estimate that includes the following variables: purchase price per bulb, bulb lifetime, installation labor hours, and labor cost per hour (i.e. the value of participant time spent changing out light bulbs). Purchase price, bulb lifetime, and installation labor hours are straightforward to quantify and likely do not vary significantly from one participant to another. Labor cost per hour, however, does vary from one participant to another.

[98] http://www.energystar.gov/index.cfm?c=products.pr_find_es_products

Barkett et al., (2006)

Participant valuation of the longer lifetime associated with CFLs has been investigated in the literature via participant surveys. In the 2006 Non-Energy Impacts Evaluation for New York Energy $mart programs, for example, respondents who owned CFLs were asked if they experienced a positive, zero, or negative impact with regards to bulb lifetime compared to incandescent light bulbs (n=10) (Barkett et al., 2006). Over 70% of respondents reported a positive impact, around 10% reported zero impact, and the remainder answered “don’t know.” When asked to value the positive impact of bulb lifetime relative to energy savings, those who indicated a positive impact reported an average of 55% of energy savings. Conjoint analysis questions asked in the same survey of all respondents (both CFL users and non-users) resulted in an annual participant valuation of $1.80 for bulb lifetime (n=21).

NMR and Conant (2009)

Another study investigating participant valuation of longer lighting life is the 2008 Evaluation of Massachusetts New Homes with ENERGY STAR Program (NMR and Conant, 2009). Eighty-one percent of respondents believed that their ENERGY STAR home provided the NEI of “lighting life/quality,” while 61% reported a positive impact with regard to “lighting life/quality” for all CFLs in their home. Via the relative valuation method, an annual NEI value of $144 (or 36% of bill savings) was reported for “lighting life/quality” (n=63). This NEI value accounts for both positive and negative valuations reported by respondents.

5.7.1 Assessment of the Literature

Several studies in the literature have examined participant valuation of longer lighting lifetime via participant surveys. While this NEI has been investigated for programs promoting CFLs, there are no studies in the literature specific to LED lighting. Monetized values of this NEI have been estimated via relative valuation and conjoint analysis methods. Relative to other participant NEIs, the NEI of lighting life is well suited for an engineering estimate approach, because light bulbs have well-documented estimated useful lifetimes and bulb prices. Therefore, the NEI of lighting life could likely be measured reliably via an engineering estimate, as opposed to the survey methods with which it has been estimated in the NEI literature.

5.7.2 Relevant PA Programs

Longer lighting lifetime applies to PA programs that install CFLs and LEDs, including the RNC programs, Mass Save, ENERGY STAR Lighting, the Multifamily Retrofit programs, and the Low-Income retrofit programs.

5.7.3 Recommendations

NMR recommends a single benefit for both lighting quality and lifetime and recommends using the one-time operation and maintenance (O&M) benefit presented in the Massachusetts Statewide Technical Reference Manual (TRM) for Estimating Savings from Energy Efficiency Measures for the 2011 program year, provided by the Massachusetts Department of Energy Resources (Massachusetts Electric and Gas Energy Efficiency Program Administrators, 2010). The one-time benefit per CFL bulb or CFL fixture installed through programs that ranges from $3.00 to $3.50 per CFL bulb or fixture, depending on the type of bulb or fixture. This applies to all of the PAs’ programs that install energy efficient lighting (i.e., RNC programs, Mass Save, ENERGY STAR Lighting, the Multifamily Retrofit programs, and the Low-Income retrofit programs)

While the surveys of program participants found that respondents assign a positive value to the lighting quality and lifetime of program sponsored energy efficient lighting ($49 for NLI participants and $56 for LI participants), the O&M benefit is a more reliable and straightforward estimate of lighting NEIs.

5.8 INCREASED HOUSING PROPERTY VALUE AND ANTICIPATED EASE OF SELLING OR LEASING HOME

Increased home property value is frequently recognized as a non-energy benefit associated with low-income weatherization programs and has also been estimated for non-low-income programs. Energy-efficient homes are generally more desirable than less efficient homes, particularly because energy bills are lower in energy-efficient homes. The benefit of increased property value has been estimated through the value of the anticipated ease of selling or renting or, in some cases, increased resale or rental value.

5.8.1 Low-income Programs

Several methods for estimating the participant benefit of increased home property value have been employed in the literature. The most commonly employed estimation method, particularly in the recent literature, is to value the structural repairs made to homes during low-income weatherization programs. Home repairs generally increase a property's value, which represents a participant benefit separate from and in addition to energy bill savings. While the benefit of increased home property value could theoretically apply to all PA programs and customers, the NEI literature has rarely quantified this benefit for non-low-income customers and programs.

The majority of NEI valuations for increased property value found in the literature are based on structural repairs made to homes through low-income weatherization programs. Home repairs are often required before weatherization measures can be installed. Examples of home repairs include repairing or replacing windows and doors, ventilating attics, and incidental roof, wall, and floor repairs.

Brown et al. (1993)

The 1993 national WAP program evaluation estimated the value of the increased property values to be equal to the weighted national average spent on materials for structural repairs, which was $126 for the program year under evaluation (Brown et al., 1993). The authors of the report noted that the quantity of home repairs performed through the national WAP varied depending on climate region, primary heating fuel, and dwelling type. In particular, structural repairs occurred most frequently to homes found in hot regions, to homes heated by gas, and to single-family detached homes.

TecMarket Works, SERA, and Megdal Associates (2001)

The LIPPT report estimated a value of $17.80 per household per year based on the cost of structural repairs made to a participant's home (TecMarket Works, SERA, and Megdal Associates, 2001). This annual NEI value assumes a ten-year benefit horizon and a participant discount rate of 18%.

Skumatz, Khawaja, and Krop (2010)

A recent review of the literature found annual participant benefits ranging from a few dollars to more than $20 per participant (Skumatz, Khawaja, and Krop, 2010).

Nevin and Watson (1998)

One study frequently cited in the literature that examined the relationship between energy efficiency and property values is that of Nevin and Watson (1998). This study employed regression models to estimate the relationship between fuel expenditures and home values. Property value data for the study incorporated a variety of home types and home heating fuels. The model results confirmed the hypothesis that homebuyers were willing to pay more for energy-efficient homes; a $10-$25 increase in property value for every $1 decrease in annual fuel bills was reported. While this particular study is often cited in low-income NEI literature, it addressed neither PA-sponsored energy efficiency programs nor the low-income population.

Riggert et al. (1999)

The property value NEI of $5,413 per home presented in the 1999 Vermont WAP evaluation was estimated by multiplying the average dollar increase reported by Nevin and Watson by the average energy savings from the Vermont WAP (Riggert et al., 1999). This NEI estimation method assumes that weatherization increases a home's value in proportion to the energy savings.

Dalhoff (2007)

A subsequent Vermont WAP report, however, stated that, for several reasons, it was not appropriate to use Nevin and Watson's regression model to quantify increased property values for the Vermont WAP (Dalhoff, 2007). Because Nevin and Watson's analysis was based on the correlation between fuel costs and property value in a national sample, the 2007 Vermont WAP evaluators argued that the analysis did not account for the fact that energy usage tends to be lower in milder climates and that people place value on numerous benefits of residing in a mild climate (not just lower fuel expenditures). Furthermore, the analysis did not directly measure the change in property value following the installation of energy efficiency measures. Consequently, the property value NEI for the 2007 Vermont WAP was valued at average program expenditures per weatherized household. The reasoning for this estimation method was that other homes in the same market could be improved by a similar expenditure.

Skumatz and Dickerson (1999)

Skumatz and Dickerson's analysis of NEIs from various low-income weatherization programs (1999) found that participants rated increased selling price as the third most important NEI from the programs that included insulation, after comfort and environmental impact. In Myers and Skumatz' evaluation of multi-family programs, participants in all-income multifamily programs gave anticipated ease of selling the third highest NEI value, again following comfort and environmental impact (Myers and Skumatz, 2006). Participants in low-income multifamily retrofit programs valued anticipated ease of selling or renting to an even higher degree, at 17% of the total NEI value, second only to environmental impact.

5.8.2 Non-low-income Programs

A high degree of energy efficiency in a home tends to be an attractive feature for homebuyers and renters. Therefore, homes with energy-efficient equipment, or homes that are built to be energy-efficient, can command a higher selling or rental price, and can be easier to sell or rent than similar homes with standard efficiency, resulting in a higher property value.

Studies show that participants of a variety of programs consider anticipated ease of selling or renting or, in some surveys, increased resale or rental value to be an important benefit.

For the two major evaluations of NEIs from new construction programs included in our literature review, homeowners were asked about the value per year of anticipating these resale benefits.

Barkett et al. (2006)

The *RV/DS* survey employed in Summit Blue's NYSERDA evaluation of NEIs from a NY ENERGY STAR Homes program (Barkett et al., 2006) asked 12 participants and 12 non-participants whether they anticipated that their new home would be easier or harder to sell than their previous home. Six participants and four non-participants indicated that it would be easier to sell. The other six participant respondents either thought it would be the same or did not know if it would be easier or harder to sell.

NMR and Conant (2009)

NMR's survey on NEIs from MA ENERGY STAR Homes (NMR and Conant, 2009) asked whether participants expected that their homes would have a higher or lower rental or resale value, compared to similar, standard-efficiency new homes. Eighty percent of the respondents said they expected it to be higher.

While these results suggest that at least some owners of ES Homes do anticipate greater ease in selling the home because of the program, estimating the annual value of that anticipation per participant is not straightforward. Summit Blue's evaluation of NY ES Homes (Barkett et al., 2006) reported a value of 62% of energy savings for anticipated ease of selling ($399), while surveyed participants in the NMR evaluation of MA ES Homes valued the increased resale or rental value at 65% of bill savings, or $259.

Although the two studies obtained similar results for this NEI, both values are likely to be overestimated, for several reasons. First, as mentioned in other sections, the survey does not account for the fact that when respondents are asked the total combined value of all the NEIs in the survey, this average value is invariably far lower than the sum of the values given individually for the NEIs, both in this survey and other similar surveys (e.g., Skumatz, 2002). In fact, the value Summit Blue (Barkett et al., 2006) reported for estimated ease of selling (62% of bill savings) is *higher* than the average value given by participants for *all the NEIs combined* (47%).

Also, the value of 62% of energy savings derived from Summit Blue's survey was calculated only from the five participants who had said they expected their new home to be easier to sell than their previous home (Barkett et al., 2006). The six participants who said either "same (no impact)" or "don't know" were not included in calculating the average valuation. Therefore, the value of 62% of energy savings does not reflect the average value per participant. Further, because four non-participants (with standard-energy homes) thought their new homes would sell more easily than their previous homes, and because they valued this anticipation to a greater extent (75% of bill savings) than did participants, interpretation of the results is difficult.

5.8.3 Assessment of the Literature

Home property valuation depends on a multitude of factors. Holding all other factors constant, an energy-efficient property is more valuable than a less efficient one. However, the magnitude by which specific energy efficiency measures increase a property's value has not been examined extensively in the NEI literature. Instead, most property value NEI estimations found in the literature are based on low-income weatherization programs; they are estimated as the average cost of materials required for minor improvements performed during home weatherizations. It is reasonable to assume that needed structural repairs improve a home's value.

For non-low-income programs, increases in property values have been measured through surveys of program participants as their valuation of the anticipated ease of selling/renting their home. This has been found to be a fairly important subjective benefit for participating homeowners for a variety of program types, including multifamily retrofit programs, as well as new construction.

5.8.4 Relevant PA Programs

NMR recommends applying this NEI to the PAs' low-income and non-low-income retrofit programs.

5.8.5 Recommendations

Based on the surveys of program participants, NMR recommends one-time value of $1,998 for NLI participants and $949 for LI participants who installed shell and weatherization measures or heating and cooling equipment. The NEI applies to the PAs' low income-retrofit programs, low-income new construction programs, residential cooling and heating programs, residential heating and hot water programs, and non-low-income retrofit programs (i.e., Mass Save, multi-family retrofit programs).

For the PAs' residential new construction program (non-low-income), NMR recommends using an annual value of $72 per participant, the scaled value from the Evaluation of the Massachusetts New Homes with ENERGY STAR Program (NMR and Conant, 2009).[99]

The evaluation team recommends replacing the current NEI value used in the TRM report with the values estimated in this report. The TRM reports a one-time property value benefit of $20.70 for every dollar in energy savings, based on the Nevin and Watson (1998) study, and the evaluation team does not recommend continuing to use this value.[100]

5.9 BUFFERS ENERGY PRICE INCREASES

Energy prices fluctuate over time, with short term fluctuations and longer-term (expected upwards) trends. This is particularly true for prices of residential home heating fuels. Energy efficiency programs mitigate the impact of energy price fluctuations that affect customers' energy bills, by reducing the amount of energy that customers consume. Program participants derive value from minimizing their exposure to price increases.[101]

According to the PAs' three-year electric plans, the TRC benefit-cost test includes Demand Reduction Induced Price Effect (DRIPE). DRIPE is a benefit realized by consumers from the response of the supply market to lowered demand attributable to energy efficiency measures. The three-year plans define DRIPE as a reduction of prices of wholesale energy and capacity market prices that result from reductions in demand as a result of energy efficiency efforts (National Grid et al, 2009). The value of DRIPE was estimated in the *Avoided Energy Supply Costs in New England: 2011 Report* (Hornby et al., 2011) and used in the TRC benefit-cost test.

5.9.1 Recommendations

Because the PAs' three-year electric plans and the TRC benefit-cost test includes DRIPE, NMR does not recommend attempting to quantify an NEI value above and beyond what has already been accounted for in the *Avoided Energy Supply Costs in New England: 2011 Report* (Hornby et al., 2011). NMR believes that DRIPE provides the best estimate of the price effects realized by consumers.

5.10 REDUCED NEED TO MOVE AND COSTS OF MOVING, INCLUDING HOMELESSNESS

High energy costs have been linked with increased rates of mobility among low-income households. High energy bills leave less money available for other necessities. When a household's income is insufficient to cover all expenses, the household is more likely to fall behind on rent and be evicted. Utility service terminations due to non-payment can render a home uninhabitable, forcing its inhabitants to move.

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[99] Resale or rental value was estimated to be equal to $259 per participant, or 18% of the $1,445 in total NEI benefits from the Evaluation of the Massachusetts New Homes with ENERGY STAR Program (NMR and Conant, 2009). Energy savings from a new ENERGY STAR rated home were estimated to be $400 per home per year. Scaling resale or rental value to 100% of the estimated bill savings results in an NEI estimate of $72 per participant (i.e., 18% * $400 = $72).

[100] According to the Nevin and Watson's study, the increase in the property value for an energy efficient home is derived from the expected energy savings. The one time increase in property value represents the current value of the stream of expected energy savings. To quote the authors: "These findings provide strong evidence that the market value of energy- efficient homes reflects projected fuel savings discounted at the average home buyer's after-tax mortgage interest rate (Nevin and Watson, 1998, p. 407)." Because energy savings are already accounted for, to count the increase in property value that is attributed to the same energy savings would be double counting of benefits.

[101] See Appendix C: Additional Literature Reviewed for Select NEIs for a review of studies that have examined participant valuation of buffering future energy price increases.

Frequent relocation results in direct and indirect costs to low-income families. Direct costs include the time, effort, and expenses incurred in moving. An indirect cost identified in the literature is the disruption in children's education associated with frequent relocation. As cited in Khawaja et al. (1999), a 1984 National Science and Law Center study in Pennsylvania found that low-income households were three times as likely to move as non-low-income households, and that the high school drop-out rate of frequent movers was four times the average. Howat and Oppenheim (1999) identify three ways in which energy efficiency programs can help reduce mobility, including freeing up funds to pay rent and other required housing costs, decreasing the likelihood of service terminations, and resolving dangerous problems with heating systems or building structures that might otherwise force a household to move.

Research linking increased mobility and/or homelessness with unaffordable energy costs indicates that decreasing the energy burden of low-income households makes more funds available within the household budget for rent and energy bills, therefore helping low-income households stay in their current homes. Because the energy savings from the programs are already counted as a benefit by the PAs, to count additional benefits that derive from these energy savings would amount to double counting. Therefore, NMR does not recommend quantifying the benefits of reduced rates of mobility and homelessness. This is not to say that low-income households do not benefit from reduced energy burdens, but rather that the benefits are already accounted for. A review of the literature linking energy costs with mobility and homelessness can be found in Appendix C: Additional Literature Reviewed for Select NEIs.

5.10.1 Recommendation

The primary mechanism by which energy efficiency programs reduce the incidence of low-income mobility and/or homelessness is through the energy bill savings. The energy bill savings represent additional dollars that can be put toward rent and energy bills. However, participant energy bill savings are already accounted for by the PAs in the AESC study and TRC test. Valuing the NEI of reduced mobility and homelessness attributable to energy efficiency programs is effectively double counting the energy bill savings. Therefore, NMR does not recommend quantifying the value of this NEI. [102]

5.11 REDUCED WATER USAGE AND SEWER COSTS (DISHWASHERS AND TANKLESS WATER HEATERS)[103]

To the extent that ENERGY STAR dishwashers and tankless water heaters use less water than conventional alternatives, participants can benefit from a decrease in their water and sewer bills. For dishwashers, the magnitude of water bill savings to a given participant depends on whether a non-ENERGY STAR dishwasher would have been installed without the program, and if so, the difference in the amount of water used between the ENERGY STAR dishwasher and the non-ENERGY STAR dishwasher that would have been installed in the absence of the program. Estimating the annual value of this NEI for dishwashers is a straightforward engineering estimate involving the following variables: annual dishwasher cycles, the quantity of water saved per cycle by the new dishwasher, and the cost of water. Sewer costs use a similar algorithm of annual dishwasher cycles, the quantity of water saved per cycle by the new dishwasher, and the sewer costs.

For water savings attributable to water heaters, water usage is likely to be related to the distance between the water heater and the faucet or appliance to which it supplies hot water. If participants do not have to run a hot faucet tap and wait for the water to warm up, then they can potentially cut down on their water bills.

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[102] If energy bill savings are not counted, we recommend that bill savings be counted rather than counting the benefits that derive from bill savings.

[103] Because clothes washers are not among the measures included in the PAs' programs, this literature review does not include a discussion of water savings attributable to energy-efficient clothes washers.

Many studies have examined the participant value of water savings from measures such as low-flow showerheads and faucet aerators, but few have focused on ENERGY STAR dishwashers. One study analyzing the non-energy benefits arising from ENERGY STAR appliances in California estimated that the value of annual water savings from ENERGY STAR dishwashers was $1.65 per participant (Equipoise Consulting, 2001). This NEI value was obtained by multiplying estimates of the following: water savings (in gallons) between conventional and ENERGY STAR dishwashers; dishwasher cycles per year; and cost of water per gallon. An important consideration noted in the report is that ENERGY STAR dishwashers do not necessarily use less water than conventional models, due to the soil sensors they contain. For example, the authors noted that soil-sensing dishwashers use between 4.9 and 8.5 gallons per load, depending on how soiled the dishes are. In order to quantify the NEI value, average water usage data for ENERGY STAR and conventional dishwashers was obtained from the Department of Energy. The estimated number of cycles per year used to estimate the program-level energy savings was applied in the formula for estimating the NEI of participant water savings. The last component to the NEI calculation, residential water rates, was estimated by averaging the rates from the water utilities within the relevant service territory.

Non-energy impacts of tankless hot water heaters have seldom been discussed in the literature. To our knowledge they have never been monetized. A 2006 survey of participants in a Massachusetts tankless water heater program found that satisfaction with tankless water heaters may be associated with the distance between the water heater and the primary faucet or appliance to which it supplies hot water (NMR, 2006). For example, respondents who reported that their tankless water heater was either closer to or the same distance from the primary faucet or appliance than their old water heater were more likely to be satisfied with the amount of time it took hot water to come out of the faucet (100% and 85%, respectively, were satisfied or extremely satisfied, versus 56% among those whose water heaters are farther away). Participants were also asked if they used more, less, or the same amount of hot water than before participating in the program. Approximately three-quarters of respondents estimated that they used the same amount of hot water as when they had a storage tank water heater, while approximately 12% reported using more hot water and 12% reported using less hot water. NEI values were not quantified in this report.

5.11.1 Assessment of the Literature

The value to participants of reduced water usage can be calculated using a straightforward engineering calculation. NEI valuations in the literature for reduced water usage from ENERGY STAR dishwashers have been estimated via this method. The non-energy impact of reduced water usage resulting from tankless hot water heaters has rarely been investigated. One study on water usage of ENERGY STAR versus non-ENERGY STAR dishwashers found that the former did not necessarily use less water than the later. As of August 2009, however, ENERGY STAR qualified dishwashers are required to use 5.8 gallons of water per cycle or less.[104] Data on water usage of the new and old dishwashers for rebate and retrofit programs is expensive to collect; therefore, NEI estimates have generally been based on average water usage for relevant dishwasher models. Because participant water rates are a component in the formula, the value of this NEI is sensitive to local water rates and pricing structures.

5.11.2 Relevant PA Programs

The non-energy benefit of reduced water usage from dishwashers and tankless hot water heaters applies to PA programs that implement ENERGY STAR dishwashers and tankless water heaters. These programs include the RNC programs and the residential heating and hot water equipment program.

[104] http://energystar.custhelp.com/cgi-bin/energystar.cfg/php/enduser/std_adp.php?p_faqid=2539&p_created=1147982777

5.11.3 Recommendations

a. Dishwashers

NMR recommends quantifying participant water savings by using the annual water savings value from the 2010 Massachusetts Technical Reference Manual (TRM) for Estimating Savings from Energy Efficiency Measures for an ENEGY STAR dishwasher of 430 gallons per year[105] and multiplying by the average cost of water per gallon in Massachusetts reported in Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan ($0.0036 per gallon) for an annual NEI value of $1.55 per dishwasher. The algorithm is as follows:

- 430 gallons (estimated annual water savings per ENERGY STAR dishwasher) * $0.0036 (average cost of water per gallon in Massachusetts reported in Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan)

NMR recommends using the same formula for sewer savings and using an average sewer rate of $0.0050 per gallon as reported in the Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan for an annual NEI value of $2.15 per dishwasher. The algorithm is as follows:

- 430 gallons (estimated annual water savings per ENERGY STAR dishwasher) * $0.0050 (average cost of sewerage per gallon in Massachusetts reported in Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan)

b. Tankless Water Heaters

Due to the lack of information in the literature, it is unclear how significant the NEI of water usage associated with tankless water heaters might be. The quantity of water reduced is zero, more or less, depending on the location of the new water heater compared to the old one. Further, because of the relatively low cost of water (average Massachusetts cost of $0.0036 per gallon); this NEI is likely to be low in value and likely does not warrant the costs of primary data collection. If the PAs are interested in quantifying its value, NMR recommends the following algorithms:

- (average number of gallons of water flowing down the drain waiting for hot from traditional water heaters - average number of gallons of water flowing down the drain waiting for hot from tankless water heaters) * $0.0036 (average cost of water per gallon in Massachusetts reported in Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan)
- (average number of gallons of water flowing down the drain waiting for hot from traditional water heaters - average number of gallons of water flowing down the drain waiting for hot from tankless water heaters) $0.0050 (average cost of sewerage per gallon in Massachusetts reported in Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan)

Because the quantity of water flowing down the drain while participants are waiting for the water to become hot depends on the distance between the water heater and the point of use, these data are likely to be extremely difficult to collect.

5.12 REDUCED DETERGENT USAGE (DISHWASHERS)

While reduced detergent usage associated with ENERGY STAR clothes washers has been addressed in the NEI literature, detergent usage associated with ENERGY STAR dishwashers has not. In fact, there is

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[105] The annual water savings from an ENEGY STAR dishwasher was derived from the Environmental Protection Agency (2010). Life Cycle Cost Estimate for ENERGY STAR Residential Dishwasher. Interactive Excel Spreadsheet found at

http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls no evidence in the literature that ENERGY STAR dishwashers require less detergent than non-ENERGY STAR dishwashers. Where detergent savings have been investigated for clothes washers, it has been found that the NEI associated with detergent usage can be either positive or negative. For example, one study found that participants who continued to use conventional clothes detergent in their new ENERGY STAR clothes washers benefited because they used less detergent per load and therefore saved on the cost of detergent (Equipoise, 2001). However, the same study found that participants that switched to high efficiency (HE) detergent actually spent more money because the HE detergent was more expensive per load than conventional detergents.

5.12.1 Assessment of the Literature

Detergent usage for energy-efficient dishwashers has not been addressed in the NEI literature. It is unclear whether detergent usage associated with energy-efficient dishwashers differs from that of non-energy-efficient dishwashers. Determining the financial impact to participants from a difference in detergent use requires determining not only the recommended detergent dosages and associated costs for both ENERGY STAR and non-ENERGY STAR dishwashers, but also determining the extent to which participants actually follow the recommended detergent dosages.

5.12.2 Relevant PA Programs

Dishwasher detergent usage is relevant to the RNC programs that install dishwashers.

5.12.3 Recommendation

Due to the lack of information in the literature, it is unclear whether detergent usage differs between ENERGY STAR and non-ENERGY STAR dishwashers, and if it does, how significant the NEI of detergent usage associated with ENERGY STAR dishwashers might be. Furthermore, because the only PA program promoting the installation of ENERGY STAR dishwashers is the residential new construction program, the baseline comparison for detergent usage would be a new, non-ENERGY STAR dishwasher. While the difference in detergent requirements between an older unit and a new ENERGY STAR dishwasher may be significant enough to warrant investigation, it is unlikely that the difference in detergent usage between a new, non-ENERGY STAR dishwasher and a new ENERGY STAR dishwasher would warrant the cost of investigation. NMR does not recommend quantifying the NEI of dishwasher detergent at this time.

5.13 REDUCED WATER USAGE AND SEWER COSTS (LOW FLOW SHOWERHEADS AND FAUCET AERATORS)

Domestic hot water (DHW) measures such as low flow showerheads and faucet aerators reduce the amount of water that flows through showerheads and faucets. Therefore, in addition to the energy savings derived from DHW measures, participants can benefit from a decrease in their water and sewer bills. A straightforward engineering algorithm can be used to estimate the value of the NEI of water and sewer bill savings from low flow showerheads and faucet aerators. The requisite variables for quantifying the annual NEI value for low flow showerheads include the pre- and post-retrofit showerhead flow rates, the amount of time the shower is in use per year, and the costs of water and sewer. Similarly, the variables required to quantify the annual NEI value for faucet aerators are the pre- and post-retrofit faucet flow rates, the amount of time the faucet is in use per year, and water and sewer costs. It is important to note that for filling applications, such as filling bathtubs for bathing or pots to cook with, a fixed quantity of water is required and therefore no post-retrofit water bill savings will be achieved.

Skumatz and Dickerson (1997 and 1999)

Earlier estimates of the participant-perspective NEI of water savings from DHW measures are provided by Skumatz and Dickerson (1997 and 1999). Skumatz and Dickerson (1997) estimated a range of $8.00-$110.00 per year in water and sewer bill savings per household from showerhead and faucet aerator retrofits based on the low-income Venture Partners Pilot (VPP) Program in California. The VPP estimate was based on estimates of reduced water use from showerheads and faucet aerators, the number of showerheads and aerators installed per dwelling, and water and sewer rates for San Francisco and San Jose, CA. The authors noted that the wide range they presented for the value of this NEI illustrates its potential variability given alternative assumptions, and the that the high end of the range reflects the fact that local water rates can vary by a factor of ten across the nation. A different low-income weatherization program in California evaluated by Skumatz and Dickerson (1999) yielded a smaller benefit range of $4.22-$57.97.

Riggert et al. (1999)

The evaluation of the energy and non-energy impacts of Vermont's Weatherization Assistance Program derived a water and sewer savings benefit of $10 per participant per year based on the estimates developed by the evaluation of the VPP program (Riggert et al., 1999).

TecMarket Works, SERA, and Megdal Associates (2001)

An annual NEI value of $11.67 per household in water cost savings from low flow showerheads and faucet aerators was estimated in the 2001 California LIPPT report (TecMarket Works, SERA, and Megdal Associates, 2001). This NEI value was based on estimates of the annual water savings per showerhead and faucet aerator, the number of showerheads and faucet aerators installed, and the cost of water. Estimates of the quantity of water saved per showerhead and faucet aerator were obtained from water conservation and utility literature. The information used to estimate the cost of water per unit was gathered via surveys of California water utilities. In addition to water rates, the authors collected information on wastewater rates and discussed the potential for wastewater rates to be included in the estimation of this NEI. However, wastewater savings associated with water-saving measures were excluded from the LIPPT NEI estimate due to the fact that many wastewater utilities in California charge fixed rates that do not vary with consumption. Results from survey information collected to determine net water savings from installed faucet aerators and low flow showerheads indicated that these measures are left in place an average of three years. Therefore, the assumed benefit period for the NEI of water cost savings from low flow showerheads and faucet aerators in the LIPPT report is three years.

Skumatz and Nordeen (2002)

A 2002 report evaluating the NEIs associated with the Connecticut WRAP program reported an annual NEI value of $13.38 per household in water and sewer bill savings from low flow showerheads and faucet aerators (Skumatz and Nordeen, 2002). The quantity of water saved per DHW measure was derived from past research by the evaluators. A cost of $0.0051 per gallon of water and an assumed benefit horizon of 6 years were used to estimate this NEI value.

Skumatz and Gardner (2005)

Two separate NEI values were estimated for reduced water bill costs resulting from DHW measures installed in the Wisconsin low-income WAP: one via an engineering estimate and the other via a participant survey (Skumatz and Gardner, 2005). An annual NEI value of $4.89 per household was estimated via an engineering estimate assuming a water cost of $1.71 per hundred cubic feet ($0.0023 per gallon) derived from a survey of 10 indicator communities within the state. In addition, an NEI value range of $8-$10 per household per year was estimated for the same program via the relative verbal scaling method from a survey of program participants.

Skumatz, Khawaja, and Krop (2010)

In a recent review of the literature, Skumatz, Khawaja, and Krop (2010) reported a range of $5-$12 per household per year for water bill savings. These authors pointed out that water saved per measure is reliable and well-known, but that behavioral impacts can affect savings estimates as some studies have revealed behavior changes such as participants taking longer showers following the installation of low flow showerheads.

Algorithms and assumptions for estimating the quantity of water saved from faucet aerators and low flow showerheads were investigated in two recent residential program evaluations in Connecticut.

Nexant (2010)

The 2008 Home Energy Solutions (HES) program evaluation recommended applying water usage metrics from industry-accepted sources such as the 1999 American Water Works Association (AWWA) study which lists per capita water usage for faucets and showers based on water end use data collected from a sample of American households (Nexant, 2010). Onsite visits conducted at a sample of HES participant households provide examples of behavioral impacts on water savings estimates. Of the 41 homes visited, two participants reported rejecting installation of low flow showerheads or faucet aerators due to preference in maintaining current flow levels. Of the 22 participants within the sample who agreed to install low flow showerheads and faucet aerators, two quickly removed the low flow equipment, two reported taking longer showers, and one stated that more effort was required to hand-wash dishes.

KEMA (2010)

For the second recent evaluation, on-site visits were conducted for the 2007-2008 evaluation of the low-income Helps and Weatherization Assistance Partnership (WRAP) Programs at a sample of low-income participating Connecticut households (KEMA, 2010). Auditors collected data such as the flow rate of installed DHW measures, the average number of showers per day, and the duration per shower in minutes. The Connecticut WRAP report recommended assuming 1.6 minutes per faucet per day for estimating faucet aerator water savings, and 2.9 showers per day per household at 12.2 minutes per shower (or 35.4 minutes per day) for estimating showerhead water savings. Additionally, the report recommended assuming 2.5 gallons per minute (GPM) as the baseline for low flow showerhead savings. In order to adjust faucet aerator water savings for the number of faucet aerators installed, the algorithm recommended for estimating water savings per household involves multiplying estimated annual gallons of water saved per household by the square root of the number of faucet aerators installed at each household.[106] Similarly, the algorithm recommended for estimating shower head water savings per household multiplies the estimated gallons of water saved per household by the square root of the number of low flow showerheads installed at each household. The square root expression in the algorithms accounts for the fact that a second unit would not save as much as a first, a third unit would not save as much as a second unit, and so on.

5.13.1 Assessment of the Literature

The value to participants of reduced water usage can be calculated using a straightforward engineering calculation. NEI valuations in the literature for reduced water usage from low flow showerheads and faucet aerators have been estimated via this method. Behavioral impacts that may reduce water savings estimates have been documented, but are not well-studied and have not been incorporated into the NEI valuations. Because participant water and sewer rates are a component in the formula, the value of this NEI is sensitive to local rates and pricing structures.

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[106] This adjustment assumes that the first faucet aerator is installed in the most commonly used faucet while subsequent aerators are installed on less commonly used faucets, resulting in fewer gallons saved per year because of lower usage.

5.13.2 Relevant PA Programs

The non-energy benefit of water bill savings from low flow showerheads and faucet aerators applies to PA programs which install low flow showerheads and faucet aerators, including the Multi-Family Retrofit, Low-Income Multi-Family Retrofit, Low-Income 1-4 Family Retrofit, and Mass Save programs.

5.13.3 Recommendations

Based on our review of the literature, NMR recommends quantifying the annual participant benefit of water and sewer bill savings from low flow showerheads and faucet aerators as follows:

a. Low Flow Showerheads

- (3696 gallons water saved per low flow showerhead per year (KEMA, 2010)) * square root of the average number of showerheads installed per site (PA data) * [$0.0036 (average cost of water per gallon in Massachusetts reported in Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan) + $0.0050 (average cost of sewerage per gallon in Massachusetts reported in Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan)]

b. Faucet Aerators

- (332 gallons water saved per faucet aerator per year (KEMA, 2010)) * square root of the average number of faucet aerator installed per site (PA data) * [$0.0036 (average cost of water per gallon in Massachusetts reported in Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan) + $0.0050 (average cost of sewerage per gallon in Massachusetts reported in Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan)]

If PA data on pre- and post-retrofit flow rates and the number of units installed at each site are available, then the recommendations for quantifying participant water and sewer bill savings are as follows:

c. Low Flow Showerheads

- ($GPM_{baseline}$(PA data) – $GPM_{retrofit}$(PA data)) * 35.4 minutes per day * 365 days per year * √number of showerheads installed at site (PA data) * [$0.0036 (average cost of water per gallon in Massachusetts reported in Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan) + $0.0050 (average cost of sewerage per gallon in Massachusetts reported in Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan)]

d. Faucet Aerators

($GPM_{baseline}$(PA data) – $GPM_{retrofit}$(PA data)) * 1.6 minutes per day * 365 days per year * √number of faucet aerators installed at site (PA data) * [$0.0036 (average cost of water per gallon in Massachusetts reported in Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan) + $0.0050 (average cost of sewerage per gallon in Massachusetts reported in Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan)]

Where:

- GPMbaseline = pre-retrofit flow rate in gallons per minute
- GPMretrofit = post-retrofit flow rate in gallons per minute

5.14 MORE DURABLE HOME AND EQUIPMENT AND APPLIANCE MAINTENANCE REQUIREMENTS

Home durability and maintenance requirements for heating and cooling equipment and appliances have generally been examined concurrently in the NEI literature. Homes built with better-quality heating, cooling, and structural materials are potentially more durable, therefore requiring less maintenance. To the extent that energy efficiency programs install better quality heating, cooling, and structural materials than what existed previously (in the case of retrofits) or what would have existed otherwise (in the case of new construction), they provide value to participants in the form of avoided maintenance costs and transaction costs. Similarly, energy efficiency programs that replace old equipment and appliances with new, energy efficiency equipment and appliances can provide value to participants in the form of avoided maintenance and transaction costs. New equipment and appliances generally require less maintenance than older ones. In addition, some energy-efficient technologies, such as CFLs, inherently require less maintenance than other technologies.

While it is possible that energy-efficient measures installed through retrofit programs may require less maintenance because they are new, it is not necessarily true that new energy-efficient measures require less maintenance than comparable, less efficient new measures.[107] In fact, instances of negative participant experiences with the maintenance of energy-efficient technologies have been documented in the NEI literature (Stoecklein and Skumatz, 2007). While decreased home maintenance requirements have been suggested multiple times in the literature as a potential participant NEI, few studies have actually estimated its value.

Barkett et al. (2006)

One study that did examine participant valuation of this NEI is the 2006 Non-Energy Impact Evaluation for the NY ENERGY STAR Labeled Homes program (Barkett et al., 2006). A survey of both participants and a comparison group found that 42% of program participants believed that their new ENERGY STAR-labeled home was more durable than their old home. Over 30% of all respondents reported that they did not know whether the new home was more durable than the old one. Those who reported either a positive or negative impact were asked to express the value of the NEI relative to the energy savings. On average, that subset of participants valued durability at around 15% of energy savings. Conjoint analysis questions asked at the end of the survey revealed that respondents placed a high value on home durability; they were willing to pay a premium of $5,648 in the upfront cost of the home to have a home that is “built following best practices in installation, so that the heating and cooling and structural materials are less prone to failure and may exceed their expected lifetimes.” The value of $5,648 was translated into an annual NEI value of $202 by dividing by an assumed measure lifetime of 28 years (Barkett et al., 2006). Sixty-four respondents completed the survey, but only 12 could be identified as program participants, due to a data recording error.

Fuchs et al. (2004)

In addition, several studies have attempted to value the NEI of decreased maintenance requirements associated with equipment and appliances installed through energy efficiency programs. For example, surveys conducted for the New York Energy $mart programs examined participant valuation of the equipment maintenance costs associated with ENERGY STAR appliances, including refrigerators, dishwashers, clothes washers, room air conditioners, CFLs, and lighting fixtures (Fuchs et al., 2004). A relative valuation method was employed, in which respondents were asked if the appliance had a positive impact, negative impact, or no impact with regard to each of 13 NEIs, one of which was “equipment

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[107] It is also possible that high-efficiency heating and cooling equipment may have higher maintenance costs because high-efficiency furnaces needed more “work out time” to adjust safety controls and settings properly. In an evaluation of high-efficiency heating and cooling equipment in Vermont, one contractor described the safety and limit controls as ‘finicky.’ Other respondents reported that high-efficiency furnaces and boilers have higher maintenance costs because more parts and controls fail, and these parts are often more complex and expensive than standard-efficiency boilers and furnaces (NMR, 2009).

maintenance costs." When respondents indicated that there was an impact (positive or negative), they were then asked for the relative value of the impact. Survey results show that respondents valued the NEI of equipment maintenance costs at 9% of total NEIs for ENERGY STAR refrigerators, 5% of total NEIs for dishwashers, 6% of total NEIs for room air conditioners, 8% of total NEIs for CFLs, and 6% of total NEIs for lighting fixtures. Monetized NEI values were not presented in this report.

Skumatz and Gardner (2005)

Another study that investigated the NEI of equipment and appliance maintenance is the 2005 evaluation of Wisconsin's low-income weatherization assistance program (Skumatz and Gardner, 2005). The most commonly installed equipment/appliances through the program were CFLs, CO detectors, and smoke detectors. At least 50% of participants received these measures. In addition, 42% of participants received new refrigerators and 37% of participants received new heating systems. The participant survey for this study revealed that 28% of respondents reported a positive change in "reliability/amount have had to maintain new equipment," 71% reported no change, and 1% reported a negative change. Using a relative verbal scaling method comparing the NEI value to energy bill savings, an NEI value range of $19-$24 was estimated per participant per year for the Wisconsin low-income WAP[108].

5.14.1 Assessment of the Literature

Only one study in the literature attempted to quantify the value of durability to participants. The survey sample in this study contained people who had purchased a new home (both ENERGY STAR and non-ENERGY STAR) within the past year (Barkett et al., 2006). The energy efficiency measures employed through the program, however, had an estimated 28-year lifetime. Therefore, the respondents had relatively little experience with which to compare the maintenance requirements of their new homes with their old ones. Additionally, the study did not collect information regarding the durability of the homes in which respondents lived previously, which was the baseline comparison for durability.

Participant valuations of non-energy benefits associated with equipment and appliance maintenance have been investigated for low-income weatherization, ENERGY STAR appliance programs, and new homes, via the relative valuation survey method. Both positive and negative relative valuations have been produced by this method, but only one study translated these relative valuations into monetized values. In addition, it seems that respondent estimations of required maintenance should be interpreted with caution, due to the likely time lag between the installation of the equipment and need for maintenance and upkeep of the equipment. If a participant is surveyed too soon after installation, then he or she will likely not have had enough experience maintaining the new equipment or appliance to provide an accurate response. Further complication arises when a given participant has received multiple measures and each of those measures requires maintenance at different intervals. Participant surveys described in the NEI literature have generally been conducted within the first few years of program implementation.

Applying maintenance NEI values quantified in different studies to the PAs' programs is problematic for several reasons. First, not all participants surveyed experienced a change in equipment maintenance requirements; therefore, the relative values reported are based on relatively few participants. Additionally, in the evaluations reviewed, programs have installed different types of equipment and appliances in different proportions across participants. For programs that have employed multiple measures, participant valuation of reduced maintenance requirements has not always been obtained on a per measure basis, but for the total measures received by a given respondent. Therefore, it is unclear what portion of the participant's stated valuation was attributed to each measure. For at least one study, participants were asked to value the maintenance NEI associated with all program measures, and not just equipment and appliances. Therefore, the maintenance NEI values from this study potentially overlap with "durability of the home."

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108 Equipment maintenance has also been examined in zero and low energy homes in New Zealand (see Appendix A for a summary of the study)

5.14.2 Relevant PA Programs

The NEI of a more durable home requiring less maintenance is applicable to the PAs' programs that install weatherization measures, shell measures, and heating and cooling equipment, including the PAs' low income-retrofit programs, low-income new construction programs, residential cooling and heating programs, residential heating and hot water programs, and non-low-income retrofit programs (i.e., Mass Save, multi-family retrofit programs).

Reduced equipment and appliance maintenance requirements is applicable to retrofit programs where new equipment and appliances replace old ones (and these replacements would not have taken place without the program), and to new construction programs employing energy-efficient technologies that inherently require less maintenance than less efficient technologies. These include the PAs' low income-retrofit programs, low-income new construction programs, residential cooling and heating programs, residential heating and hot water programs, and non-low-income retrofit programs (i.e., Mass Save, multi-family retrofit programs).

5.14.3 Recommendations

a. More Durable Home

Based on the surveys of program participants, NMR recommends an annual value of $49 for NLI participants and $35 for LI participants who installed shell and weatherization measures or heating and cooling equipment.

b. Equipment and Appliance Maintenance

Based on the surveys of program participants, NMR recommends an annual, per participant value of $124 for NLI participants and $54 for LI participants who installed heating and cooling equipment.

5.15 REDUCING ENERGY EXPENSES, MAKING MORE MONEY AVAILABLE FOR OTHER USES, SUCH AS HEALTH CARE

Low-income households spend a disproportionate amount of their income on energy costs, when compared to the population at large and to wealthier households. For example, low-income families spend approximately 17% of their income on energy costs, compared to higher income households, who spend 8% of their income on energy costs (Child Health Impact Working Group, 2007). Energy efficiency programs can reduce energy costs and therefore allow participating households to spend more money on food, healthcare, or other household needs. However, because the energy savings from these programs are already accounted for by the PAs in the AESC study and the TRC calculations, to count additional benefits from these energy savings would amount to double counting. This is not to say that low-income households do not benefit from reduced energy burdens, but rather that the benefits are already accounted for. For a more detailed discussion of the benefits from a reduced energy burden, see Appendix C.

5.15.1 Assessment of the NEI Literature

While reducing energy expenses has been linked to health benefits, energy savings from the programs are already counted as a benefit by the PAs in the AESC study and the TRC calculations. Counting additional benefits experienced by participants from these energy savings would amount to double counting.

5.15.2 Recommendations

Because energy savings from the programs are already accounted for by the PAs in the AESC study and the TRC calculations, NMR does not recommend counting participant benefits that derive from reduced energy costs. However, health improvements associated with improved home environments are considered below (section 5.16) and societal benefits such as reduced hospitalizations and health care costs should be considered and are discussed in section 6.4. Improved Health. [109]

5.16 HEALTH-RELATED NEIS – FEWER COLDS AND VIRUSES, IMPROVED INDOOR AIR QUALITY, EASE OF MAINTAINING HEALTHY RELATIVE HUMIDITY

Energy efficiency programs may have direct impacts on health through improved home environments, reduced exposure to hypothermia or hyperthermia—particularly during heat waves and cold spells—improved indoor air quality, and potential reductions in moisture and mold, leading to amelioration of asthma triggers and other respiratory ailments. The health-related non-energy impacts of energy efficiency programs have traditionally been difficult to estimate, in large part because of the lack of research directly examining these impacts, and because of the difficulty in isolating the impacts of the programs from other, potentially confounding, factors. [110]

Research has noted that, in cold climates, the number of deaths during winter months exceeds the number of deaths at other times of the year, known as "excess winter mortality." Cold weather deaths have been linked to cold indoor temperatures, often attributed to poorly insulated homes (Liddell, 2009). Cold-related deaths are most often associated with changes in blood pressure and blood chemistry, which increase the risk of strokes, heart attacks and other ailments. Cold temperatures are also linked to suppressed immune systems, increasing the risk of infections, and potentially linked to mental health. [111] In addition, other studies have suggested that exposure to cold, damp living conditions in infancy and childhood may affect longer-term health (Liddell, 2009).

Adverse health outcomes are also associated with excessive hot and cold weather, with increased prevalence of deaths and hospitalizations on excessively hot and cold days (Knowlton et al., 2009; O'Neil et al., 2005; Ostro et al., 2010; Snyder and Baker, 2010). Nationwide, studies have estimated that there are 1,700 to 1,800 heat-related deaths annually (Snyder and Baker, 2010). In addition, heat waves are associated with increased risks of hospitalizations for multiple diseases, including cardiovascular disease, respiratory disease, pneumonia and heat stroke (Ostro et al., 2010).

Asthma, a national public health concern, given the approximately 22 million cases of asthma in the United States, is also associated with housing-related factors (Mudarri and Fisk, 2007). Asthma attacks can be triggered by certain housing conditions, including presence of moisture and mold, pests (i.e., cockroaches and rodents), dust allergens, and particulate matter (Tohn, 2006; McCormack et al., 2009). Asthma is the most common chronic childhood disease and is one of the leading causes of missed school days, missed work days, emergency room visits, and hospitalizations (Tohn, 2006). In addition, asthma rates are higher among low-income populations than among other income groups (Stillman and Adams, 2010; Tohn, 2006). Of the 22 million cases of asthma, approximately 4.6 million are attributable to dampness and mold exposure in the home, at a cost of approximately $3.5 billion annually (Mudarri and Fisk, 2007). In general, building dampness and mold are associated with a 30% to 50% increase in a number of respiratory and asthma-related health problems, including upper respiratory tract ailments, coughing and wheezing, and asthma (Fisk et al., 2007; Institute of Medicine, 2004). A study of the Maine

[109] If energy bill savings are not counted, we recommend that bill savings be counted rather than counting the benefits that derive from bill savings.

[110] In addition to the potential health impacts documented in the literature review, all of the health and safety experts interviewed (n=4) and all of the social service providers interviewed (n=3) believe that energy efficiency programs have positive health impacts on program participants.

[111] Two health experts and one social service provider identified amelioration of mental illness and reduced stress as possible health benefits.

State Housing Authority's weatherization program found high rates of asthma among participating households. It also found that a home with moisture and mold issues was more than three times as likely to include a resident with asthma, as a home without moisture and mold problems (Tohn, 2006).[112]

In addition to potential health benefits, two of the health experts interviewed for this project cautioned that energy efficiency programs may have negative health impacts, due to buildings become "too tight," leading to declining indoor air quality. This is particularly the case if a pollutant source, such as mold or pests, is not removed, so that exposure levels are in effect increased by reducing air infiltration, due to changes in the home made by the efficiency program. However, the studies examined in this literature review did not document any declines in health due to energy efficiency programs.

A number of recent studies in Europe and New Zealand have found associations of weatherization and other energy efficiency retrofits with improved health. A study in New Zealand examined the impacts of insulation and heating system retrofit program. The study included random assignment of families to experimental and control conditions. Study households were at particularly high risk, as study participants lived in uninsulated homes and included at least one household member diagnosed with respiratory illnesses. The study found that participants self-reported improved overall health, fewer incidents of wheezing over the past three months, fewer missed days of school and work, and fewer visits to their doctors after their homes had insulation and new heating systems installed (Howden-Chapmen et al., 2007, Liddell, 2009). The same study found improvements in the mental health of participants, though the authors emphasize that program participants were at clinical risk before intervention, so findings may not be broadly applicable to the population at large (Liddell, 2009).

Another study in New Zealand examined the impacts of installing energy-efficient and healthy heating systems into homes with basic insulation and poor heating systems (either un-flued natural gas or plug-in electric systems). Each household included a child diagnosed with asthma. Using a randomized design, the study found that the program significantly reduced symptoms of asthma, missed days from school, and visits to doctors and pharmacists, accompanied by fewer reports of poor health, sleep disturbed by wheezing, dry cough at night and lower respiratory tract symptoms. However, there were no differences in lung function between the participating and control households. Participating households were warmer than before the retrofit and recorded lower levels of nitrogen dioxide. The results provide evidence of a link between higher indoor air temperature on one hand, and reduced levels of nitrogen dioxide and reduced symptoms of asthma on the other (Howden-Chapmen et al., 2008; Preval et al., 2010). However, because of the very specialized nature of the study population (i.e., un-flued natural gas furnaces or plug-in electric heaters and presence of a child with asthma), it is not clear how applicable these findings are to the general population and more generalized weatherization and energy efficiency programs.[113] Further, it is difficult to differentiate the impact of the increase in housing temperature from the impact of reduced indoor air pollutants on health outcomes.

A study of heating and insulation retrofits in the United Kingdom (UK Fuel Poverty Strategy) included both longitudinal and cross-sectional research design elements. It examined the health impacts of the retrofits from 2001 to 2003. The study found that program participants who, after the retrofits, increased their indoor air temperature to temperatures recommended by the World Health Organization (WHO) (69.8°F for living rooms and 64.4°F for all other rooms) increased their life expectancy by ten days for men and seven days for women, compared to those who did not increase the temperature of their homes. In addition, the study found mental health improvements, with reductions in anxiety and depression among program participants. The research suggests that for every 10,000 retrofitted homes, 3,000 participants will show improvements in measures of anxiety or depression (Liddell, 2009).

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[112] Pre- and post-program participation data and data comparing participating to non-participating households were not available for asthma rates and incidences of moisture and mold issue.

[113] The authors note that they are examining potential health impacts on other household members (Howden-Chapmen et al., 2008).

The United Kingdom's National Center for Social Research (NATCEN) conducted a longitudinal study from 2001 to 2005, examining the association between housing conditions and the well being of English children. The study found long-term negative effects for children living in homes considered cold and damp. Children living in homes considered cold and damp for at least three years were more likely to have respiratory problems than children who had never lived in homes considered cold and damp (15% of children, compared to 6% of children) (Liddell, 2009). The same study found that homes that lacked affordable heat were associated with "multiple mental health risk" for adolescents and children living in those homes, but it is difficult to isolate the impact of unaffordable heating from other contributing factors (Liddell, 2009).

A study of the Scottish Central Heating Programme (CHP) compared 1,281 retrofitted households (two years after the retrofits) with 1,084 households on the CHP waiting list. The study found more limited impacts on health than the UK Fuel Poverty study, but still found that participants had significantly better self-reported health outcomes on four of 22 possible health outcomes (Liddell, 2009).

A study in Glasgow, Scotland, found that compared to a control population, homes upgraded from being cold, damp, and moldy to being warm, dry and mold-free resulted in improvements in blood pressure and general health, as well as reduced use of medications and hospitalizations and heating costs. However, it is not clear what portion of the health improvements were attributable to home temperatures or the reduction in mold (Lloyd, et al., 2008).

Studies of asthma in–home interventions suggest that weatherization programs may have some indirect benefits to asthmatics. Asthma in-home interventions generally include a number of elements, including education and outreach from nurses or public health workers, pest eradication, removal of carpets and visible mold, repairing water leaks and water intrusions, provision of bedding covers, provision of vacuums and cleaning supplies, providing social support, and improving ventilation. These interventions have been shown to reduce asthma symptoms, asthma triggers, and hospitalizations (Center for Managing Chronic Disease, 2007; Hoppin and Donahue, 2004; Takaro et al., 2004). Some research, in addition to traditional asthma interventions, has examined inclusion of heating and cooling repairs, finding that construction repairs that alleviated the root cause of moisture sources, combined with medical and behavioral interventions, reduced symptom days and health care use for asthmatic children living in homes with documented mold problems (Kercsmar et al., 2006).

While in-home interventions for asthma differ dramatically from energy efficiency programs, health and safety experts interviewed suggested that any programs, such as weatherization programs, that included repairs to water intrusions, would likely have health impacts related to asthma and other respiratory ailments. Further, Jacobs and Baeder (2009), in a review of the literature examining the effects of housing interventions on health, found that eliminating moisture intrusion and leaks, combined with the removal of mold and moldy items, reduced asthma triggers and exposure. Other research suggests that envelope sealing of homes may help to reduce particulate matter in the home, with potential benefits for respiratory ailments (Jacobs and Baeder, 2009).

Finally, recent research has begun to examine the association between the effects of air conditioning on hospitalizations and deaths related to excessive heat and heat waves. A study in California found that ownership and usage of air conditioning reduces the risks of hospitalizations during days of excessive heat. A 10% increase in air conditioning ownership resulted in reductions in excess risks of mortality for a number of diseases (Ostro et al., 2010). Similarly, a study of heat waves in Philadelphia, Chicago, and Cincinnati found people living in homes with central air conditioning were less likely to die than people living in homes without air conditioning (Snyder and Baker, 2010).

5.16.1 Evidence from the NEI evaluation literature

Health-related NEIs have rarely been included in the evaluation literature, and when they have been included, they have been measured by reductions in symptoms or lost days from work. They have not been linked to potential causal mechanisms such as increased temperature of the home during winter or reduced prevalence of mold spores or other indoor air pollutants.

TecMarket Works, SERA, and Megdal Associates (2001)

For example, the California LIPPT report estimated the value of health benefits of $3.78 by attributing reductions in self-reported sick days to weatherization programs (calculated as the number of reduced sick days multiplied by the minimum wage for a work day), but the LIPPT did not estimate values for reductions in lost days of school (TecMarket Works, SERA and Megdal Associates, 2001).

Skumatz and Dickerson (1997)

The evaluation of the VPP program estimated health benefits by assuming a reduction of four lost workdays due to reduced illnesses attributed to the weatherization program, plus the cost of one bottle of over-the-counter cold medicine (Skumatz and Dickerson, 1997).

Riggert et al. (1999)

The evaluation of the energy and non-energy impacts of Vermont's Weatherization Assistance Program derived a health benefit of $75 per participant per year, based on the estimates developed by the evaluation of the VPP program (Riggert et al., 1999).

Skumatz and Gardner (2005)

The evaluation of the Wisconsin WAP estimated health benefits through a relative valuation method, asking respondents to estimate the benefits of reductions in sick days, lost school days, visits to doctors, and frequency and intensity of various ailments, including asthma, headaches, and other ailments. Values for each ranged from $1 to $12 (Skumatz and Gardner, 2005). However, 90% of program participants reported no effect from the program on the health benefits.

NMR and Conant (2009)

The evaluation of the Massachusetts New Homes with ENERGY STAR program estimated the benefits of improved indoor air quality (IAQ) through a relative valuation method, using participant surveys. Participants estimated the value of improved IAQ at 32% of energy savings, or $126 per year (NMR and Conant, 2009).

Oppenheim and MacGregor (2002); Howat and Oppenheim (1999)

Other studies have estimated participant health benefits based on lost days of work (Oppenheim and MacGregor, 2002) or reduced public expenditures on health care (Howat and Oppenheim, 1999).

5.16.2 Assessment of the Literature

Health-related benefits to energy efficiency programs have been examined more extensively in Europe and New Zealand than in the United States. They have typically focused on programs targeting low-income households or households with particular health risks, such as asthma. These studies have found positive health impacts. Health effects appear to be linked to warmer indoor air temperatures in cold climates and reduced exposure to excessive heat in warmer climates, less indoor air moisture and other asthma triggers, and reductions in indoor air pollutants such as carbon monoxide. These improved housing conditions can be a result of energy efficiency measures and programs, such as insulating and weatherizing un-insulated or poorly insulated homes, repairing or replacing heating and air conditioning equipment. Health effects include fewer asthma attacks and symptoms, fewer sick days from work, fewer lost school days, fewer doctor and hospital visits, and fewer and less intense ailments more generally.

However, health benefits have not been monetized in the medical literature. Applying health impacts from these studies is problematic, for several reasons. Because of the targeted nature of some of the programs, the findings are not generalizable to the PAs' programs. Because of geographic and climatic differences, it is difficult to estimate program impacts from studies conducted in Europe and New Zealand.

Similarly, applying health impacts from the few studies in the evaluation literature is problematic, either because of climatic and geographic differences or because of the methods used to estimate the benefit.

5.16.3 Relevant PA Programs

The non-energy benefit of improved health applies to all PA programs that include shell measures or heating and cooling measures, especially low-income programs, including the PAs' low income-retrofit programs, low-income new construction programs, residential cooling and heating programs, residential heating and hot water programs, and non-low-income retrofit programs (i.e., Mass Save, multi-family retrofit programs).

5.16.4 Recommendations

Based on the surveys of program participants, NMR recommends an annual value of $4 for NLI participants and $19 for LI participants who installed shell and weatherization measures or heating and cooling equipment.

These findings are comparable to other estimates of health impacts reported in the NEI literature. For example, the California LIPPT estimated an annual health benefit of $3.98 based on survey data of reduced missed days from work (TecMarket Works, SERA and Megdal, 2001), while a $28 to $35 annual benefit was estimated in the 2005 WI low-income weatherization report, based on survey data using relative valuation of several, potentially overlapping, health benefits: missed days from work, fewer colds and viruses, fewer chronic conditions, less money spent on medicine, fewer headaches, fewer doctor's visits (Skumatz and Gardener, 2005).

We do not recommend deriving a value from the literature. The literature on the health impacts of energy efficiency programs is still limited. While there is literature suggesting potential impacts, in some cases it is extremely difficult to isolate the impacts of the programs from other, confounding factors, while in others it is difficult to generalize results based on a program that targets specialized populations.

Potential societal benefits such as reduced medical costs due to reductions in the incidence of symptoms or occurrences of specific health problems (such as asthma or other respiratory problems, heat stress and hypothermia) are discussed in section 6.4. Improved Health

In addition, health benefits are currently being examined by the evaluation of the national WAP, with some benefits being monetized (via reduced missed days from work), while others are not being monetized, such as reductions in incidence of symptoms such as asthma (Ternes et al., 2007). The report, which is expected to be released in 2011, could serve as a valuable addition to the literature on participant benefits.

We feel that further study examining the potential health impacts of the programs should be considered.

5.17 IMPROVED SAFETY (HEATING SYSTEM, VENTILATION, CARBON MONOXIDE, FIRES)

Reduced incidence of fire and carbon monoxide exposure are commonly identified as safety-related benefits resulting from weatherization programs in the NEI literature. Faulty heating equipment is among the common causes of residential fires (Insurance Information Institute, 1990 as cited in Brown et al., 1993). Additionally, low-income households that cannot afford to pay their heating bills, or have been terminated from service due to nonpayment, have been known to resort to alternative sources of home heating, which are more likely to cause fires and carbon monoxide poisoning. Similarly, households that have had electric service shut off and resort to candles for lighting are at an elevated risk of experiencing a fire. Weatherization programs often include measures that mitigate fire and CO exposure risks, such as heating system inspection, repair, and/or replacement, CO testing, and CO and fire detectors. The NEI value of reduced fires attributable to programs can be estimated, using data on the incidence and causes of residential fires and estimates of the avoided costs from fires, including loss of life, personal injury, and property loss. The value of reduced CO exposure has not been quantified as often as fire reduction in the NEI literature, but it could be quantified in a similar manner, for programs that provide CO testing and CO detectors, and to the extent that programs obviate the need for low-income households to resort to unconventional heat sources which emit CO in the home.

Brown et al. (1993)

The 1993 ORNL national WAP report identified fire prevention and carbon monoxide-related indoor air quality as safety-related benefits associated with the program (Brown et al., 1993). While a monetized NEI value was estimated in the report for program-induced avoided fire costs, the value of carbon monoxide mitigation was not estimated, due to insufficient data and incomplete understanding of the numerous interacting factors associated with weatherization and indoor air quality. During the 1989 program year for the national WAP, heating system repairs or safety improvements were made to 7% of weatherized homes, including fixing gas leaks and carbon monoxide problems, and repairing or replacing the following: thermocouples, thermostats, fan switches, furnace filters, gas valves, gas controls, lead detectors, and limit switches. Brown et al. (1993) noted that the measures installed through the national WAP reduce the costs of fires in several ways. First, safety measures, including fixing gas leaks, reduce the probability of fires. Additionally, cellulose insulation installed through the program tends to snuff out fires that occur in weatherized homes. Lastly, by making home heating bills more affordable, the program reduces the likelihood of participants resorting to the use of heat sources which have a greater fire risk, such as electric space heaters, wood burning stoves, kerosene heaters, extension cords from a neighbor's home, and illegal reconnections to power lines. Brown et al. (1993) estimated the value of avoided costs due to prevented deaths and property losses from fires to be $3.25 per weatherized dwelling. Although avoided fire-related injuries were identified as an NEI, in addition to fire-related deaths and property loss, the value of avoided fire-related injuries was excluded from the calculation, due to the difficulty in quantifying it and the anticipated low value of avoided injuries relative to the values of avoided deaths and property loss. The formula for estimating the value of avoided fire deaths used by Brown et al. (1993) included the following: the number of elderly and non-elderly occupants of weatherized dwellings, the expected rate of fire deaths each for elderly and non-elderly individuals (data has shown that the elderly are more likely to die in a residential fire than the non-elderly), the rate of 10% of fire deaths caused by residential heating equipment (Insurance Information Institute 1990; National Safety Council, 1989), and the average lifetime cost due to a fire death ($250,000 for the non-elderly and $24,000 for the elderly, taken from Statistical Abstract of the US, 1991). The avoided fire death component of the NEI value assumes that all potential fire deaths (attributable to residential heating equipment) are avoided by the program. The formula for estimating the value of avoided property loss due to fires includes an estimate of the rate at which low-income residential fires occur (assuming that low-income households are twice as likely to have a fire than the average US household), the rate of 21% of residential fires caused by heating systems (Insurance Information Institute, 1990), an estimate of the value of property loss due to a residential fire (assuming that the average property loss for low-income households is half that of the national average), and an assumed 25% reduction in fires due to the program. Carbon monoxide deaths and fires caused by alternative heating sources were not accounted for in the monetized NEI valuation.

Riggert et al, (1999)

The same estimation method employed by Brown et al. (1993) for the national WAP was used to estimate the NEI value of avoided fire deaths and property losses in the 1999 evaluation of Vermont's WAP (Riggert et al., 1999). However, the Vermont NEI value of $29.75 per weatherized home is much greater than the national WAP value of $3.25, due to the use of a different estimate of the value of a human life in the NEI valuation formula. Instead of the $250,000 per non-elderly person and $24,000 per elderly person assumed per avoided fire death in the national WAP estimation, a value of $4 million per avoided fire death taken from Ottinger (1990) was used in the Vermont estimation. Skumatz and Nordeen (2002) employed a similar estimation method as Brown et al. (1993) for the value of reduced fires associated with the Connecticut WRAP Program. Their value of $0.18 per participant was estimated based on the following: average property loss data from the Insurance Institute Fact Book (IIFB); an estimate of the percent of fires caused by equipment that might be fixed by the program (IIFB and program data); the percent of participants receiving health and safety equipment; an assumed percent of fires eliminated by the program based on the evaluator's judgment; and average loss of life and value of life estimates based on previous research by the author.

Blasnik (1997)

The value of the health and safety NEIs associated with the Ohio HWAP was based simply on the cost of health and safety measures employed by the program. The Ohio low-income HWAP included heating and water heating safety testing, repairing combustion equipment, and occasional safety-related replacements (Blasnik, 1997). The avoided use of alternative heating sources associated with service disconnection was also identified as a potential safety-related benefit from the program. Blasnik noted that the sample sizes and timeframes required to quantify the reduced frequency of fires and other rare, "high cost" events from the program were unavailable. Therefore, he proposed valuing the health and safety benefits of the program at the amount of money spent on health and safety measures. As cited in Riggert et al. (1999), the amount spent per home on measures associated with health and safety benefits for the 1994 Ohio HWAP was $317.

Barkett et al. (2006); NMR and Conant (2009); Skumatz and Gardner (2005)

Three recent studies have examined participant valuation of safety through the use of participant surveys. The first study is the 2006 Non-Energy Impact Evaluation for the NY ENERGY STAR Labeled Homes program. A survey comprising both participants and a comparison group found that 42% of program participants believed that their new ENERGY STAR labeled home was safer than their old home (Barkett et al., 2006).[114] Those respondents who reported either a positive or negative impact were asked to express the value of the NEI relative to the energy savings. On average, respondents valued the NEI of safety at about 35% of energy savings. Conjoint analysis questions asked at the end of the survey indicate that respondents were willing to pay a premium of $5,072 in the upfront cost of the home with a heating system that has backdraft protection (as opposed to one that has no backdraft protection), making it safer in terms of carbon monoxide levels. The value of $5,072 was translated into an annual NEI value of $181 by dividing by an assumed measure lifetime of 28 years (Barkett et al., 2006). Sixty-four respondents completed the survey, but only 12 could be identified as program participants, due to a data recording error. The second study in which safety was estimated via a participant survey is the 2008 Evaluation of Massachusetts New Homes with ENERGY STAR Program. Forty-six percent of respondents believed that their new ENERGY STAR homes provided more safety; out of all seven NEIs included in the survey, respondents were least likely to identify safety as an NEI associated with their new home (NMR and Conant, 2009). Via the relative valuation method, an annual NEI value of $105 (or 26% of bill savings) was reported for safety (n=63). Respondents valued the NEI of safety lower than the value of every other NEI included in the survey. The third study is the 2005 evaluation of Wisconsin's low-income weatherization assistance program. Using a relative verbal scaling method comparing the NEI value to energy bill savings, an NEI value range of $20-$26 was estimated per participant per year for the Wisconsin low-income WAP (Skumatz and Gardner, 2005).

Ternes et al. (2007)

Numerous safety-related impacts will be investigated in the upcoming evaluation of the national WAP. Some will be assigned monetized values, while others will not be monetized. A monetized value of reduction in fires will be calculated, based on the number of households weatherized, the average reduction in number of fires per weatherized household, and the average monetary loss in property, injury, and death per fire (Ternes et al., 2007). On a scale of low, medium, and high, Ternes et al. (2007) anticipate that the uncertainty involved in the average reduction in number of fires per household and the uncertainty in the average monetary loss per fire to be medium. CO levels will be measured before and after weatherization, but a monetized value to the change in CO levels resulting from the program will not be estimated. On the scale of low, medium, and high, the uncertainty regarding the change in CO levels in weatherized homes is expected to be high. In addition to fire and CO impacts, several other safety

[114] Approximately 40% of all respondents reported no change with regard to safety, and 18% reported "don't know" (Barkett et al., 2006).

impacts will be included in the evaluation. For example, the evaluators at ORNL plan to estimate monetized values of the reduction in emergency medical care for tripping and falling in the home, the reduction in emergency medical care for burns from scalding domestic hot water, and for the reduction in theft from break-ins in weatherized homes. Moreover, non-monetized measurements of asbestos and radon will be collected pre- and post-weatherization for the WAP evaluation. .

5.17.1 Assessment of the Literature

Four estimation methods have been employed in quantifying the value of improved safety resulting from energy efficiency programs in the NEI literature. One of the most commonly employed methods is an algorithm including estimates of residential fires caused by faulty heating equipment, the program-induced decrease in incidence of residential fires, the number of deaths per fire, and property loss per fire. Data on the frequency, causes, and monetary losses associated with residential fires that have been used in these algorithms have been obtained from reliable sources, including the US Census Bureau and various insurance and safety organizations. Estimates of the value of a life lost in a fire are open to interpretation and can vary dramatically, based on the estimation method. The estimates of the program-induced decrease in incidence of residential fires have not been based on any program data, but seem to have been subjectively selected. All of the programs for which the NEI value of improved safety was estimated via this method were low-income weatherization programs. Although avoided deaths and injuries (including CO poisoning) attributable to the use of dangerous alternative heating and lighting sources have been discussed in the literature as safety-related non-energy impacts, none of the NEI values produced by this method incorporates estimates of CO poisonings or fires started by alternative heating or lighting sources.

The second commonly employed estimation method that has been used to value the safety impacts of energy efficiency programs is the relative valuation survey method, which has been applied to new homes with ENERGY STAR program, an ENERGY STAR Labeled Homes program, and a low-income weatherization program. For the two non-low-income programs, the proportions of respondents reporting safety as an impact (46% and 42%) are similar. The monetized NEI value of safety estimated for the retrofit program is double the NEI value for the new construction program. The baseline for comparison for each of these surveys is quite different: “a similar, newly constructed non-ENERGY STAR home” for the new construction program and “the home in which you last lived” for the retrofit program. The NEI values estimated via relative valuation for the non-low-income programs are much higher than the values estimated for the low-income program. This difference may be explained in part due to the difference in expected annual energy savings from the programs (which is the basis for estimating the benefit); but it is also likely due to the fact that the value for the low-income program was scaled relative to total NEIs and the non-low-income program NEI values were not.

Two other estimation methods have been used to value the NEI of improved safety. One of those methods is to value the NEI of improved safety as the amount of money spent on health and safety measures per weatherized home. This estimation method was applied for a low-income weatherization program, combining health and safety NEIs into one value. The other estimation method that has been used is the conjoint analysis method. This method was applied to an ENERGY STAR Labeled Homes program in which safety was described to respondents as “a heating system with backdraft protection.”

5.17.2 Relevant PA Programs

The NEI of improved safety applies to programs that implement measures reducing the risk of fires and CO exposure. However, since unsafe heating and ventilation systems are more likely to be prevalent in low-income households, and low-income households are least able to resolve unsafe conditions, NMR recommends quantifying this NEI for the PAs’ low-income programs.

5.17.3 Recommendation

Based on our review of the literature, NMR recommends the following annual values, per installed heating system, based on the accompanying algorithms:

- Avoided fire deaths:$37.40
    - [(0.004 (Rate of fire deaths caused by residential heating equipment per 1,000 households, US)[115] * $9,100,000 (Value of lost life, US EPA)[116] * (Number of heating systems replaced & repaired by PA programs / 1,000)]
- Avoided fire-related injuries: $0.03
    - [(0.014 (Rate of fire injuries caused by residential heating equipment per 1,000 households, US) [117] * $7,421 (Value of medical costs for treating fires, CDC) [118] * (Number of heating systems replaced & repaired by PA programs / 1,000) * 0.25 (percentage of heating system related fire injuries avoided, Brown et al., 1993)]
- Avoided fire-related property damage: $1.24
    - [(0.566 (Rate of fires caused by residential heating equipment per 1,000 households, US) [119] * $17,483 (Average value of residential property loss) * (Number of heating systems replaced & repaired by PA programs / 1,000) * 0.25 (percentage of fires avoided, Brown et al., 1993))/ 2 (Brown et al., 1993)]
- Avoided deaths attributable to CO poisonings: $6.38
    - [(0.0007 (Rate of deaths attributable to CO poisonings due to residential heating equipment per 1,000 households, US) [120] * $9,100,000 (Value of lost life, US EPA) * (Number of heating systems replaced & repaired by PA programs / 1,000)]

The algorithms outlined above are similar to the one used by Brown et al. (1993) to estimate the value of improved safety attributable to the national WAP.

For the value of a loss of life, NMR recommends using the EPA's Value of a Statistical Life (VSL) of $9.1 million. [121] Brown et al. assumed that 25% of fires would be prevented by the national WAP, that 100% of fire deaths from such fires would be prevented, and that the dollar value of property loss damages to low-income households would be half that of the national average. While these assumptions were not based on a program impact analysis, we believe that they are reasonable. For avoided CO poisonings, NMR recommends following the national WAP standard for avoided fire deaths and assuming that 100% of CO poisonings attributable to heating systems are avoided. If, however, further precision is sought, then the recommendation is to conduct a pre/post impact analysis on the incidence of fires and fire deaths in participant homes.

Alternatively, upon completion of the national WAP evaluation in 2011, an estimate of safety from avoided fires could be derived from the national evaluation and applied to the PAs' low-income programs.

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115 Fire data provided by Hall (2010) and Karter (2010).

116 Sinha, Depro and Braun (2010).

117 Fire data provided by Hall (2010) and Karter (2010).

118 Medical cost data provided by CDC 2011.

119 Fire data provided by Hall (2010) and Karter (2010).

120 CO data provided by Hall (2010) and Karter (2010).

121 Sinha, Depro and Braun, 2010. http://www.epa.gov/ttn/atw/rice/rice_neshap_ria2-17-10.pdf

5.18 IMPROVED SAFETY (LIGHTING)

CFLs have longer lifetimes than traditional incandescent light bulbs and therefore do not need to be replaced as frequently. Individuals potentially face the risk of injury from falling, while attempting to change ceiling light bulbs. The reduction in this risk has been suggested as an NEI associated with efficient lighting (TecMarket Works, SERA, and Megdal Associates, 2001). It has also been suggested that the value of this NEI might be significant for the elderly, who are likely to sustain greater injuries from a fall.

5.18.1 Assessment of the Literature

Improved safety from reduced falls has been suggested as an NEI associated with CFLs, but the value of this NEI has not been estimated in the literature. Moreover, the literature does not contain any evidence of decreased rates of injuries associated with replacing light bulbs.

5.18.2 Relevant PA Programs

The NEI value of improved safety associated with lighting potentially applies to all PA programs that include CFLs.

5.18.3 Recommendation

Due to the lack of research on injuries associated with changing light bulbs, NMR does not recommend quantifying the value of this NEI, at this time.

5.19 HEAT (OR LACK THEREOF) GENERATED

Incandescent light bulbs convert approximately 10% of electricity to light, with the remaining 90% converted to heat. Energy-efficient CFLs and LEDs do not generate as much heat as traditional light bulbs do. Replacing heat-generating incandescent light bulbs with energy-efficient bulbs can impact the heating and cooling requirements of a participant’s home and should therefore be considered an energy impact, not a non-energy impact.

The 2006 Non-Energy Impacts Evaluation for New York Energy $mart programs sought to measure participant valuation of the lack of heat generated by CFLs (Barkett et al., 2006). A survey employing both relative valuation and conjoint analysis methods was completed by ten respondents who owned CFLs and 14 who did not. The relative value method in this survey did not produce a value for the NEI of “heat generated” while the conjoint analysis estimated an annual NEI value for “heat generated” of $0.92 per participant (n=21).

5.19.1 Recommendations

Because the lack of heat generated by CFLs compared to incandescent light bulbs is an energy-related impact, NMR does not recommend including this as an NEI.

5.20 WARM UP DELAY

CFLs can take a longer time to reach full light output than incandescent light bulbs. This warm-up delay can represent a negative non-energy impact to participants in energy-efficient lighting programs. Warm-up delay can be differentiated from turn-on delay (the amount of time it takes for a light to come on once the switch is turned), but it is unclear whether participants actually make this differentiation.

An estimated value of the non-energy impact arising from the warm up delay associated with CFLs is presented in the 2006 Non-Energy Impacts Evaluation for New York Energy $mart programs (Barkett et al., 2006). The annual value of $0.29 per participant was estimated via the conjoint analysis method. This value represents a negative impact, indicating how much respondents are willing to pay to go from a long warm up delay to a short delay. Therefore, this value should be subtracted from the sum of positive NEIs, in order to accurately reflect the total NEIs associated with energy-efficient lighting. Respondents who owned CFLs were asked if they had experienced a positive, zero, or negative impact with regards to warm up delay compared to incandescent light bulbs (n=10). About 36% of respondents reported no difference, 53% reported a negative impact, and the remainder answered “don’t know.” In this survey, warm-up delay was one of three attributes for which respondents reported negative NEIs; the other two attributes were turn-on delay and lighting quality. When asked to value the negative impact of warm-up delay relative to energy savings, those who indicated a negative impact reported a range of approximately 0%-15% of energy savings. The conjoint analysis question on which the monetized NEI value was based asked all respondents (n=21) to choose between two light bulb options with different prices. Participants were asked to choose between a light bulb that, when the switch is turned on, “the bulb provides full light output immediately,” or a bulb that “takes about 90 seconds to reach full light output.”

5.20.1 Assessment of the Literature

Only one study in the NEI literature examined participant valuation of the warm-up delay of CFLs compared to incandescent light bulbs. It is not clear that the respondents in this survey differentiated warm-up delay from turn-on delay. NMR does not believe that the NEI value produced by a small number of respondents to one study is reliable enough to extrapolate to all CFL users.

5.20.2 Relevant PA Programs

The NEI of warm-up delay potentially applies to all programs that implement CFLs.

5.20.3 Recommendations

Due to the lack of literature on participant valuation of the warm up delay associated with CFLs and its relatively small anticipated value, NMR does not recommend quantifying it at this time.

5.21 PRODUCT LIFETIME (HVAC EQUIPMENT, DOMESTIC HOT WATER EQUIPMENT, AND APPLIANCES)[122]

Products such as HVAC equipment, domestic hot water equipment, and appliances installed through energy efficiency retrofit programs are likely to have longer lifetimes than the remaining useful life of the products they replaced.[123] In addition to energy bill savings, participants may derive value from knowing that their new equipment will not need to be replaced for some time. In the case of new construction programs, where technological differences between energy-efficient and standard-efficiency HVAC equipment, domestic hot water equipment, and appliances result in a longer useful life of the energy-efficient versions, participants may derive value from knowing that they can put off the hassle and

[122] This report does not include a review of the NEI of avoided refrigerator replacement. Outside of the value currently included in the TRM, we found no instance of this benefit in the literature and we do not know the basis for claiming this value. It appears that the basis is program experience and assumptions: “Efficiency programs typically replace inefficient refrigerators where it is cost-effective to do so. Based on program experience, assumed five-year deferral was discounted at 20-year (life of measure) Treasury bond rate, minus inflation. Http://online.wsj.com/mdc/public/page/2_3020-treasury.html?mod=2_0031.” (Oppenheim and MacGregor, 2008). While we have not reviewed the study that this benefit was based on, the logic of the benefit is sound and the benefit seems reasonable.

[123] However, if the equipment replaced by a retrofit has reached its end-of-life, the more accurate comparison is between the lifetime of the new energy efficient equipment and new standard efficiency equipment.

expense of replacing their equipment longer than would have been possible had they chosen the standard-efficiency equipment.

Participant valuation of longer product lifetime has rarely been investigated in the NEI literature for residential programs. Where this NEI has been measured, a relative valuation survey method has been employed. For example, a survey conducted for the New York Energy $mart programs examined participant valuation of "appliance lifetime" associated with ENERGY STAR appliances, including refrigerators, dishwashers, clothes washers, and room air conditioners (Fuchs et al., 2004). The relative valuation method was employed in which respondents were asked if the appliance had a positive, negative, or no impact with regard to each of 13 NEIs. When respondents indicated that there was an impact (positive or negative), they were then asked for the relative value of the impact. Survey results show that respondents valued the NEI of appliance lifetime at 7% of total NEIs for ENERGY STAR refrigerators, 8% of total NEIs for dishwashers, 10% of total NEIs for ENERGY STAR clothes washers, and 8% of total NEIs for room air conditioners. Participant valuation of equipment lifetime was measured via the same method for a low-income multifamily retrofit program, and was found to be 3% of total NEIs (Myers and Skumatz, 2006). Monetized NEI values were not presented in either of the reports.

5.21.1 Assessment of the Literature

Participant valuation of longer lifetime has rarely been investigated in the NEI literature. Where this NEI has been assessed, it has been done so for ENERGY STAR appliances and a low-income multifamily retrofit program, via relative valuation participant surveys which reported appliance or equipment lifetime valuation relative to the total NEI value reported by participants. In order for the results from these surveys to produce reliable values, it is necessary for the participants to have some knowledge of the typical life of their equipment or appliance. However, past NEI studies on ENERGY STAR appliances, while showing that customers value the longer life of these appliances generally, have not provided participants with information on the actual expected lifetime (Violette et al., 2006). Therefore, for appliances and equipment with well-documented estimated useful lifetimes, an engineering estimate approach is a more appropriate estimation method for this NEI.

5.21.2 Relevant PA Programs

Product lifetime potentially applies to all PA programs that install HVAC equipment, domestic hot water equipment, and appliances that would not have been adopted in the absence of the program.

5.21.3 Recommendations

Due to the lack of literature on participant valuation of product lifetime, the relatively small value and potentially unreliable valuation found in the literature, NMR does not recommend applying values from the literature to the PAs' programs. And because of the expense and difficulty in providing an engineering estimate,[124] NMR does not recommend quantifying this NEI. Moreover, in cases of end-of-life equipment replacements, it is not clear that the efficient equipment has a longer lifetime or requires less maintenance than standard equipment. [125]

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[124] The NEI value of product lifetime can be positive, negative, or zero, depending on the whether the estimated useful life of energy efficient equipment installed through programs exceeds the estimated useful life of the equipment which would have been installed in the absence of the program. Financial savings are realized when expenses are pushed further into the future due to the time value of money. If a participant chooses equipment which has a longer useful lifetime than other equipment, the participant can delay the future expense of replacing the equipment at the end of its useful life. Therefore, the financial savings (or loss) derived from delaying (or advancing) the investment of replacing equipment represent the non-energy benefit of product lifetime.

[125] For example, high-efficiency heating and cooling equipment may have higher maintenance costs because high-efficiency furnaces needed more "work out time" to adjust safety controls and settings properly. In an evaluation of high-efficiency heating and cooling equipment in Vermont, one contractor described the safety and limit controls as 'finicky.' Other respondents reported that high-efficiency furnaces and boilers

5.22 AVAILABILITY OF HOT WATER

In addition to using less energy, tankless water heaters produce an endless supply of hot water. Never running out of hot water is a non-energy benefit to participants. Participant satisfaction with this feature of tankless water heaters was measured through a survey of 101 individuals who participated in a tankless water heater program in Massachusetts during 2005 and 2006. When asked to rate their level of satisfaction with the length of time they can use hot water without running out, nearly 90% of respondents reported being extremely satisfied with this aspect of their water heater (NMR, 2006). However, neither this report nor any other in the NEI literature attempted to quantify participant valuation of this NEI.

5.22.1 Assessment of the Literature

Availability of hot water is rarely discussed in the NEI literature. Participant valuation of this NEI does not appear to have ever been estimated before.

5.22.2 Relevant PA Programs

The non-energy benefit of endless hot water supply associated with tankless water heaters applies to PA programs which install tankless water heaters, including the residential new construction programs, residential water heating program, Mass Save, and the multifamily and one to four family programs.

5.22.3 Recommendation

Because there are no values in the literature for the NEI of availability of hot water, NMR does not recommend quantifying this NEI at this time.

5.23 PRODUCT PERFORMANCE

Appliances installed through energy efficiency programs may perform better than the appliances they replaced. For example, a participant may notice that his or her ENERGY STAR dishwasher cleans dishes better than the participant's old dishwasher, or that an ENERGY STAR room air conditioner circulates air more effectively through the room. It is not inherently true, however, that all new, energy-efficient appliances perform better in such ways than new, less efficient appliances. Furthermore, depending on the age of the appliance being replaced, it is likely that any new appliance, regardless of how energy efficient it is, will perform better than the old one.

Fuchs et al. (2004)

Participant valuation of appliance performance was examined for the New York Energy $mart programs (Fuchs et al., 2004). A relative valuation method was employed, in which respondents were asked if the appliance or lighting measure had a positive, negative, or no impact with regards to each of 13 NEIs, including "appliance performance." When respondents indicated that there was an impact (positive or negative), they were then asked for the relative value of the impact. Survey results show that, on average, respondents valued the NEI of appliance performance at 13% of total NEIs for ENERGY STAR refrigerators, 8% of total NEIs for dishwashers, 10% of total NEIs for room air conditioners, 10% of total NEIs for CFL bulbs, and 12% of total NEIs for lighting fixtures. Monetized NEI values were not presented in this report.

Skumatz and Gardner (2005)

have higher maintenance costs because more parts and controls fail, and these parts are often more complex and expensive than standard-efficiency boilers and furnaces (NMR, 2009).

Another study that investigated the NEI of product performance is the 2005 evaluation of Wisconsin's low-income weatherization assistance program (WAP) (Skumatz and Gardner, 2005). The most commonly installed measures through the program were CFLs, CO detectors, smoke detectors, attic insulation, and water pipe insulation; at least 50% of participants received these measures. In addition, 42% of participants received new refrigerators, 37% received new heating systems, and 45% received other heating system work. The participant survey for this study revealed that 21% of respondents reported a positive change in "equipment performance or features," 75% reported no change, and 4% reported a negative change. Using a relative verbal scaling method comparing the NEI value to energy bill savings, an NEI value range of $14-$18 was estimated per participant per year for the Wisconsin low-income WAP. This value reflects the cumulative value for equipment performance and features for all measures installed in the participant's home and is averaged across all participants.

5.23.1 Assessment of the Literature

Equipment and appliance performance has been investigated in the literature for several types of programs, via the relative valuation survey method. Often, the programs for which the NEI of performance has been estimated have included a mix of HVAC measures and appliances; therefore, it is unclear what portion of participant valuation of performance produced by these reports is due to which appliances or HVAC equipment. Additionally, surveys of participant valuation of performance have sometimes grouped performance and features together, which likely overlap for certain measures, but are arguably two distinct characteristics for other measures. Participant valuation of just "performance of appliances" has rarely been examined in the literature.

5.23.2 Relevant PA Programs

Product performance of appliances potentially applies to all PA programs that install appliances that would not have been adopted in the absence of the program.

5.23.3 Recommendation

NMR does not recommend quantifying the value of appliance performance due to the lack of research in the literature examining this NEI.

5.24 NEIS ASSOCIATED WITH LOW-INCOME ROOM AIR CONDITIONER REPLACEMENT

Quantec and SERA (2005)

According to the Massachusetts Statewide Technical Reference Manual, the PA's currently claim a $104 annual participant benefit including comfort, safety, and health effects for window AC replacement in Low-Income 1-4 Family Retrofit and Low-Income Multifamily Retrofit programs (Massachusetts Electric and Gas Energy Efficiency Program Administrators, 2010). The value of $104 per year was estimated in the evaluation of National Grid's 2003 Appliance Management Program (AMP), a pilot program that replaced inefficient air-conditioning units in low-income households (Quantec and SERA, 2005). In addition to an income eligibility requirement, the AMP program targeted participants who were typically home using their air-conditioning during peak hours (weekdays, 11 a.m. through 3 p.m.). Twenty-two homes in total received a new air conditioning unit through the program. NEI values were derived from two telephone surveys conducted for the evaluation: a pre-cooling season survey of 12 participants and 47 non-participants, and a post-cooling season survey of 12 participants and 60 non-participants. The survey found that participant homes had an average of 0.81 chronically ill or bedridden members per household, which the authors characterized as a "very high percentage." Respondents were asked to estimate the value of 11 individual NEIs derived from the efficient window air conditioning units via a relative valuation method, and were asked to specify the net impact from the efficient unit above and beyond the effect they would have realized from the installation of a standard efficiency unit. The 11 NEIs included in the survey were equipment maintenance, equipment performance, equipment lifetime, comfort, aesthetics, noise, safety, housing value, doing good for the environment, ability to pay energy and other bills, and health effects. The sum of each of these 11 NEIs is $104 – the NEI value that the PAs currently claim. The survey found that the most highly valued NEIs by participants were equipment performance ($14), comfort ($14), aesthetics ($13), and ability to pay energy and other bills ($13). Individual NEI valuations were scaled to respondents' estimation of total NEIs, which was estimated at $92-$122 via the willingness to pay method. An impact evaluation conducted for the AMP program estimated participant bill savings at about $8.50 per year. The average estimated annual savings reported by participants, however, was $120 per year – over ten times greater than the impact evaluation savings estimate. Valuation of the NEIs was calculated based on participants' perceived energy bill savings as opposed to the actual measured energy savings. The authors note that the NEI values derived from the participant survey would be approximately one-tenth as high if the actual, measured energy savings had been used instead.

5.24.1 Assessment of the Literature

The NEI values associated with low-income room air conditioner replacement reported in the evaluation of National Grid's 2003 Appliance Management Program were estimated via a relative valuation survey method, a commonly used technique for estimating the value of non-market goods and services. However, these values are likely inflated because they were calculated based on participants' perceptions of energy savings from the program (as opposed to actual energy savings), which were an order of magnitude greater than the actual energy savings. Additionally, it may not be appropriate to extrapolate the values derived from this report to all of the PAs' low-income customers, because the target population for the AMP program was restricted to low-income households in which members tended to be at home with the air conditioning on during peak usage hours. AMP participant households had an average of 0.81 chronically ill or bedridden members. Lastly, it is important to note that the value of $104 represents participant valuation of all 11 NEIs covered by the survey, and not just comfort, safety, and health effects – the three NEIs named in the TRM.

5.24.2 Relevant PA Programs

NEIs associated with low-income room air conditioner replacements apply to the PAs' Low-Income 1-4 Family Retrofit and Low-Income Multifamily Retrofit programs.

5.24.3 Recommendation

NMR recommends a value of $49.50 per low-income household that receives a room air conditioner replacement. We believe the NEI value of $104 is inflated for several reasons:

- NEIs were estimated based on perceived energy benefits which were over ten times greater than the impact evaluation savings estimate. The evaluators noted that the NEI values derived from the participant survey would be approximately one-tenth as high if the actual, measured energy savings had been used instead.
- The program targeted a specialized low-income population that may experience higher levels of NEIs than the general population of program participants who receive replacement window ACs.
- The total NEIs included NEIs that are accounted for elsewhere in this report (i.e., property value, doing good for the environment, and ability to pay).

To arrive at this estimate we first removed NEIs that are accounted for elsewhere in this report (i.e., aesthetics, property value, environmental benefits and ability to pay bills), leaving a value of $66 for the remaining NEIs. Next, we reduced the value of $66 by 25%, to adjust for the specialized population served by the program. The program targeted participants who were typically home using their air-conditioning during peak hours (weekdays, 11 a.m. through 3 p.m.). These participants may experience higher levels of NEIs than the general population of program participants who receive replacement window ACs.

5.25 ADDITIONAL PARTICIPANT NEIS FOUND IN THE LITERATURE

NMR's review of the literature found several participant-perspective NEIs in addition to the ones originally identified in the kick-off meeting. These additional NEIs have not often been quantified. They include the participant-perspective value of terminations and reconnections, bill-related calls, reduced transaction costs, and education. Although NMR does not recommend quantifying these additional NEIs, they are worth reviewing briefly.

5.25.1 Termination and Reconnection

Just as utilities incur costs associated with terminations and reconnections, participants incur costs when their service is terminated due to non-payment. Participant costs associated with service termination identified in the literature include the reconnection fee, the cost of borrowing money for the reconnection fee, participant time in arranging the reconnection, and the lost value of the dwelling, from it being uninhabitable for the duration of the service disconnection. Energy efficiency programs can reduce energy costs and therefore reduce the incidence of terminations and reconnections. However, because the energy savings from these programs are already counted by the PAs in the AESC study and the TRC calculations, to count additional benefits from these energy savings would amount to double counting. For a review of studies that have quantified participant benefits of reduced terminations and reconnections, see Appendix A.

a. Recommendation

Because energy savings from the programs are already counted as a benefit by the PAs, NMR does not recommend counting participant benefits that derive from reduced energy costs. .

5.25.2 Bill-related Calls

Just as the PAs incur costs associated with fielding or making bill-related calls to payment-troubled participants, participants incur the opportunity cost of time spent on the phone discussing bill-related issues with utilities. Since each party (participant and utility) spends time on a bill-related call, each incurs a cost. The value of time spent on bill-related calls by participants represents the value of the participant-perspective NEI of bill-related calls. This NEI has been assessed several times in the literature pertaining to low-income programs, based on the principle that, by making bills more affordable to participants and thereby reducing late or non-payment, participants will not need to call the utility as often regarding bill-related issues. However, as with terminations and reconnections, reductions in bill-related calls are realized because of energy savings from the programs. Because the energy savings from these programs are already counted by the PAs in the AESC study and the TRC calculations, to count additional benefits from these energy savings would amount to double counting. For a review of studies that have quantified participant benefits of reduced bill-related calls, see Appendix A.

a. Recommendations

Because energy savings from the programs are already counted as a benefit by the PAs, NMR does not recommend counting benefits that derive from reduced energy costs.[126]

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[126] If energy bill savings are not counted, we recommend that bill savings be counted rather than counting the benefits that derive from bill savings, as it would be much easier to count bill savings than the multiple benefits that derive from bill savings

5.25.3 Reduced Transaction Costs

Energy efficiency programs can help individuals avoid the transaction costs of weatherizing their homes on their own. These transaction costs include the time and effort spent learning about the energy efficiency opportunities in the home and locating the appropriate energy efficiency measures in the marketplace.

Skumatz and Dickerson (1999)

The participant NEI of reduced transaction costs was estimated to range from $0.00-$5.00 per participant for the VPP program and $0.00-$2.90 per participant for another low-income weatherization program in California (Skumatz and Dickerson, 1999). These estimates were based upon estimates by Feldman (1996) of participant transaction cost associated with programs, including CFLs. In order to derive the value ranges, the number of CFLs installed per household for each program was multiplied by Feldman's estimate of the transaction costs per bulb. The resulting product was then doubled, to account for the transaction costs associated with additional program measures beyond CFLs.

TecMarket Works, SERA, and Megdal Associates (2001)

Although a discussion of participant transaction costs was included in the 2001 LIPPT report, no monetized NEI value was computed there (TecMarket Works, SERA, and Megdal Associates, 2001). The estimation method outlined in the LIPPT report was the same method used to estimate the VPP and California weatherization program values, based on Feldman's 1996 work on CFLs. The RRM Working Group's Cost Effectiveness Subcommittee did not approve a monetized NEI value for transaction costs estimated in this manner for the LIPPT report.

Ternes et al. (2007)

In their upcoming evaluation of the national WAP, the evaluators at ORNL intend to include a monetized value of reduced participant transaction costs as a result of the program (Ternes et al., 2007). The proposed estimation method for this report is to multiply the average number of hours required to become familiar with energy-saving products per household by hourly minimum wage.

a. Assessment of the Literature

Participant valuation of reduced transaction costs has rarely been quantified. The few NEI values that have been quantified have been based on transaction cost estimates for CFLs only.

b. Relevant PA Programs

The participant NEI of avoided transaction costs potentially applies to any program that saves participants the time and effort of educating one's self about the energy efficiency opportunities in the home and locating the appropriate energy efficiency measures in the marketplace.

c. Recommendation

Due to the lack of research on participant valuation of avoided transaction costs, NMR does not recommend quantifying the value of this NEI at this time.

5.25.4 Education[127]

Education has sometimes been identified in the NEI literature as a participant benefit resulting from energy efficiency programs, although it has rarely been quantified. Two of the PA staff interviewed for this evaluation identified education as a non-energy impact associated with their programs. One interviewee pointed out that, regardless of whether they pursue any energy efficiency measures, homeowners benefit from the home energy audit because "they now have a much better understanding of how their house works." Another interviewee stated that the program taught customers what questions to ask when dealing with HVAC contractors.

Participant valuation of education from energy efficiency programs has rarely been quantified in the literature. The value of education is inherently difficult to measure. While education is often identified as a non-energy benefit in the literature, the type and amount of education provided to program participants varies widely amongst programs.

For programs that do not include an educational component over and above a basic introduction to energy efficiency and measures, this NEI potentially overlaps with the participant NEI of reduced transaction costs. Unlike the reduced transaction costs NEI, education is not recognized as its own NEI and will not be investigated for the upcoming evaluation of the national WAP (Ternes et al., 2007). A review of studies that have examined educational benefits of energy efficiency programs is available in Appendix A.

a. Recommendation

Due to the lack of research on participant valuation of education from energy efficiency programs, NMR does not recommend quantifying the value of this NEI at this time.

[127] The educational benefits reviewed in this section pertain to improved understanding of energy and energy efficiency. The literature on reduced energy burdens reviewed in Appendix C sometimes discusses educational benefits.

6. SOCIETAL-PERSPECTIVE NEIs—LITERATURE REVIEW

Society may realize a number of non-energy impacts (NEIs) from energy efficiency programs. NEIs from the societal perspective are indirect program effects not realized by utilities, ratepayers, or program participants, but rather accrue to society at large. There is a growing NEI literature on the effects of reducing greenhouse gas emissions and other air pollutants through energy efficiency measures, which may mitigate the effects of climate change or may reduce respiratory and other ailments, benefitting the whole of society.[128] Much of the latest NEI literature focuses on these societal NEIs, given the interest in climate change and associated national "green" objectives. Economic development benefits have also been widely studied and the positive impacts on employment, tax revenues, earnings and economic output due to energy efficiency programs has been well established (Skumatz, Khawaja, and Krop, 2010). These economic and environmental NEIs are not included in this review because the environmental benefits and economic development benefits have been counted in the PAs' three-year plans (National Grid et al., 2009; NSTAR et al., 2009).

Many of the remaining societal NEIs of interest to the PAs, non-economic and non-environmental, are sparsely reported and quantified from the societal perspective. For example, improved equity benefits for the low-income population have rarely been quantified in the NEI literature. Where equity benefits associated with low-income programs have been addressed in the literature, improving the economic status of the low-income participants is often the primary program goal. Therefore, these programs tend to emphasize program elements that are not part of the PA programs, such as education, counseling, financial assistance, and job training. Additional societal NEIs that have been addressed in the NEI literature include health, safety, infrastructure (water), national security, and indoor air/environmental quality (IAQ/IEQ) impacts. As expected, a more developed literature exists for economic impacts (job creation and economic development) and environmental impacts (emissions).[129]

In this section we provide a review of the societal-perspective NEIs found in the literature.

6.1 EQUITY AND HARDSHIP

Low-income program studies have often focused on 'hardship' related benefits. These benefits are often measured not monetarily, but via other metrics such as family development models and the Home Energy Insecurity Scale developed for the federal LIHEAP office. These include NEIs on family stability, mobility, and reduced dependence on social assistance. A recent national study on the energy cost burden to low-income households found that the average energy burden of low-income households is about twice that of the national average: 13.5% for LIHEAP eligible households versus 7% for all US households (Snyder and Baker, 2010). One method of quantifying the reduced societal disparity for the low-income population is to value this NEI as equal to the energy cost savings benefit of the program. One study finds that if the energy savings benefit over time of a given program is at least 75% of the total program costs, it is appropriate to apply an avoided cost adder of 75% to this equity NEI (Howat and Oppenheim 1999).

With respect to further hardship benefits (family stability, mobility, and reduced dependence on state benefits), few studies of low-income programs have attempted to monetize hardship NEIs.

[128] Two PA interviewees identified reduced GHG emissions as a societal NEI associated with their programs. Additionally, one of the health and safety experts interviewed identified reduced power plant emissions associated with the reduced energy use resulting from energy efficiency programs as a potential societal respiratory health benefit.

[129] Other societal benefits may exist, such as improved stability of neighborhoods, but to our knowledge the benefits have not been measured or quantified in the literature.

Khawaja (2001)

An evaluation of the Indiana REACH program, which provided energy assistance through LIHEAP and counseling, rather than implementing energy efficiency measures, found the program was successful in alleviating hardships and resulted in improvements in measures of social well-being. For example, program participants experienced the following improvements: an 18% reduction in school absences; 52% reduction in family moves; 9% increase in federal and state benefits per month; variable impacts on family debt; increase of 22% in total income; increase of 28% in total employment income; reduction of 12.5% in annual energy consumption expenditures; and a reduction of 28% in energy burden (Khawaja, 2001).

Drakos et al. (2008)

Another program that achieved reduced hardship and improved equity for low-income participants is the Oregon REACH program (Drakos et al., 2008). The Oregon REACH program employed a variety of program elements to achieve its goal of reducing the energy vulnerability of low-income families, including energy education, bill-payment assistance, family assessment, budget counseling, referral to other community services, solar hot water heating, and weatherization. Average income of program participants increased 4%, while employment scores, as measured by the family development tool, increased 6% over the course of the program. Many participants received do-it-yourself energy conservation kits, though only 10% of participants in the Oregon REACH program received weatherization. While quantifications of improvements in social indicators were provided in these reports, quantifications of the societal NEI of improved equity were not computed.

6.1.1 Assessment of the Literature

Results from the Indiana REACH, Oregon REACH, and numerous other low-income programs found in the literature demonstrate that programs that reduce the energy burden of the low-income population contribute to improved equity. However, none of the program reports in the literature quantified these equity benefits in the form of a monetized societal NEI. Moreover, these programs differ significantly from the PA programs in their goals and activities. Unlike the PA programs, the Indiana and Oregon REACH programs were designed specifically to improve the economic status of low-income participants. Additionally, relatively little emphasis was placed on the types of program measures employed in the PA programs, such as weatherization measures. Therefore, it is unclear how applicable the equity benefits demonstrated by these types of programs are to the PA programs. One proposed valuation method for the societal NEI of improved social equity is to compute an adder equal to the energy savings achieved by low-income energy efficiency program participants; however, this valuation method has not been employed in any of the energy efficiency program reports found in the literature. Skumatz, Khawaja, and Krop (2010), in assessing the current literature, rated the need for research on societal hardship benefits at a “High Priority,” due to the lack of existing research. NMR agrees with this assessment, as no monetized values can be derived from the literature.

6.1.2 Relevant PA Programs

The NEI of equity and hardship has generally been applied to low-income programs that result in substantial energy savings for participants. The energy savings result in improved equity and decreased social burdens for participants.

6.1.3 Recommendation

Because this NEI has not been quantified in the literature, NMR does not recommend quantifying equity and hardship for this evaluation.

In order to measure hardship or equity benefits, NMR recommends conducting primary research using the “Home Energy Security” scale in the participant surveys. This is a commonly used scale to measure the energy needs of program participants (Child Health Impact Working Group, 2007; Skumatz and Khawaja, 2010).

6.2 WEATHERIZATION BY UTILITY PROGRAMS SAVES COSTS OF INSPECTIONS AND UPGRADES BY OTHER AGENCIES

To the extent that weatherization programs obviate the need for other agencies to perform inspections and upgrades to low-income participant homes, financial savings can be realized. These savings accrue to society because the agencies that perform low-income housing inspections and upgrades are generally funded by tax dollars. Howat and Oppenheim (1999) identified reduced public expenditure on building inspections as a societal NEI, derived from weatherization programs that bring buildings up to code as a result of a weatherization. No quantified value of this NEI was provided in this report. In fact, NMR's review of the literature did not find any quantifications of this societal NEI.[130]

6.2.1 Assessment of the Literature

To our knowledge, the societal NEI of weatherization saving the costs of inspections and upgrades by other agencies has never been quantified.

6.2.2 Relevant PA Programs

This NEI potentially applies to any low-income program that implements structural or other safety measures which have the effect of bringing substandard buildings up to code.

6.2.3 Recommendation

Due to the absence of research in the literature on the impact of weatherization programs on reduced building inspections and upgrades by other agencies, NMR does not recommend quantifying the value of this NEI now.

6.3 ADDITIONAL SOCIETAL NEIs FOUND IN THE LITERATURE

NMR's review of the literature found several societal-perspective NEIs in addition to the ones originally identified during the kick-off meeting. These additional NEIs have not often been quantified and include the societal-perspective value of improved health, improved safety, reduced water consumption, and improved national security.

6.4 IMPROVED HEALTH – REDUCED MEDICAL COSTS

As noted in the participant NEI pertaining to health (see section 5.16. Health-Related NEIs – Fewer Colds and Viruses, Improved Indoor Air Quality, Ease of Maintaining Healthy Relative Humidity), energy efficiency programs may have direct impacts on health through improved home environments, such as reduced exposure to hypothermia or hyperthermia (particularly during heat waves and cold spells), and improved indoor air quality and potential reductions in moisture and mold, leading to amelioration of asthma triggers and other respiratory ailments. However, as noted by Skumatz, Khawaja, and Krop (2010), health impacts have rarely been studied, despite their potential impacts on the health care

[130] During interviews with social service program providers conducted for this evaluation, interviewees were asked if their programs coordinate with any low-income energy efficiency programs. One interviewee strongly believed that participation in "energy cost savings programs" by low-income individuals had the effect of decreasing the costs of the social service agency for which this interviewee worked and of freeing up resources to help additional low-income clients, but that no attempt had been made to quantify this benefit.

system. Society benefits from positive health impacts through, for example, reduced hospitalizations and visits to doctors due to reduced incidences of illnesses or reduced incidence rates of chronic conditions.

For example, Mudarri and Fisk (2007) estimate that approximately 4.6 million cases of asthma are attributable to dampness and mold exposure in the home, at a cost of approximately $3.5 billion annually (Mudarri and Fisk, 2007). Mason and Brown (2010) estimate that the annual medical costs of children with asthma are $1,044 more than medical costs for children without asthma and $2,157 more for adults with asthma, compared to adults without asthma. Further, building dampness and mold are associated with a 30%-50% increase in a number of respiratory and asthma related health problems, including upper respiratory tract ailments, coughing and wheezing, and asthma (Fisk et al., 2007; Institute of Medicine, 2004). A review of additional studies that have examined the health impacts of energy efficiency in office settings is presented in Appendix A.

To the extent that energy efficiency programs can improve health and reduce health care costs, they provide a benefit to society.

6.4.1 Assessment of the Literature

Savings from improved health from a societal perspective are not well documented in the literature. Health NEIs have rarely been studied, even though the impacts on the overall health care system are possibly very large. Possible measures of program impacts include reductions in visits to doctors, hospitals, or health clinics, due to health improvements in program participants that are attributable to the PAs' programs.

6.4.2 Relevant PA Programs

The NEI of improved health applies to all PA programs that include shell measures as well as heating and cooling measures, particularly low-income programs. The NEI applies to the PAs' low income-retrofit programs, low-income new construction programs, residential cooling and heating programs, residential heating and hot water programs, and non-low-income retrofit programs (i.e., Mass Save, multi-family retrofit programs).

6.4.3 Recommendation

Due to small sample sizes, NMR does not recommend a value for improved health (reduced medical costs) from the societal perspective at this time. NMR did not find convincing evidence of major health effects in terms of asthma, heat stress, and hypothermia. However, because of the potential health impacts of energy efficiency, NMR recommends reviewing the results of the current evaluation of the national WAP when the findings become available. Values for societal health benefits might be derived from these findings once the study is complete (Ternes et al., 2007).

If the national WAP evaluation does find societal health impacts, NMR recommends quantifying the societal benefit of improved health as follows:

- **Heat Stress:** [(Reductions in visits to hospital, emergency room, or urgent care facilities for heat stress (participant surveys) * $1,469.79 (Cost of general injury emergency room visit, adjusted for inflation)[131]) / Total number of participants]

[131] Centers for Disease Control and Prevention, 2011. Treatment for heat stress is considered a "general injury by the CDC: "According to the Injury Surveillance Guidelines, an injury is the physical damage that results when a human body is suddenly or briefly subjected to intolerable levels of energy. Injury can … be an impairment of function resulting from a lack of one or more vital elements (i.e., air, water, or warmth), as in strangulation, drowning, or freezing…. The energy causing an injury may be one of the following: … thermal (e.g., air or water that is too hot or too cold."

- **Cold exposure:** [(Reductions in visits to hospital, emergency room, or urgent care facilities for cold exposure (participant surveys) * $1,469.79 (Cost of general injury emergency room visit, adjusted for inflation)[132]) / Total number of participants]
- **Asthma:** [(Reductions in visits to hospital, emergency room, or urgent care facilities for asthma (participant surveys) * $737.74 (Cost of treating asthma at emergency room, adjusted for inflation)[133]) / Total number of participants]
- In addition, we feel that further study examining the potential health impacts of the programs should be considered

6.5 IMPROVED SAFETY

The societal benefit of reduced emergency calls and hospital visits has been identified in the literature as an NEI resulting from improved safety attributable to energy efficiency programs. However, safety from a societal perspective is another NEI that has not been well researched. Of the reviewed literature, few studies have provided estimates for improved societal safety.

The most commonly included safety benefit is derived from providing a carbon monoxide (CO) monitor as part of a weatherization program. The LIPPT report (TecMarket Works, SERA, and Megdal Associates, 2001) notes that 4 to 5 carbon monoxide-related crises occur annually per 400,000 customers, according to a study conducted in Wisconsin. These are more likely to occur in a low-income household and to cost on average about $5,000 per incident. Because the California programs do not install CO monitors, the LIPPT did not recommend including a benefit for reductions in carbon monoxide-related crises.

However, the LIPPT did suggest two methods to estimate a safety benefit. One was to assume the benefit was equal to the value of the CO monitors. The second method was to estimate the likelihood of a crisis in program participants, an assumption of the percentage of carbon monoxide risks for these households would be eliminated (the LIPPT assumed a 100% reduction), and the estimated value of the crisis avoided. These two methods result in an estimated societal benefit of reducing these CO crises between $0.00 to 0.29 per household annually.

6.5.1 Assessment of the Literature

There are very few studies related to safety NEIs from a societal perspective, with the most common benefit deriving from the provision of CO monitors as part of weatherization programs. In the case of a specific type of safety equipment or measure, such as a CO monitor, a common method of calculating the NEI is to estimate the average number of crises avoided per household times the cost per avoided crisis or to use the value of the installed safety equipment. While the PAs' programs do not include CO monitors, furnace repairs and replacements may reduce carbon monoxide-related crises.

6.5.2 Relevant PA Programs

While the PAs' programs do not include CO monitors and few studies have examined safety from a societal perspective beyond CO monitors, this NEI may apply to PA programs that implement measures reducing the risk of fires and CO exposure. However, since unsafe heating and ventilation systems are

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[132] Centers for Disease Control and Prevention, 2011. Treatment for cold exposure is considered a "general injury by the CDC: "According to the Injury Surveillance Guidelines, an injury is the physical damage that results when a human body is suddenly or briefly subjected to intolerable levels of energy. Injury can ... be an impairment of function resulting from a lack of one or more vital elements (i.e., air, water, or warmth), as in strangulation, drowning, or freezing.... The energy causing an injury may be one of the following: ... thermal (e.g., air or water that is too hot or too cold."

[133] Agency for Healthcare Research and Quality, 2008.

more likely to be prevalent in low-income households, and low-income households are least able to resolve unsafe conditions, NMR recommends limiting this NEI to the PAs' low-income programs.

Unfortunately, NMR could not find reliable data on either the reduction of CO poisonings attributable to furnace repairs or replacements or incidence of CO poisonings.[134]

6.5.3 Recommendation

Due to the lack of research in the literature on the valuation of improved safety from the societal perspective, NMR does not recommend estimating value of this NEI at this time.

6.6 OTHER – WATER, NATIONAL SECURITY

A further review of the literature found several other societal related NEIs of potential interest to the PAs' programs, though with very little quantifiable analysis. For instance, water is a scarce resource, managed heavily in many areas. Measures that save water benefit everyone in the area. The degree to which development of new water supply is avoided due to efficiency measures is the societal benefit of interest. The costs of developing new water capacity are often prohibitive. The societal benefit of water savings was investigated in the 2001 California LIPPT report. However, because the LIPPT assumed that low-flow water measures such as aerators and low-flow shower heads have relatively short lifetimes—an average of three years— the LIPPT determined that they only provided short-term water savings. This yields a NEI value of $0.00, due to the short duration of the measure, compared to the cost of development of new supply (TecMarket, SERA, and Megdal Associates, 2001).

Another societal NEI that has rarely been considered is that of improved national security. The most notable benefit comes from reducing the need for energy imports, thereby enhancing national security. In areas where fuel oil or kerosene are commonly used to heat homes, comprehensive weatherization programs have the greatest effect in reducing the amount of imported energy consumed. Riggert et al. (1999) derived a national security NEI benefit of $202 per household from avoided imported fuel sources by comprehensive weatherization measures in Vermont by assuming a ten percent adder effect for avoided imported oil. NMR updated Riggert et al.'s adder effect variable, which represents the cost of relying on imported oil, by calculating ten percent of the 2012-2016 levelized cost per MMBtu of crude oil from the AESC study (2011 dollars).

6.6.1 Assessment of the Literature

The societal-perspective NEIs of reduced water usage and improved national security have rarely been studied. Water savings are relatively straightforward to estimate and can provide relevant savings for programs that include water measures; however, the societal NEI value for water savings is negligible. NMR does not believe that a value for water savings can be derived from existing studies.

The NEI of national security is most valuable for programs in which participant homes are heated by fuel oil or kerosene. If the PAs' programs install weatherization and other heating related measures into homes that use fuel oil or kerosene as the primary heating fuel, an NEI value of improved national security can be derived from an algorithm developed from the literature (see Riggert et al., 1999).

[134] Hall (2010) reports emergency room visits caused by heating equipment, including anoxia (defined as "lack of oxygen, which may occur in a fire-affected atmosphere or when carbon monoxide from malfunctioning equipment crowds out oxygen"), but emergency room visits from CO specific causes are not reported.

6.6.2 Relevant PA Programs

The societal NEI of water savings potentially applies to PA programs that implement water-saving measures.

The NEI of national security potentially applies to all programs that reduce the consumption of imported fuels, such as the PAs' low-income programs and non-low-income retrofit programs that install weatherization and other heating related measures.

6.6.3 Recommendation

Based on the review of the literature for water, NMR does not recommend including estimates for water savings from the societal perspective (participant water savings are reviewed and estimated in section 5.13).

Based on the review of the literature, NMR recommends the following annual national security NEI for PA program participants' homes that use fuel oil or kerosene as the primary heating fuel, derived from the following algorithm, developed by Riggert et al. (1999):

- [(Estimated annual savings in fuel oil and kerosene, per measure, MMBtu (PA Data) * $1.83 (10% adder for cost of relying on imported oil or kerosene, per MMBtu)[135] * number of homes that use fuel oil or kerosene as the primary heating fuel)]

[135] The price per MMBtu represents a 10% adder of the forecasted 2012 to 2016 levelized cost of imported low-sulfur oil, as reported in the 2011 AESC report (Hornby et al., 2011)

7. PARTICIPANT-PERSPECTIVE NEIS, OWNERS OF LOW-INCOME RENTAL HOUSING—LITERATURE REVIEW

Our review of the literature found no mention of non-energy impacts pertaining to participating owners of low-income rental housing. However, interviews with PA staff identified several potential NEIs, including reduced maintenance pertaining to lighting (attributed to the longer life of a CFL, thus reducing labor costs), improved sense of environmental responsibility, improved marketing of rental property (i.e., a more energy-efficient rental unit is easier to market and rent), and reduced tenant turnover.

The following NEIs were estimated in the analysis of owners of low-income rental housing NEI surveys:

- Marketability and ease of finding renters
- Reduced maintenance of heating and cooling equipment
- Reduced maintenance for lighting (as with the occupant NEIs, NMR recommends that the PAs either use the value derived from the surveys or the O&M value from the TRM, but not both values)
- Reduced tenant turnover
- Reduced tenant complaints
- Expected increase in property value
- Improved durability of property
- NEI values are reported in section 10. Participant NEIs Estimated from Surveys—Owners of Low-income Rental Housing.
- NMR recommends applying the NEI values to the PAs' low-income multi-family programs.

8. NON-RESOURCE BENEFITS

Our evaluation also found what we believe to be a non-resource benefit of waste savings from the Massachusetts Appliance Turn-in Program.

8.1 WASTE SAVINGS: REFRIGERATOR/FREEZER TURN-IN PROGRAMS

The Massachusetts Appliance Turn-in Program is a regional refrigerator and freezer collection initiative administered through the Northeast Energy Efficiency Partnerships by National Grid, NSTAR Electric, Western Massachusetts Electric Company, and the Cape Light Compact in Massachusetts. JACO, a third party implementation contractor, handles all aspects of program implementation, including recycling the refrigerators and freezers that it collects. Hazardous materials such as chlorofluorocarbon (CFC) or hydro chlorofluorocarbon (HCFC) gases, polychlorinated biphenyls (PCBs), mercury, and oils contaminated with CFCs and HCFCs are removed from the collected units and disposed of in accordance with US EPA Responsible Appliance Disposal (RAD) program guidelines.[136]

By removing from customers' homes refrigerators and freezers that are inefficient or unnecessary, the program creates energy savings and reduces demand on the electrical grid. The program also creates non-energy impacts (NEIs), which are the effects of the program other than those energy savings. In general, programs may create both positive and negative NEIs, but this analysis investigates the beneficial NEIs of the appliance recycling program, such as the environmental benefits derived from properly collecting, destroying, or recycling the materials contained within these units. According to an analysis of program records from June 2009 through November 2010, on average, each unit collected in Massachusetts contained approximately 100 pounds of metal, 20.0 pounds of plastic, 1.5 pounds of glass, 8.5 pounds of foam insulation, and 0.6 pounds of Freon. The metal is sold to scrap metal dealers, plastic and glass are stripped from the units and recycled, and the foam insulation (which potentially contains ozone-depleting CFCs) is taken to a waste to energy plant and incinerated at a high temperature. By following the stringent RAD guidelines, JACO recycles the refrigerators and freezers it collects to a level that exceeds EPA regulations, which do not require foam incineration or recycling of the glass and plastic in the units.[137]

To the extent that appliance turn-in programs ensure that hazardous materials are disposed of properly and that the materials comprising old appliances are recycled, beneficial societal non-energy impacts can be derived in the form of 1) avoided landfill space, 2) avoided use of raw or virgin materials in the production of new goods through the use of recycled components, and 3) avoided release of ozone-depleting substances and greenhouse gases into the atmosphere. Federal law and regulations do, however, require the proper disposal or storage of refrigerant, mercury, PCBs, and used oil, such that the sponsors cannot claim the environmental and health benefit associated with avoiding the release of these materials, because they would have already been properly managed, barring illegal activity.

Non-energy impacts associated with appliance turn-in programs have not been estimated in NEI literature. However, the three impacts previously mentioned can be estimated via the following engineering algorithms.

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[136] U.S. Environmental Protection Agency, Stratospheric Protection Division. "Responsible Appliance Disposal (RAD) Program." Accessed May 10, 2011. http://www.epa.gov/ozone/partnerships/rad/.

[137] 40 C.F.R. § 82 Subpart F, http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=f40bf28473d6464a12bfbe9adb547cd2&rgn=div6&view=text&node=40:17.0.1.1.2.6&idno=40.

8.1.1 Avoided Landfill Space

According to program data, between June 2009 and November 2010,[138] JACO collected approximately 30 pounds of plastic, glass, and insulating foam from each unit. These materials were either recycled or incinerated, and were thus diverted from eventual disposal in landfills as a result of the program.[139] The NEI value of this avoided landfill space can be estimated by multiplying the quantity of recycled materials per appliance by average landfill tip fees. The average landfill tip fee in the Northeast in 2004, the most recent year that data was made publicly available by the National Solid Wastes Management Association (NSWMA), is $70.53 per ton.[140] Estimated in this manner, the NEI value of avoided landfill space per unit is approximately $1.06.

8.1.2 Recycling of Plastics and Glass

The program recycles plastic and glass that would typically be landfilled in the absence of the program, thereby returning these materials to the manufacturing stream. Producing goods from such recycled materials is generally less energy-intensive than producing goods from virgin inputs; therefore, recycling this plastic and glass results in decreased GHG emissions.

The societal benefit of avoided emissions attributable to the program can be estimated using the EPA's Waste Reduction Model (WARM) which employs a materials life-cycle approach allowing users to estimate energy impacts and GHG emissions of alternative waste management practices. WARM assumes that recycled materials displace virgin materials in manufacturing. JACO program records indicate that 20.0 pounds of plastic and 1.5 pounds of glass per unit were recycled through the program. The emissions reduction associated with recycling 20.0 pounds of plastic and 1.5 pounds of glass and returning them to the manufacturing stream (as opposed to disposing of these quantities in landfills and producing virgin materials to take their place in the manufacturing stream) is 0.01564 metric tons of carbon dioxide equivalent (CO_2e).[141] The 2009 Avoided Energy Supply Costs (AESC) in New England reports an estimated value for carbon dioxide emissions of $80 per ton. Multiplying the avoided 0.01564 CO_2e per unit by $80 per ton of CO_2 yields an NEI value of approximately $1.25 per unit for the reduced use of virgin materials in the manufacturing process.

8.1.3 Incineration of Insulating Foam

Chemical blowing-agents, typically CFCs or HCFCs, are used to spray foam into refrigerators and freezers when they are being manufactured. These gases are trapped in the air pockets of the foam for the life of the appliance, and in the absence of the program, they are released into the atmosphere when

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[138] This data was reported by NMR Group in its evaluation of the 2009-2010 Massachusetts Appliance Turn-in Program, submitted to National Grid, NSTAR Electric, Cape Light Compact, and Western Massachusetts Electric Company in May 2011.

[139] Although the metal that is sold to scrap dealers is ultimately recycled into new products, NMR does not include metal in the estimation of NEI values. Instead, NMR assumes that the metal from old units would have likely been sold to a scrap yard (and ultimately recycled) in the absence of the program by another channel due to its relatively high scrap value. Alternate channels by which used appliances end up in scrap yards include haulers, municipal disposal channels, and scavengers. These findings, derived from secondary research and interviews with market actors, are reported in NMR's *Massachusetts Appliance Turn-in Program – Secondary Market and Appliance Disposal Report*, submitted to National Grid, NSTAR Electric, Cape Light Compact, and Western Massachusetts Electric Company in May 2011. The EPA also confirms that metals are generally salvaged while foams, plastics, and glass are typically landfilled: "Appliance Disposal Practices in the United States." Accessed May 10, 2011. http://www.epa.gov/ozone/partnerships/rad/raddisposal_factsheet.html.

[140] The following states were included in the Northeast region for the NSWMA analysis: CT, ME, MA, NH, NY, RI, VT.

[141] Carbon dioxide equivalent is a measurement used to compare the emissions of various greenhouses gases to carbon dioxide, based on their global warming potential (GWP). Global Warming Potential is the "ratio of the [global] warming caused by a substance to the warming caused by a similar mass of carbon dioxide." The GWP of CO_2, for example, is 1. CFC-11 thus causes 4,750 times more global warming than would an equivalent quantity of CO_2.
Source: U.S. Environmental Protection Agency. "Ozone Layer Protection Glossary." Accessed March 20, 2011, http://www.epa.gov/ozone/defns.html.

the unit is shredded at a metal shredding facility. After the unit is shredded at such a facility, the foam is typically landfilled, where any remaining blowing-agent escapes into the atmosphere. These blowing-agents are potent greenhouse gases, and through high temperature incineration, the program prevents their release into the atmosphere.

The EPA estimates that an average refrigerator or freezer contains 1.0 pounds of blowing-agent in its foam.[142] These blowing-agents could be a number of different chemicals depending on the date of manufacture, as certain chemicals were phased out due to environmental regulations. According to the EPA, prior to 1995, the blowing-agent is likely to have been CFC-11, with a global warming potential (GWP) of 4,750, and from 1995 onward, HCFC-141b is the assumed blowing-agent, with a GWP of 725.[143] According to program data, 87.7% of units collected were manufactured prior to 1995, and are thus assumed to have contained CFC-11, with a significantly higher GWP than newer units.

The per unit NEI value of the avoided release of blowing-agent into the atmosphere can be estimated by multiplying the CO_2e of the blowing-agent by the 2009 Avoided Energy Supply Costs in New England's externality value of CO_2, which is $80/ton. To estimate the CO_2e of each unit collected by the program, the evaluation team used the EPA's RAD data to assume that each unit contained 1.0 pounds of blowing-agent,[144] and then multiplied that quantity by the GWP of the likely blowing-agent based on the unit's age, which results in the CO_2e, in pounds, of each unit's blowing-agent. The average CO_2e value per unit of a pre-1995 unit is 4,750 pounds, and 725 pounds for a unit manufactured in 1995 or later. Each of these values can then be multiplied by $0.04 per pound (AESC value of $80/ton of CO_2). Thus, the average per unit value of preventing the environmental release of one pound of blowing agent from a pre-1995 unit is $190, and $29 from a unit manufactured in or after 1995. Over time, as the prevalence of pre-1995 units declines, the average per unit value preventing the environmental release of one pound of blowing agent will decline.

For the Massachusetts program, the average CO_2e of all collected units from June 2009 to November 2010 was 4,256 lbs, and the average per unit value of preventing the environmental release that material was $170.22.[145]

8.1.4 Relevant PA Programs

The NEIs derived from appliance turn-in programs apply to the Massachusetts Appliance Turn-in Program.

[142] U.S. Environmental Protection Agency, Stratospheric Protection Division. *RAD 2009 Annual Report*. August 2010. http://www.epa.gov/Ozone/partnerships/rad/downloads/RAD_2009_Annual_Report.pdf.

[143] Evelyn Swain. U.S. Environmental Protection Agency. EPA Responsible Appliance Disposal Program Webinar for National Association of State Energy Officials. March 2010. Accessed May 10, 2011. http://www.naseo.org/events/webinars/RAD/NASEO_RAD_Presentation_March2010.pdf.

Ms. Swain indicated in telephone conversations with evaluators that in the 2000's, manufacturers shifted away from HCFC-141b to blowing-agents with lower GWPs, but this transition did not happen uniformly across all manufacturers. In addition, less than 2% of units collected by the Massachusetts program were manufactured more recently than 2000. Therefore, we are only taking into account the 1995 blowing-agent transition in our estimates of the blowing-agent types present in the collected units.

[144] The data JACO was able to provide the evaluation team did not identify the specific types or quantities of blowing-agents that were recovered from each individual model, therefore the team relied on EPA estimates from its 2009 RAD Annual Report.

[145] Note that these values do not account for any potential CO_2 emissions released during the incineration process. We are assuming that the emissions released from the incineration process is equivalent to the CO_2 emissions that would have been generated by the metal shredding facilities when shredding the appliances and foam in preparation for the landfill.

8.1.5 Recommendations

NMR recommends a one-time NEI value of avoided landfill space of $1.06 per unit, a one-time NEI value of reduced use of virgin materials in the manufacturing process of $1.25 per unit, and a one-time NEI value of preventing the environmental release of CFCs or HCFCs from insulating foam of $170.22 per unit. These values are derived from the following algorithms:

Avoided landfill space:

- (30 lb plastic, foam, and glass material/unit) / (2,000 lb/ton) * [$70.53 /ton (2004 Northeast regional average landfill tipping fee)]

Avoided use of raw/virgin materials in the manufacturing process:

- 0.01564 MTCO_2e/unit (WARM) * $80/ton (Avoided Energy Supply Costs in New England: 2011 Report)

Avoided GHG emissions:

- For pre-1995 units:
- Average CO_2e/pre-1995 unit (4,750 CO_2e/unit (EPA and JACO)) * $80/ton (Avoided Energy Supply Costs in New England: 2011 Report)
- For units manufactured 1995 and after:
- Average CO_2e/1995 and later unit (725 CO_2e/unit (EPA and JACO)) * $80/ton (Avoided Energy Supply Costs in New England: 2011 Report)

9. PARTICIPANT NEIs ESTIMATED FROM SURVEYS—OCCUPANTS

Large majorities of low-income (LI) and non-low-income (NLI) respondents believed that the energy efficiency retrofits provide NEIs and that the NEIs provide hundreds of dollars of benefit to them.

For example, among NLI respondents four out of five (80%) believed the retrofits have increased the value of their property, three out of four (76%) said that thermal comfort had increased, 73% reported increased reliability or reduced maintenance of their new heating or cooling equipment, and seven out of ten (70%) NLI respondents thought that the quality and lifetime of the lighting, when taken together, was a positive impact. Among LI respondents, about two-thirds of respondents (65%) said that the improvements had increased the comfort level of their home, and a similar percentage (68%) said that the quality and lifetime of the lighting, when taken together, constituted a positive impact. Slightly fewer than six out of ten respondents (57%) reported an expected increase in property value.[146]

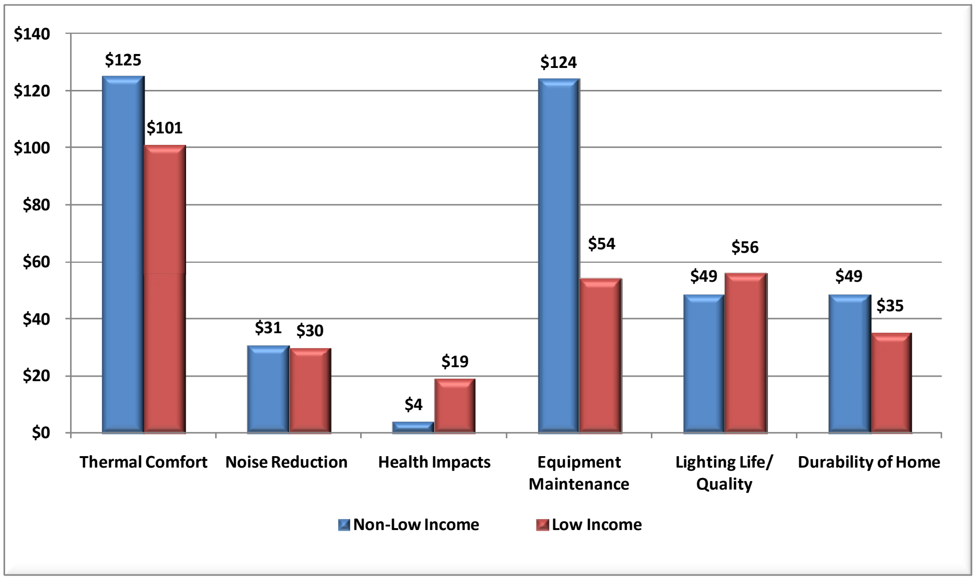
Overall, on average, non-low-income participants believed that NEIs were worth $261 and low-income participants believed that their NEIs were worth $242. In terms of energy bill savings, NLI participants believed that their NEIs were worth 77% of their energy savings, while low-income participants believed that NEIs were worth 52% of their own energy savings. Values for individual NEIs are scaled to these total NEI values.[147]

In general, NLI respondents placed a higher value per participant than did the LI respondents on the NEIs that provide annual benefits, except health impacts and lighting life and quality (Figure 9-1). NLI respondents valued thermal comfort and equipment maintenance the most ($125 and $124 per year, respectively), while LI respondents valued thermal comfort, lighting life and quality, and equipment maintenance the most ($101, $56, and $54, respectively).

[146] Only homeowners were asked about impacts on property values.

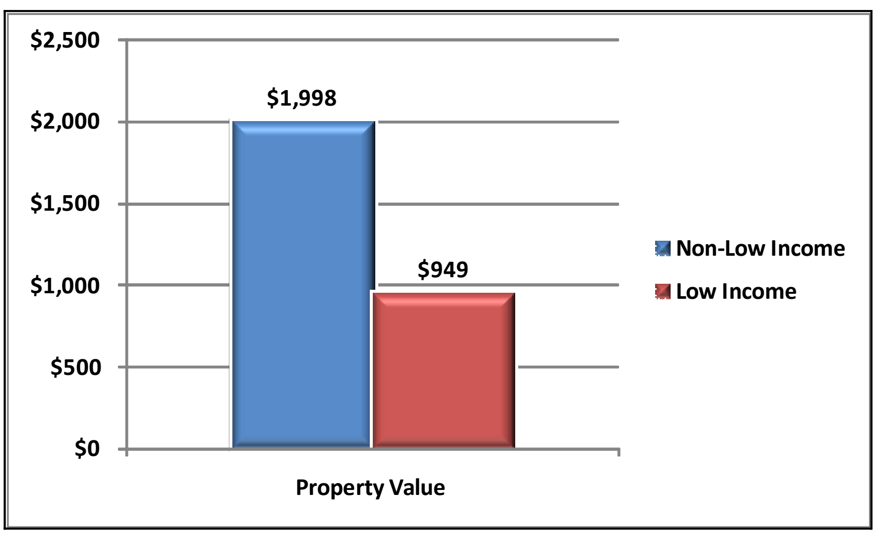
[147] Scaling was done at the individual respondent level, for those NEIs applicable to the particular respondents. This leads to individual NEI values that are not directly additive, since only some respondents experienced each NEI.

Figure 9-1. Low-income and Non-low-income Respondent Valuation of Annual NEIs



Non-low-income respondents estimated a substantially higher one-time property value increase attributable to the energy efficiency retrofits than did low-income respondents (Figure 9-2).

Figure 9-2. Low-income and Non-low-income Valuation of One-time Property Value NEI



In addition, this portion of the study attempted an alternative method of estimating participant perspective health benefits—via reductions in sick days attributed to the energy efficiency retrofits, as well as societal benefits via reduced medical costs flowing from reduced incidence of heat stress, hypothermia, and asthma. Because of the extremely small number of respondents reporting program induced changes in health, NMR does not recommend using results from this method. Findings are reported in Appendix A.6 and A.7. However, health benefits are also being examined in the current evaluation of the national WAP; values might be able to be derived from these findings once the study is complete (Ternes et al., 2007).

9.1 PERCEPTION OF EFFICIENCY IMPROVEMENT AND NEIS

Respondents were asked about their perception of the energy-efficiency of their homes after the improvements as compared to before. As a whole, respondents perceived that the improvements made their homes more efficient, but the extent to which respondents perceived their homes' efficiency to have improved appears to differ between the two income groups (Table 9-1). Non-low-income (NLI) respondents were somewhat more likely than low-income (LI) respondents to report greater efficiency (90% versus 74%) and less likely to report that the efficiency had not changed (7% versus 18%).

Table 9-1. Perception of Energy-Efficiency after Improvements

	Low-income	Non-low-income
Sample size	213	209
More efficient	74%	90%
Less efficient	2%	0%
Same efficiency	18%	7%
DK/Refused	5%	3%

Before respondents were asked about specific non-energy impacts (NEIs), they were asked if there were any positive or negative impacts they might have noticed as a result of the improvements, other than energy savings. The most frequently mentioned positive impact for both groups was thermal comfort, with over one-third (36%) of the NLI respondents and over one-quarter (27%) of the LI respondents reporting this benefit. About one out of four respondents (26% and 23% for the LI and NLI groups, respectively) cited more affordable energy bills (Table 9-2). In addition, noise reduction (both equipment noise and noise from outside the home) was reported by about one out of ten (11%) NLI respondents and a small percent of the LI respondents (3%). Other benefits respondents mentioned include equipment reliability, less use of fuel, and the life and or/quality of the energy-efficient light bulbs. Respondents also volunteered several non-energy benefits not directly asked about in the survey, including safety, ease of use of the new equipment, reduction in ice dams on the roof, increased hot water availability, and fewer rodents and insects entering the home.

Table 9-2. Positive Impacts of Installations Noticed by Occupants

NEI	Low-income	Non-low-income
Sample size	**213**	**209**
Increased thermal comfort	27%	36%
More affordable energy bills	26%	23%
Reduced noise	3%	11%
Equipment reliability/reduced maintenance	3%	6%
Less use of energy/fuel	3%	4%
Improvement in lighting life/quality	2%	1%
Increased safety	1%	1%
Equipment easier to use	1%	0%
Home heats up faster	1%	1%
Cooler in summer	1%	1%
Fewer ice dams on roof	1%	1%
Fewer rodents or insects	1%	1%
More hot water available	1%	1%
Less odor (e.g., when switching from oil to gas heat)	1%	1%
Household health benefits	0%	1%
Improved temperature control	--	1%
Improved humidity control	--	1%
Other benefits	6%	6%
No benefits mentioned	36%	28%

Very few negative impacts were identified by the respondents. Eight out of ten LI respondents and nearly nine out of ten NLI respondents (88%) said they had not noticed any negative impacts from the efficiency improvements (Table 9-3). Further, no single negative impact was mentioned by more than four percent of respondents, suggesting that negative impacts are few in number and not consistent across the handful of households that have experienced them. The negative impacts reported include continued draftiness, dissatisfaction with the new lighting, remaining ice dams or snow accumulation on the roof, and increased time for the hot water to heat.

Table 9-3. Negative Impacts of Installations Noticed by Occupants

NEI	Low-income	Non-low-income
Sample size	**213**	**209**
Lack of thermal comfort (draftiness)	4%	1%
Dissatisfaction with lighting	4%	2%
Ice dams or snow accumulation on roof	2%	1%
Leaks in attic	2%	--
Weather stripping is ineffective	2%	--
Increased equipment noise	1%	1%
Reduced equipment reliability	1%	--
Less affordable energy bills	1%	--
Hot water takes too long to heat	1%	3%
Increased insect activity	1%	1%
Other negative impacts	4%	2%
No negative impacts mentioned	80%	88%

9.2 PERCEPTION OF NEIS

After respondents were asked about impacts they might have noticed, they were asked about specific NEIs. First, they were asked whether they had noticed the impact since the efficiency improvements, as well as whether the impact was positive or negative. For example, for thermal comfort, we inquired whether their homes were more comfortable, less comfortable or the same comfort level as before the improvements (Table 9-4).

Among the LI respondents, about two-thirds (65%) said that the improvements had increased the comfort level of their home, and a similar percentage (68%) said that the quality and lifetime of the lighting, when taken together, constituted a positive impact. Slightly fewer than six out of ten respondents (57%) reported an expected increase in property value.[148] Less than one-half of respondents said that the other NEIs were positive, with just over four out of ten (43%) reporting increased reliability of equipment, about one out of three (34%) reporting increased durability of the home, one out of four (25%) reporting decreased noise from outside the home, and one out of five (20%) reporting a reduction in colds, flus, and asthma-related conditions. No NEI was regarded as negative by more than one out of ten respondents. When asked about the total impact of all the NEIs that had been discussed in the survey (except property value), eight out of ten LI respondents (80%) said that the impact was positive, while about one out of six

[148] Only homeowners were asked about impacts on property values.

(14%) said that it was neither positive nor negative. Only two percent of LI respondents judged the overall impact to be negative.

In general, the NLI respondents appear to have been more likely than the LI respondents to report positive impacts of the improvements. The NEI most frequently regarded as positive by the NLI group was property value, with four out of five (80%) saying that they expected the value of their property to increase. Approximately three out of four (76%) said that thermal comfort had increased, and a similar percentage (73%) reported increased reliability or reduced maintenance of the new equipment. In addition, seven out of ten (70%) NLI respondents thought that the quality and lifetime of the lighting, when taken together, was a positive impact. Each of the remaining NEIs received positive ratings from less than one-half of this group: durability of the home (44%), noise (30%), and health impacts (20%). No NEI received negative ratings from more than 6% of the NLI respondents. A large majority (92%) of the NLI group said that the total impact of all the NEIs (except property value) was positive, and fewer than one out of ten (7%) said the overall impact was neither positive nor negative.

Table 9-4. Respondents who Say Home Provides NEIs

	Low-income (n=213)				Non-low-income (n=209)			
NEI	*Sample size*	Positive	Negative	No difference	*Sample size*	Positive	Negative	No difference
Thermal comfort	*213*	65%	1%	31%	*209*	76%	1%	20%
Noise (from equipment or outside home)	*213*	25%	1%	72%	*209*	30%	2%	65%
Health (colds/flus/asthma)	*213*	20%	4%	73%	*209*	20%	1%	72%
Property value (homeowners only)	*176*	57%	1%	38%	*207*	80%	0%	15%
Equipment reliability/maintenance	*141*	43%	6%	47%	*139*	73%	3%	21%
Lighting quality and lifetime	*148*	68%	10%	20%	*107*	70%	6%	21%
Durability of home	*213*	34%	2%	60%	*209*	44%	1%	52%
Overall impact of NEIs*	*213*	80%	2%	14%	*209*	92%	1%	7%

*Does not include property value.

Comparisons to other studies provide additional understanding into NEIs. In particular, we compared the results of this study with one of participants in Mass Save and another with participants in the ENERGY STAR Homes program. The LI and NLI respondents report similar levels of positive impacts of energy efficiency improvements in a recent survey of Mass Save program participants.[149] The Mass Save survey

[149] In the fall of 2010 Cadmus and Opinion Dynamics Corporation (ODC) conducted surveys with 1,202 customers who participated in the 2010 Mass Save® Residential Single Family Retrofit (Mass Save) Program

included a brief set of questions asking respondents if they experienced non-energy impacts as a result of their energy efficiency retrofits. Overall, 63% of Mass Save participants experienced a positive change in thermal comfort, 33% experienced a positive change in noise, 22% experienced a positive change in asthma and other chronic health conditions and 34% experienced a positive change in the durability of their home. More details of the Mass Save survey results are provided in Appendix B: Mass Save NEIs .

However, LI and NLI respondents appear to report lower positive levels for some NEIs than homeowners of new ENEGY STAR (ES) homes in Massachusetts (NMR and Conant, 2009). For example, 86% of ES homeowners who responded to the ES Homes survey believed their new home provided an NEI of thermal comfort compared to 76% of NLI retrofit participants and 65% of LI retrofit participants. Further, 67% of ES homeowners stated that their home provided a benefit of reduced noise compared to 30% of NLI retrofit participants and 25% of LI retrofit participants. However, lighting life and quality appeared to be slightly less likely to be perceived as a positive NEI by ES homeowners, with 61% reporting this as a positive NEI compared to 70% of NLI retrofit participants and 68% of LI retrofit participants. An important difference between the two surveys is that the ES homeowners were comparing their homes to what they imagined other new, non-ES homes, were like, whereas the respondents in the current study were comparing their current experience with their actual previous experience in the same home.

9.3 NEI VALUE CALCULATION

Survey respondents were asked to estimate an annual value for the NEIs they experience in their homes.[150] The survey used a *relative valuation* method, asking respondents to value each NEI in relation to their annual energy bill savings, either as a dollar amount or as a percentage of energy savings.[151] Each respondent was told an estimate of their annual energy bill savings based on the measures the participant had installed with the PAs' programs.

The survey first asked homeowners if they believed their home had a particular NEI, and whether it was positive or negative. Taking the thermal comfort NEI as an example, respondents were asked if they believed their home, because of the energy efficiency improvements, was more comfortable than before, less comfortable, or no different in its comfort level (in terms of temperature and draftiness). Those who believed it was more comfortable were asked to place a value per year on this increased comfort, with a choice of dollars or a percentage of energy savings. Those who believed it was less comfortable were asked how much the decreased comfort took away from the value of living in the home, either in dollars or as a percentage of energy savings. NEI values for those who believed their home was no different in comfort level from before the improvements were set to zero.

Assigning monetary values to intangibles such as comfort is not an easy task. Respondents who responded that they did not know were further prompted with the following questions:

> "Compared to energy bill savings, would you say increased comfort is worth nothing, about a one fourth of energy bill savings, about a half of energy bill savings, about three-fourths of energy bill savings, about equal to energy bill savings, or more than energy bill savings? If the latter, how much more?"

The NEIs for respondents who still could not provide an answer are treated as missing in the calculation of average NEI values.

After providing values for the individual NEIs, respondents were asked to assign an annual value to the total impact of all the NEIs together (except for any changes in property value). Each respondent's

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[150] The NEI of property value as asked in terms of a one-time change in value

[151] A discussion of the various methods used to estimate NEIs in the literature is found in the section 5.1: Methods Used to Measure Participant NEIs

individual NEI values were scaled in proportion to the respondent's valuation of the total impact of all the NEIs in order to account for any overlap in NEIs or over-estimation of the individual NEIs. Potential overlap and overestimation can be conceptualized in two ways. First, when asking respondents to valuate non-market goods with multiple parts or components, the stated value of the whole is often less than the value of the sum of the parts. This is often referred to as 'part-whole bias' when the values of the individual parts are not adjusted for the value of the whole (Bateman et al., 1996; Brown and Duffield, 1995). Second, when valuating several related things, the stated value of the total is often less than that of the sum of the individual items, often referred to as an "embedding effect" (Baron and Greene, 1996; Brown et al, 1995). There could be any number of explanations for this, but in the case of NEIs it is likely that there is "overlap" among the various NEIs asked about, such that respondents do not conceptualize the individual NEIs as being completely distinct and therefore their values are not additive.

Overlap could be occurring among NEIs in a few different possible ways. One way is if there is an implied causal relationship in the respondent's mind between two NEIs, so that it would be redundant to "pay for" each separately. For example, if a respondent thinks that fewer drafts lead to fewer colds and viruses, the respondent might think that both NEIs are valuable, but when combined, the NEIs are less valuable in total because when the respondent 'pays' for fewer drafts the respondent also benefits from fewer colds/viruses. Alternatively, two or more NEIs could be conceptually or experientially similar, so that they share at least some of their perceived meaning. For example, a respondent might perceive comfort, fewer illnesses, and reduced noise as all being different but somewhat overlapping aspects of an overall sense of "well-being," such that the various aspects, when taken separately, add up to more than the overall sense. Finally, one NEI can be considered a subset of another NEI, such that the value of one "contains" the value of another. For example, longer lighting life and even durable home could be perceived as part of "reduced equipment maintenance," such that the value of equipment maintenance includes the value of the other two.

The individual NEI values were scaled in the following way: each NEI value was represented as a proportion of the sum of that respondent's individual NEI values. This proportion was then applied to the respondent's reported valuation of the total impact of all the NEIs, yielding the scaled value for each NEI[152]. The scaling factor is specific to each respondent and varies widely throughout the sample. For example, if a respondent said their total NEI value was $300, while reporting their health NEI as $300 and their thermal comfort NEI as $100, the scaled NEI values for this respondent would be a health NEI of $225 and a thermal comfort NEI of $75. The specific NEI values for this same respondent would be much different if the respondent reported their total NEI value to be $1000 or $100. In addition to scaling, respondent values were weighted according to their strata. For example, NLI respondents in the heating and cooling strata received a weight of 1.53 while NLI respondents in the shell plus heating and cooling strata received a weight of 0.10. Thus, the scaling and the weights affect the calculation of average values.

As an example, assume respondent A is from the heating and cooling strata and reports total NEIs as $300, health NEI as $300 and their thermal comfort NEI as $100, the scaled NEI values for this respondent would be a health NEI of $225 and a thermal comfort NEI of $75. Respondent B, from the shell plus heating and cooling strata, reports total NEIs as $650, health NEI as $500 and their thermal comfort NEI as $200, the scaled NEI values for this respondent would be a health NEI of $464 and a thermal comfort NEI of $186. Because the respondents are weighted differently, the weighted average value for health would equal $240 and the weighted average value for comfort would equal $82. A more detailed discussion of the scaling of the NEI values is presented in Appendix A.2 (Scaling of NEI Values)

Table 9-5 and Table 9-6 present the mean NEI values of non-low-income and low-income respondents. Two mean values are presented for each NEI—the first reflects reported NEI values (shown in dollars as well as in terms of mean percent of bill savings), while the second reflects respondents' reported values

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[152] When the respondent failed to give a value when asked for Total NEI value the scaling was based on the sum of the respondents individual measure values.

scaled in proportion to the total NEI value provided by respondents. Upper and lower bounds of values are calculated at a 90% confidence level; the central estimate may be considered for planning purposes. The mean of the sum of the individual NEIs as well as the mean total NEI values, are also presented. Sum of NEIs is the sum of the unscaled values of the individual annual NEIs (i.e., excluding property value) while total NEI value is the value provided by respondents when asked for the total value of all NEIs, excluding property value. The values reported in Table 9-5 and Table 9-6 and the overall population values reported in Table 9-7 and Table 9-8 are weighted to strata and income group. The following weights were applied to the non-low-income sample: a weight of 1.53 for the heating and cooling strata, a weight of 1.40 for the shell strata a weight of 0.10 for the shell plus heating and cooling strata. For the low-income sample, the following weights were applied: a weight of 1.22 for the heating and cooling strata, a weight of 0.98 for the shell strata a weight of 0.79 for the shell plus heating and cooling strata. In addition, cases that are at least three times the standard deviation of percent bill savings of the total scaled NEI value are excluded

It should be noted that the individual NEI values do not sum to equal the mean "Sum of NEIs" and "Total NEI" values presented in the table, because the individual NEIs were based on respondents who expressed a value for a given NEI, whereas the Sum of NEIs and Total NEIs apply to all respondents. For example, lighting quality and lifetime was only estimated for respondents who had installed energy efficient lighting through the PAs' programs and estimated a value for lighting quality and lifetime (40 NLI respondents and 88 LI respondents). As a result, for 168 NLI respondents, the Sum of NEIs does not include a dollar value for lighting quality and lifetime (because they did not install lighting through the programs). Similarly, equipment maintenance was only estimated for respondents who had installed energy efficient heating and cooling equipment through the PAs' programs and estimated a value for reduced equipment maintenance (117 NLI respondents and 122 LI respondents).Therefore, the number of NEIs that contribute to the Sum of NEIs varies from respondent to respondent. This variation in sample size also has an impact on the consistency of scaling across measures, the scaled value for lighting measure is based on 40 NLI respondents and 88 LI respondents while the scaled value for equipment maintenance was only based on those respondents who had installed energy efficient heating a cooling equipment. This variation in sample size translates into a different base for the scaling, so it should not be expected that lighting and equipment maintenance be subject to the same scaling factor. For a detailed explanation as to how these factors interplay in the scaling, see Table A-4 in Appendix A.

As shown in Table 9-5, the most highly valued annual-value NEI by the NLI respondents is thermal comfort, with a mean annual value of $125 (nearly $300 before scaling to total impact values) and reduced equipment maintenance, with a mean annual value of $124 (nearly $200 before scaling). Reduced noise, improved health, and increased durability of the home were valued the least, each with a mean value of less than $50 annually. Respondents assigned a far higher value to expected increase in property value, a one-time impact, than those for the annual-value NEIs, with a mean of nearly $2,000, [153]

The LI respondents show a similar pattern to that of the NLI respondents (Table 9-6).Among the annual-value NEIs, increased thermal comfort was given the highest value, with a mean annual value of $101 (over $200 before scaling), and reduced equipment maintenance, with a mean annual value of $54 (over $100 before scaling). Similar to the LI group, for the NLI group reduced noise, improved health, and increased durability were given the lowest values, all means of less than $60 annually. Again, the expected increase in property value (a one-time impact) was valued more highly than the annual NEIs, with a mean of nearly $1000,

Table 9-7 reports the mean NEI values by strata for the NLI population. The shell plus heating and cooling strata consistently valued their NEIs higher than did the other strata. The heating and cooling strata valued thermal, comfort health impacts, property value, and durability of home more highly than did the shell strata.

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[153] As noted earlier, property value represents a one-time benefit while the remaining NEIs are annual benefits.

Within the LI population (Table 9-8), the shell strata gave a larger value to thermal comfort and noise reduction than did the other strata. Property value and equipment maintenance were valued more highly by the heating and cooling strata than by the other two strata.

Table 9-5. Mean NEI Values from Survey[1]: Non-low-income Population

	Value per year	Thermal comfort		Noise reduction		Health impacts		Property Value [2]	Equipment maintenance [3]		Lighting life/quality [4]		Durability of home		Sum of NEIs	Total NEI Value
		Value	Scaled value	Value	Scaled value	Value	Scaled value	Value	Value	Scaled value	Value	Scaled value	Value	Scaled value	Value	Scaled value
Sample size		**165**		**183**		**176**		**157**	**117**		**40**		**173**		**208**	
Overall	Dollars	$272	$125	$53	$31	$40	$4	$1,998	$175	$124	$104	$49	$57	$49	$472	$261
	% Bill Savings	48%	37%	12%	11%	0%	3%	NA[5]	33%	36%	5%	7%	10%	12%	136%	77%
Lower Bound NEI Value	Dollars	$196	$95	$32	$18	$12	$-3	$1,493	$134	$92	$33	$20	$34	$30	$354	$211
	% Bill Savings	41%	29%	7%	6%	-9%	1%	NA	27%	25%	-3%	3%	7%	8%	111%	65%
Upper Bound NEI Value	Dollars	$348	$154	$73	$44	$67	$12	$2,502	$216	$157	$174	$78	$80	$67	$589	$310
	% Bill Savings	55%	45%	17%	15%	9%	4%	NA	40%	46%	13%	11%	12%	16%	161%	89%

[1]The values reported in this table are weighted to strata and income group. In addition, cases that are at least three times the standard deviation of percent bill savings of the total scaled NEI value are excluded. The following weights were applied to the non-low-income population: a weight of 1.53 for the heating and cooling strata, a weight of 1.40 for the shell strata a weight of 0.10 for the shell plus heating and cooling strata. For the low-income sample, the following weights were applied: a weight of 1.22 for the heating and cooling strata, a weight of 0.98 for the shell strata a weight of 0.79 for the shell plus heating and cooling strata.

[2]Property Value was not scaled because, as a one-time NEI value, it was excluded from the survey question about total annual value of NEIs. Property value was limited to respondents who own their home.

[3]Equipment maintenance was only asked of respondents who installed heating or cooling equipment.

[4]Lighting was only asked of respondents who installed energy efficient lighting through the PAs' programs.

[5]Percent of annual bill savings is not shown for Property Value because it is a one-time NEI.

Table 9-6. Mean NEI Values from Survey[1]: Low-income Population

	Value per year	Thermal comfort		Noise reduction		Health impacts		Property Value [2]	Equipment maintenance [3]		Lighting life/quality [4]		Durability of home		Sum of NEIs [5]	Total NEI Value [6]
		Value	Scaled value	Value	Scaled value	Value	Scaled value	Value	Value	Scaled value	Value	Scaled value	Value	Scaled value	Value	Scaled value
Sample size		172		193		195		143	122		88		185		208	
Overall	Dollars	$205	$101	$63	$30	$29	$19	$949	$116	$54	$103	$56	$78	$35	$431	$242
	% Bill Savings	34%	20%	7%	4%	5%	4%	NA[5]	16%	12%	32%	15%	16%	8%	132%	52%
Lower Bound NEI Value	Dollars	$158	$67	$41	$16	$15	$5	$495	$75	$34	$72	$38	$43	$21	$341	$192
	% Bill Savings	29%	13%	5%	3%	2%	1%	NA	12%	8%	24%	9%	12%	5%	69%	44%
Upper Bound NEI Value	Dollars	$251	$134	$84	$45	$42	$33	$1,404	$156	$74	$133	$74	$113	$48	$521	$293
	% Bill Savings	38%	27%	9%	6%	8%	5%	NA	21%	16%	40%	20%	19%	11%	195%	60%

1The values reported in this table are weighted to strata and income group. In addition, cases that are at least three times the standard deviation of percent bill savings of the total scaled NEI value are excluded. The following weights were applied to the non-low-income population: a weight of 1.53 for the heating and cooling strata, a weight of 1.40 for the shell strata a weight of 0.10 for the shell plus heating and cooling strata. For the low-income sample, the following weights were applied: a weight of 1.22 for the heating and cooling strata, a weight of 0.98 for the shell strata a weight of 0.79 for the shell plus heating and cooling strata.

2Property Value was not scaled because, as a one-time NEI value, it was excluded from the survey question about total annual value of NEIs. Property value was limited to respondents who own their home.

3Equipment maintenance was only asked of respondents who installed heating or cooling equipment.

4Lighting was only asked of respondents who installed energy efficient lighting through the PAs' programs.

5Percent of annual bill savings is not shown for Property Value because it is a one-time NEI.

Table 9-7. Mean NEI Values from Survey[1]: Non-low-income Population, by Strata

	Thermal comfort		Noise reduction		Health impacts		Property Value [2]	Equipment maintenance[3]		Lighting life/quality[4]		Durability of home		Sum of NEIs[5]	Total NEI Value[6]
	Value	Scaled value	Value	Scaled value	Value	Scaled value	Value	Value	Scaled value	Value	Scaled value	Value	Scaled value	Value	Scaled value
Shell measures	$204	$130	$51	$22	$19	$9	$973	-	-	$94	$47	$21	$18	$260	$170
Heating and Cooling measures	$284	$103	$44	$35	$49	$-2	$2,534	$157	$120	$62	$34	$70	$64	$562	$300
Shell Plus Heating and Cooling	$872	$384	$197	$86	$186	$38	$4,929	$423	$183	$494	$186	$312	$192	$1,886	$864
Overall Population	$272	$125	$53	$31	$40	$4	$1,998	$175	$124	$104	$49	$57	$49	$472	$261

[1] Cases that are three times the standard deviation of percent bill savings of the total scaled NEI value are excluded. The following weights were applied to the overall population values: a weight of 1.53 for the heating and cooling strata, a weight of 1.40 for the shell strata a weight of 0.10 for the shell plus heating and cooling strata. Because of the removal out outliers, applying the strata weights to the respective strata level NEI values in order to estimate the overall population mean will not yield the overall population mean values reported in this table.

[2] Property Value was not scaled because, as a one-time NEI value, it was excluded from the survey question about total annual value of NEIs. Property value was limited to respondents who own their home.

[3] Equipment maintenance was only asked of respondents how installed heating or cooling equipment.

[4] Lighting was only asked of respondents who installed energy efficient lighting through the PAs' programs.

Table 9-8. Mean NEI Values from Survey[1]: Low-income Population, by Strata

	Thermal comfort		Noise reduction		Health impacts		Property Value [2]	Equipment maintenance [3]		Lighting life/quality [4]		Durability of home		Sum of NEIs [5]	Total NEI Value [6]
	Value	Scaled value	Value	Scaled value	Value	Scaled value	Value	Value	Scaled value	Value	Scaled value	Value	Scaled value	Value	Scaled value
Shell	$225	$190	$99	$65	$19	$31	$568	-	-	$117	$64	$71	$55	$374	$341
Heating and Cooling	$185	$69	$28	$11	$19	$11	$1,740	$167	$79	$67	$80	$82	$18	$415	$213
Shell Plus Heating and Cooling	$211	$40	$68	$13	$56	$17	$343	$69	$17	$122	$39	$80	$32	$531	$159
Overall Population	$205	$101	$63	$30	$29	$19	$949	$116	$54	$103	$56	$78	$35	$431	$242

[1] Cases that are at least three times the standard deviation of percent bill savings of the total scaled NEI value are excluded. The following weights were applied to the overall population values: a weight of 1.22 for the heating and cooling strata, a weight of 0.98 for the shell strata a weight of 0.79 for the shell plus heating and cooling strata.

[2] Property Value was not scaled because, as a one-time NEI value, it was excluded from the survey question about total annual value of NEIs. Property value was limited to respondents who own their home.

[3] Equipment maintenance questions were only asked of respondents who installed heating or cooling equipment.

[4] Lighting was only asked of respondents who installed energy efficient lighting through the PAs' programs.

Table 9-9 reports the results of further analysis of the property value NEI. It reveals relatively modest differences in the estimated impact of the efficiency improvements on property values of detached single family homes and all other housing types (i.e., townhouses or duplexes, homes in buildings with two to four units and homes in buildings with five or more units).

Table 9-9. Mean Property Value NEI, by Type of Housing and Population

	Detached Single Family Home	Multi-family Home
Sample Size	*184 (NLI); 164 (LI)*	*25 (NLI); 26 (LI)*
Non-low-income	$2,024	$1,863
Low-income	$924	$1,116

9.4 ASSOCIATION BETWEEN NEI VALUES AND INSTALLED MEASURES

Most NEI evaluations estimate NEI values at the participant level, rather than at the measure level, due to the diversity of measures installed by programs evaluated for NEIs and because of the interaction among measures to produce an individual NEI. For example, heating systems, insulation, air sealing, windows, and doors are among the measures that likely contribute to increased thermal comfort of a home. To estimate NEIs at the measure level, NMR assigned a portion of a given NEI value to an individual measure, based on the average energy bill savings for which the measure is responsible. In addition, NMR examined a second method, using OLS regression models to determine the monetary relationship between the energy efficient measure and the NEIs. However, NMR does not recommend using the results to estimate NEI values at the measure level, but instead reports the results in Appendix A: Additional Analysis of NEI Surveys

9.4.1 Association between NEI Values and Installed Measures: Percentage of Bill Savings

To estimate NEIs at the measure level, NMR assigned a portion of a given NEI value to an individual measure based on the average energy bill savings for which the measure is responsible. This method has also been used for the *2001 California Low Income Public Purpose Test (LIPPT) report for the Reporting Requirements Manual (RRM) Working Group Cost Effectiveness Committee* (TecMarket Works, SERA and Megdal Associates, 2001).

Computation of dollar values for a specific NEI begins with calculating the average portion of bill savings attributed to each measure for an individual NEI. As a first step, the NMR team made a determination whether a measure reasonably contributes to an individual NEI. For example, air sealing, cooling equipment, door, insulation, window, and weatherization measures contribute to changes in outside noise heard inside the home.[154] Next, the team calculated the average percentage of bill savings for each measure that contributes to an NEI. For example, air sealing represents, on average, 8% of the bill savings of measures that contribute to Thermal Comfort, while heating systems represent 39% of those bill savings; combined, all of the measures sum to 100% of the bill savings associated with each NEI.

[154] For the NLI sample, the following measures were not included in this analysis: doors, heating controls, pipe wrap, hot water tank wrap, pool timer and faucet aerators. For the LI sample, the following measures were not included in the analysis: cooling systems, heating and cooling systems, heating and hot water systems, heating controls, AC system sizing, pool timer, and hot water tank wrap. While these measures reasonably contribute to several NEIs, such as comfort or property value, the measures were either not installed in any homes included in this study or savings data at the measure level were not available.

Last, the team multiplied the average percentage of bill savings by the average NEI value to estimate an NEI value for each measure.

As illustrated in Table 9-10 and Table 9-11, the attribution of NEI values to measures by non- and low-income participants reveals that several measures typically account for the bulk of dollar benefits for a particular NEI: heating systems, insulation, weatherization measures,[155] and air sealing. In both the non-low-income and low-income sample, the largest absolute dollar value benefit from installed measures is found in the property value NEI. The non-low-income sample estimated an NEI value of $1,998 and low-income respondents an NEI value of $949. The installed heating systems, insulation and additional air sealing accounts for $1,193 of the property value NEI for non-low-income participants and $618 in value to low-income participants, or 60% and 65% of the total annual property value NEI respectively. Thermal comfort and equipment maintenance also derive a large NEI dollar value from participation in various PA programs. Heating systems, air sealing, insulation, and various weatherization programs have the greatest impact, a benefit to the thermal comfort NEI in both samples. Heating system measures provide the greatest benefit in the equipment maintenance NEI.

Looking more closely at the non-low-income sample (Table 9-10), it is evident that heating systems across the various NEIs provide the largest percentage and annual dollar benefit. Insulation measures provide the second largest additional benefit or roughly 20% of the total NEI value for each NEI contribution. Finally, the weatherization measure, which represents program level rather than measure level savings for National Grid and Berkshire gas program participants, contributes similarly to the NEIs as did insulation. Weatherization contributions range from 19% to 36% of the annual bill savings for the NEIs or $1 to $25 in annual benefit.

The low-income sample exhibits a similar distribution of NEI benefits with some notable exceptions (Table 9-10). For example, air sealing measures generally represent the highest percentage of bill savings, followed by insulation measures. Air sealing represents the largest percentage of bill savings for noise reduction at 55% of the NEI or valued at $16 annually. Another marked difference from non-low-income participants is the contribution of the lighting measure to the property value NEI. Lighting accounts for 24% of the total property value NEI and a $226 one-time benefit for the low-income sample while the non-low-income sample only derives 5% of total benefit from lighting (or $97 in dollar terms).

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155 The 'Weatherization' measure represents the program level savings for National Grid and Berkshire Gas customers; savings data for the individual measures installed were not available for these programs

Table 9-10. Attribution of NEI Values to Energy Efficiency Measures, Non-low-income Participants, Dollars per Measure[156]
(Weighted mean value of all respondents)

	Thermal Comfort		Noise Reduction		Health Impacts		Property Value		Equipment Maintenance		Lighting Quality		Durability of Home	
	% bill savings	$[157]	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$
Sample size, by NEI[158]	*209*	*180*	*147*	*187*	*209*	*190*	*209*	*171*	*139*	*125*	*47*	*41*	*209*	*188*
Air sealing	8%	$10.13	16%	$4.88	8%	$0.32	7%	$135.83	-	-	-	-	8%	$3.95
Appliance (refrigerators and freezers)	-	-	-	-	-	-	<1%	$1.44	-	-	-	-	-	-
Cooling systems	3%	$3.92	9%	$2.83	3%	$0.13	3%	$62.65	6%	$7.54	-	-	3%	$1.54
Duct sealing	<1%	$0.16	-	-	<1%	$0.01	<1%	$2.51	-	-	-	-	<1%	$0.06
Heating & cooling syst.	4%	$5.05	-	-	4%	$0.16	4%	$80.69	8%	$9.42	-	-	4%	$1.98
Heating & hot water sys.	1%	$1.83	-	-	1%	$0.06	1%	$29.17	3%	$3.41	-	-	1%	$0.72
Heating system	39%	$48.63	-	-	39%	$1.56	34%	$678.52	83%	$102.40	-	-	36%	$17.42
Hot water system	-	-	-	-	-	-	4%	$82.56	-	-	-	-	4%	$2.13
Insulation	20%	$25.15	37%	$11.54	20%	$0.80	19%	$378.05	-	-	-	-	20%	$9.82
Lighting	-	-	-	-	-	-	5%	$96.61	-	-	100%	$49.00	-	-
Service to heating or cooling system	<1%	$0.47	-	-	<1%	$0.01	<1%	$7.44	1%	$0.87	-	-	<1%	$0.18
Low flow showerhead	-	-	-	-	-	-	<1%	$0.03	-	-	-	-	-	-
AC system sizing	<1%	$0.19	-	-	<1%	$0.01	<1%	$3.01	<1%	$0.37	-	-	<1%	$0.07
Programmable thermo.	3%	$3.99	-	-	3%	$0.13	3%	$51.49	-	-	-	-	3%	$1.33
Window	1%	$0.68	2%	$0.54	1%	$0.02	<1%	$6.72	-	-	-	-	<1%	$0.21
Weatherization[159]	20%	$25.00	36%	$11.22	20%	$0.79	19%	$381.28	-	-	-	-	19%	$9.57
Total Value	100%	$125	100%	$31	100%	$4	100%	$1,998	100%	$124	100%	$49	100%	$49

156 For the purpose of attributing NEI values to individual measure, the evaluation team only included measures that reasonably have an impact on an individual NEI. For example, heating, cooling and shell measures are included in the NEI for thermal comfort. A cell with a '-' indicates that the measure does not reasonably impact the individual NEI. The following measures were not included in this analysis: doors, heating controls, pipe wrap, hot water tank wrap, pool timer and faucet aerators. While these measures reasonably contribute to several NEIs, such as comfort or property value, the measures were either not installed in any homes included in this study or savings data at the measure level were not available.

157 The values in the table are reported as dollars per measure.

158 The sample size for each individual NEI varies because analysis is limited to those respondents who had specific measures installed.

159 The 'Weatherization' measure represents the program level savings for National Grid and Berkshire Gas customers; savings data for the individual measures installed were not available for these programs.

Table 9-11. Attribution of NEI Values to Energy Efficiency Measures, Low-income Participants, Dollars per Measure[160]
(Weighted mean value of all respondents)

	Thermal Comfort		Noise Reduction		Health Impacts		Property Value		Equipment Maintenance		Lighting Quality		Durability of Home	
	% bill savings	$[161]	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$
Sample size, by NEI[162]	*211*	*177*	*141*	*191*	*211*	*199*	*213*	*147*	*140*	*122*	*108*	*89*	*212*	*189*
Aerator	-	-	-	-	-	-	3%	$26.61	-	-	-	-	-	-
Air sealing	30%	$30.23	55%	$16.39	30%	$5.69	15%	$144.93	-	-	-	-	30%	$10.61
Appliance (refrigerators and freezers)	-	-	-	-	-	-	3%	$26.61	-	-	-	-	-	-
Door	<1%	$0.01	<1%	$0.01	<1%	$0.01	<1%	$0.04	-	-	-	-	<1%	$0.01
Duct sealing	1%	$0.68	-	-	1%	$0.13	1%	$5.11	-	-	-	-	1%	$0.23
Heating system	28%	$28.01	-	-	28%	$5.27	26%	$249.20	51%	$27.43	-	-	28%	$9.72
Hot water system	-	-	-	-	-	-	<1%	$1.65	-	-	-	-	1%	$0.20
Insulation	25%	$25.38	45%	$13.56	25%	$4.77	24%	$223.63	-	-	-	-	25%	$8.76
Lighting	-	-	-	-	-	-	24%	$226.31	-	-	100%	$56.00	-	-
Pipe wrap	6%	$5.56	-	-	6%	$1.05	1%	$5.00	-	-	-	-	-	-
Service to heating or cooling system	6%	$6.18	-	-	6%	$1.16	<1%	$3.52	49%	$26.57	-	-	11%	$3.77
Low flow showerhead	-	-	-	-	-	-	<1%	$1.72	-	-	-	-	-	-
Programmable thermostat	5%	$4.87	-	-	5%	$0.92	4%	$34.47	-	-	-	-	5%	$1.68
Window	<1%	$0.08	<1%	$0.04	<1%	$0.01	<1%	$0.19	-	-	-	-	<1%	$0.03
Total Value	100%	$101	100%	$30	100%	$19	100%	$949	100%	$54	100%	$56	100%	$35

160 For the purpose of attributing NEI values to individual measure, the evaluation team only included measures that reasonably have an impact on an individual NEI. For example, heating, cooling and shell measures are included in the NEI for thermal comfort. A cell with a '-' indicates that the measure does not reasonably impact the individual NEI. The following measures were not included in the analysis: cooling systems, heating and cooling systems, heating and hot water systems, heating controls, AC system sizing, pool timer, and hot water tank wrap. While these measures reasonably contribute to several NEIs, such as comfort or property value, the measures were either not installed in any homes included in this study or savings data at the measure level were not available.

161 The values in the table are reported as dollars per measure.

162 The sample size for each individual NEI varies because analysis is limited to those respondents having specific measures installed.

9.5 OTHER HEALTH IMPACTS

This evaluation attempted an alternative method of estimating participant perspective health benefits—via reductions in sick days attributed to the energy efficiency retrofits, as well as societal benefits via reduced medical costs flowing from reduced incidence of heat stress, hypothermia, and asthma. Because of the extremely small number of respondents reporting program induced changes in health, NMR does not recommend using results from this method. Findings are reported in Appendix A.6 and A.7. NMR did not find convincing evidence of major health effects in terms of asthma, heat stress, and hypothermia. However, because of the potential health impacts of energy efficiency, NMR recommends reviewing the results of the current evaluation of the national WAP when the findings become available. Values for participant and societal health benefits might be derived from these findings once the study is complete (Ternes et al., 2007).

9.6 DEMOGRAPHICS

Respondents were asked to provide the number of household members in three different age groups. Overall, the LI respondents' households are more likely to be elderly, with nearly half of respondents (49%) reporting having a member of the household that is 65 years or older compared to 29% of NLI households. Also, the average NLI household is slightly larger than the LI household, with an average of 2.8 total household members compared to 2.3 for LI households. The majority of both the LI and the NLI respondents (69% and 63% respectively) had no household members of 18 years old or younger, but, among those households with children, most had one to three children living in the home (26% LI and 35% NLI), but only low-income households had more than three children living in the home (3%). More than one-third (37%) of the LI respondents, but only one-fifth of the NLI respondents, had no household members between the ages of 19 and 64, while over one-half (54%) of the LI respondents and three-quarters of the NLI respondents reported between one and three household members in this age group.

Table 9-12. Ages of Household Members

	18 years or younger		19 to 64 years		65 or older		Total number of household members	
	Non-LI	LI	Non-LI	LI	Non-LI	LI	Non-LI	LI
Sample size	*209*	*210*	*209*	210	*209*	*210*	*209*	*210*
Zero	63%	69%	20%	37%	70%	49%	0%	0%
One to three	35%	26%	75%	54%	29%	49%	68%	77%
Four to six	0%	3%	4%	3%	0%	0%	30%	20%
DK/Refused	1%	2%	1%	2%	1%	2%	2%	3%
Mean	0.6	0 .6	1.7	1.1	0.5	0.6	2.8	2.3

Although most respondents in both samples own their homes, a sizeable proportion of LI respondents rent their home (17%).

Table 9-13. Home Ownership

	Non-low-income	Low-income
Sample size	*209*	*213*
Own home	99%	83%
Rent home	1%	17%

Over three-quarters (77%) of the LI respondents and nearly nine out of ten NLI respondents (88%) live in detached, single-family homes. Less than 5% of each group lives in larger buildings with five or more units.

Table 9-14. Type of Building

	Non-low-income	Low-income
Sample size	*209*	*213*
Detached single-family home	88%	77%
Townhouse/duplex	5%	8%
Two-to-four family building	5%	9%
Part of a building with five or more units	1%	4%
Mobile home	0%	1%
DK/Refused	0%	1%

NLI respondents are more likely to live in larger homes, with close to one-half (47%) of the NLI respondents living in homes 2,000 square feet or larger, whereas just over one-quarter (27%) of LI respondents live in homes this size. The most common home size for both groups was between 1,500 and 1,999 square feet, with close to two out of five in the LI group, and about three out of ten in the NLI group, reporting that their home was in this range. About one-quarter of respondents (26% of the LI respondents and 23% of the NLI respondents) lived in homes of fewer than 1,500 square feet.

Table 9-15. Size of Home*

Square Feet	Non-low-income	Low-income
Sample size	*209*	*210*
Less than 1,500	23%	26%
1,500 – 1,999	29%	37%
2,000 – 2,499	25%	17%
2,500 – 2,999	11%	6%
3,000 – 4,000	6%	3%
4,000 – 4,999	2%	0%
5,000 or more	1%	1%
Don't know/refused	2%	10%

*Respondents who said "don't know" or "refused" to this question were asked the number of rooms in their home. Number of rooms was then converted to square feet for these respondents using the assumption that the average room is 300 square feet.

The NLI respondents reported higher levels of education than did the LI respondents. Whereas 41% of LI respondents had no more than a high school education, only 12% NLI respondents attained no more than a high school diploma. Also, only 34% of the LI respondents had completed college or graduate/professional school, while nearly three-quarters (73%) of the NLI respondents who had done so.

The right-most column shows the educational attainment levels for the overall MA population ages 25 years and older, as collected through the American Community Survey and reported by the US Census Bureau.[163] In terms of educational attainment, the LI respondents appear to be more similar to the MA population as a whole than might be expected, given their low-income status. Compared to the MA population, the LI group is slightly *less* likely to have a less-than-high-school education (10% for the LI group and 12% for MA), somewhat *more* likely to have graduated from high school (31% and 27% for the LI group and MA respectively), and slightly *more* likely to have some college but no degree (18% and 16%). However, they were also slightly *less* likely to be a college graduate (19% versus 22%) or to have a graduate or professional degree (13% versus 16%).

[163] United States Bureau of the Census. 2009. *2005-2009 American Community Survey 5-Year Estimates.* http://factfinder.census.gov/servlet/ADPTable?_bm=y&-geo_id=04000US25&-qr_name=ACS_2009_5YR_G00_DP5YR2&-ds_name=ACS_2009_5YR_G00_&-_lang=en&-_sse=on

Table 9-16. Level of Education

Degree attained	Non-low-income	Low-income	MA (US Census)*
Sample size	*210*	*209*	*4,416,135*
Less than high school	1%	10%	12%
High school graduate (includes GED)	11%	31%	27%
Technical or trade school graduate; Associates Degree	3%	6%	16%**
Some college, no degree	13%	18%	16%
College graduate	32%	19%	22%
Some graduate school	5%	2%	***
Graduate or professional degree	35%	13%	16%
Don't know/refused	1%	1%	_

*Education levels for the state of Massachusetts as estimated by the United States Bureau of the Census's 2005 to 2009 American Community Survey. http://factfinder.census.gov/servlet/ADPTable?_bm=y&-geo_id=04000US25&-qr_name=ACS_2009_5YR_G00_DP5YR2&-ds_name=ACS_2009_5YR_G00_&-_lang=en&-_sse=on
** Reported as Percent with Associate's Degree in The American Community Survey
**The ACS did not include "some gradual school" as an educational category.
***Percents for the educational categories above are based only on those who gave a valid response, and therefore sum to 100%. The percent who said "don't know" or "refuse" are shown in this row.

Overall, LI respondents appear to be older than NLI respondents. For LI respondents, the most frequently reported age range was sixty-five years and older (45%); for the NLI respondents, the most frequently reported range was fifty-five to sixty-five years. In addition, NLI respondents were more likely to be younger, with over one-quarter (28%) of NLI respondents between 25 and 44 years old while only 15% of the LI respondents who were of this age range.

Both the NLI and LI groups are also older than the MA population as a whole, particularly for the LI population. The LI population has much smaller proportions of people under 35 and larger proportions of people over 65. The NLI has a smaller proportion of people under the age of 35 and much higher proportion of people age 55 to 64.

Table 9-17. Age of Respondent

Age range	Non-low-income	Low-income	MA (US Census)*
Sample size	*209*	*210*	*4,857,420***
18 to 24	0%	0%	9%***
25 to 34	8%	4%	17%
35 to 44	20%	11%	20%
45 to 54	19%	20%	21%
55 to 64	30%	18%	15%
65 or over	23%	45%	18%
Don't know/refused ****	1%	1%	__

* Age for the population of the state Massachusetts as estimated by the United States Bureau of the Census's 2005 to 2009 American Community Survey. http://factfinder.census.gov/servlet/ADPTable?_bm=y&-geo_id=04000US25&-qr_name=ACS_2009_5YR_G00_DP5YR5&-ds_name=&-_lang=en&-redoLog=false
**Population of the state of Massachusetts limited to those 20 years or older for purposes of comparison to survey respondents
***Reflects the percent of population that is 20-24.
****Percents for the age categories above are based only on those who gave a valid response, and therefore sum to 100%. The percent who said "don't know" or "refuse" are shown in this row.

The results of a question asking about household income confirm that the NLI respondents have higher income levels, overall, than the LI respondents. Whereas nearly one-half (47%) of the LI respondents reported incomes of $25,000 or less, only four percent of the NLI respondents did so. In addition, less than ten percent (8%) of the LI respondents, versus nearly one-half (47%) of the LI respondents, reported incomes of $75,000 or higher.

The LI group also has lower income levels than the population of Massachusetts as a whole: More than one-half (55%) of the LI respondents who gave valid responses reported household incomes of $25,000 or less, versus only 20% who reported incomes this low in the MA population. Also, while only one in ten LI respondents reported household incomes of $75,000 or more, more than four times that many (43%) reported such incomes in the MA population

Table 9-18. Household Income

Household income	Non-low-income	Low-income	MA (US Census)*
Sample size	*209*	*210*	*2,465,654*
$14,999 or less	1%	29%	12%
$15,000 to $25,000	4%	26%	8%
$25,000 to $34,999	7%	13%	8%
$35,000 to $49,999	10%	14%	11%
$50,000 to $74,999	22%	7%	17%
$75,000 to $99,999	24%	5%	14%
$100,000 to $149,999	20%	4%	16%
$150,000 or more	13%	1%	13%
Don't know/refused**	18%	15%	--

* Income levels for the state of Massachusetts as estimated by the United States Bureau of the Census's 2005 to 2009 American Community Survey. http://factfinder.census.gov/servlet/ADPTable?_bm=y&-geo_id=04000US25&-qr_name=ACS_2009_5YR_G00_DP5YR3&-ds_name=ACS_2009_5YR_G00_&-_lang=en&-redoLog=false&-_sse=on

**Percents for the income categories above are based only on those who gave a valid response, and therefore sum to 100%. The percent who said "don't know" or "refuse" are shown in this row.

Two-thirds of the LI respondents (67%) were women, whereas the majority of the NLI respondents (59%) were men. This is consistent with broader demographic patterns of households headed by women being more likely to be considered low-income than households headed by males.

Table 9-19. Gender

	Non-low-income	Low-income
Sample size	*209*	*210*
Female	41%	67%
Male	59%	33%

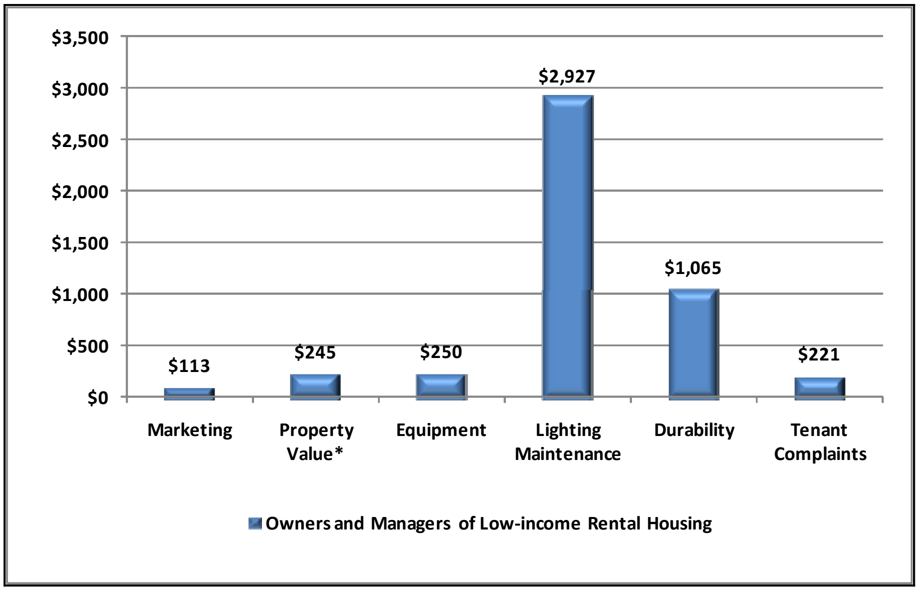
10. PARTICIPANT NEIs ESTIMATED FROM SURVEYS—OWNERS OF LOW-INCOME RENTAL HOUSING

In addition to surveying occupants of homes retrofitted through the PAs' programs, we surveyed 21 owners and managers of low-income rental housing concerning 27 low-income rental facilities (containing more than 7,000 housing units), via computer-assisted telephone interviewing. Compared to the occupant survey, smaller percentages of owners and managers of low-income rental housing believe the retrofits provide NEIs. However, some of the NEIs, particularly reduced maintenance costs associated with lighting and increased durability of the property, provide substantial benefits.

The NEI most frequently regarded as positive was *lighting maintenance*, with 80% of respondents reporting reduced maintenance for the new lighting that was installed. In addition, over two out of five respondents (42%) said that the improvements had resulted in increased durability of their buildings. Less than one-third of respondents considered the other NEIs to be positive; approximately one-third (31%) reported fewer tenant complaints, approximately one-quarter (23%) reported an expected increase in property value, one-sixth (15%) reported increased marketability, but none reported a positive impact on tenant turnover.

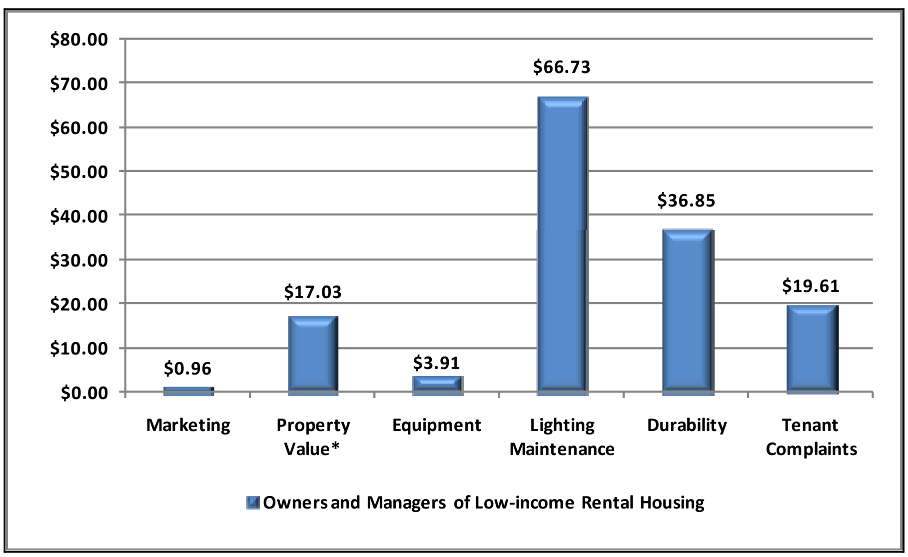
NEI values are reported on a per building basis in Figure 10-1 and on a per housing unit basis in Figure 10-2. The most highly valued NEI by the owners and managers of low-income rental housing was reduced costs associated with lighting maintenance with a mean annual value of $2,927 per building and $66.73 per housing unit, followed by increased durability of their building or property, with a mean annual value of $1,065 per building and $36.85 per housing unit. Improved marketing, equipment maintenance, property value (one-time benefit) and tenant complaints were all valued at $250 a year or less per building and under $20 per unit. One NEI, reduced tenant turnover, was valued at $0 for all respondents.

Figure 10-1. Owners and Managers of Low-income Rental Housing Valuation of NEIs. Per Building



*Property Value is a one-time benefit while the remaining NEIs are annual benefits.

Figure 10-2. Owners and Managers of Low-income Rental Housing Valuation of NEIs. Per Unit



*Property Value is a one-time benefit while the remaining NEIs are annual benefits

10.1 PERCEPTION OF EFFICIENCY IMPROVEMENTS AND NEIS

We asked owners and managers of multifamily low-income housing whether they thought the energy efficiency of their property had changed since the measures were installed. More than eight out of ten (82%) said it was more efficient than before, while one out of six (15%) said the efficiency had not changed (Table 10-1). No owners and managers thought the building was less efficient.

Table 10-1. Owners' Perception of Building's Energy Efficiency after Improvements

	Owners & Managers, LI Rental Housing
Sample size	*27*
More efficient	82%
Less efficient	0%
Same efficiency	15%
DK/Refused	4%

In response to a question asking whether they had noticed any changes in their energy bills since the measures were installed, nearly four out of ten building owners (37%) reported that the bills had decreased, while approximately one-quarter (26%) said the bills had not changed (Table 10-2). Nearly four out of ten (37%) did not know whether the bills had changed; presumably, many of these owners do not see the bills because the tenants pay them directly.

Table 10-2. Energy Bill Changes Noticed by Owners

	Owners & Managers, LI Rental Housing
Sample size	*27*
Lower bills	37%
Higher bills	0%
No change in bills	26%
Don't know	37%

Respondents whose tenants paid their energy bills directly (nine owners or 33% of all owners) were also asked whether their tenants had told them about any changes in their bills (Table 10-3). Of the five respondents whose tenants had mentioned the bills, four said that the bills were lower since the measures were installed.

Table 10-3. Energy Bill Changes Mentioned by Tenants to Owners

(Base: Owners whose tenants pay their own energy bills)

	Number of Owners & Managers, LI Rental Housing
Sample size	*9*
Lower bills	4
Higher bills	0
No change in bills	1
Tenants have not mentioned bills	4

Respondents were then asked about any comments their tenants might have made to them about the impacts of the measures that were installed. Over one-half (52%) said that their tenants mentioned that their bills had decreased (Table 10-4). About one out of ten respondents (11%) reported that their tenants were pleased with the new refrigerators that were installed. According to the landlords and managers, other positive impacts mentioned by tenants include thermal comfort, longer-lasting bulbs, improved equipment, and less equipment noise. Negative impacts mentioned by tenants include decreased reliability of equipment (11%), too much time for the lights to come on (4%), and that the lights were either too bright or too dim (4%).

Table 10-4. Tenants' Comments to Owners about Impacts of Improvements

NEI	
Sample size	*27*
Lower energy bills	52%
Increased reliability of equipment	11%
Pleased with new refrigerators	11%
More comfortable temperature	7%
Bulbs last longer	7%
Improved lighting	4%
Less equipment noise	4%
Takes too long for lights to come on	4%
Noisier equipment	4%
Lighting too bright or too dim	4%
Other comments	4%
No comments	0%

The owners were asked whether they had personally noticed any positive or negative impacts of the installments, other than changes in energy bills. Nineteen percent of owners mentioned that the lights were brighter and 11% said that that the lights required less maintenance (Table 10-5).[164] Other positive impacts mentioned by respondents include that their tenants were made more aware of energy efficiency (7%), that their tenants appreciate the new refrigerators (7%), that the new equipment or appliances were more reliable than the previous ones (4%), and that the temperature of the building was more comfortable than before (4%).

Table 10-5. Positive Impacts Noticed by Respondents

NEI	
Sample size	27
Brighter lights	19%
Less lighting maintenance	11%
Tenants more aware of energy efficiency	7%
Tenants appreciate new refrigerators	7%
Improved reliability of equipment/appliances	4%
Thermal comfort	4%
Other benefits	4%
Don't know	22%
No benefits noticed	52%

When asked about any negative impacts of the measures that were installed, about three out of four respondents (74%) said that they had not noticed any negative impacts (Table 10-6). Approximately two out of ten (19%) mentioned increased lighting maintenance, and less than one out of ten (7%) mentioned that there was mercury in the light bulbs.

Table 10-6. Negative Impacts Noticed by Respondents

NEI	
Sample size	27
Increased maintenance for lighting*	19%
Mercury in bulbs	7%
Other negative impacts	7%
Don't know	4%
No negative impacts	74%

*Increased maintenance includes cost of replacement bulbs and difficulty finding them.

[164] The lighting maintenance benefit likely applies to lights in common areas and to units in which the landlord is responsible for replacing light bulbs.

10.2 PERCEPTION OF NEIS

Before we asked owners and managers of multi-family buildings to estimate a monetary value for the NEIs they experienced in their buildings, we inquired whether they had noticed the impact since the efficiency improvements, as well as whether the impact was positive or negative. For example, for *marketability*, we asked respondents whether their rental units were more marketable, less marketable, or the same level of marketability as before the improvements. The NEI most frequently regarded as positive was *lighting maintenance*, with 80% of respondents reporting reduced maintenance for the new lighting that was installed (Table 10-7). In addition, over two out of five respondents (42%) said that the improvements had resulted in increased durability of their buildings. Less than one-third of respondents considered the other NEIs to be positive; approximately one-third (31%) reported fewer tenant complaints, approximately one-quarter (23%) reported an expected increase in property value, and one-sixth (15%) reported increased marketability. No respondents said that tenant turnover had changed since the improvements. Regarding negative impacts, slightly more than one out of ten respondents (12%) said that tenant complaints had increased, and a small percent (4%) said that the building had become less durable. Six respondents reported an additional impact not discussed previously in the survey. Of these, five reported a positive impact and one reported a negative impact. Specifically, these additional NEIs included helping the “bottom line” due to lower energy bills, increasing tenants’ awareness of energy efficiency, increased safety, respect from the community, and the bulbs not lasting long enough.

When asked whether the total impact of the NEIs discussed in the survey (not including any change in property value) was positive, negative, or had no effect, about four out of five respondents (81%) said that the total impact was positive, and the remaining respondents (19%) said that the total impact was neither positive nor negative.

Table 10-7. Respondents who Say Building Provides NEI

NEI	*Sample size*	Positive	Negative	No difference
Marketability of rental units	*26*	15%	0%	81%
Tenant turnover	*26*	0%	0%	96%
Property value	*26*	23%	0%	77%
Equipment maintenance	*22*	20%	0%	60%
Lighting maintenance	*15*	80%	0%	13%
Durability of home	*26*	42%	4%	54%
Tenant complaints	*26*	31%	12%	58%
Other NEI	*6*	83%	17%	--
Overall impact of NEIs*	*26*	81%	0%	19%

*Does not include property value.

10.2.1 NEI Value Calculation

Survey respondents were asked to estimate an annual monetary value for the NEIs they experience in their buildings.[165] The survey used a *relative valuation* method, asking respondents to value NEIs as a percentage of energy savings.[166] Each respondent was told an estimate of the annual energy bill savings for the retrofitted building based on the measures installed in the building.

The survey first asked the owners and managers of low-income rental housing if they believed their building had a particular NEI, then whether it was positive or negative. Taking the marketability NEI as an example, respondents were asked if they believed that the energy efficiency improvements had made their building more marketable than before, less marketable, or no different in the marketability. Those who believed their property or units in their building were more marketable were asked to place a value per year for the ease in marketing and renting either in dollars or as a percentage of energy savings. Those who believed their property or units in their building were less marketable were asked to place a value per year for the difficulty in marketing and renting either in dollars or as a percentage of energy savings. NEI values for those who believed there was no difference in the marketability of their property or units in their building from before the improvements were set to zero.

Finally, those respondents who were unable to place a value on the NEIs were further prompted with the following questions:

> "In terms of energy bill savings, which of the following would you say is closest to the value of having your property easier to market and rent, about a one fourth of energy bill savings, about a half of energy bill savings, about three-fourths of energy bill savings, about equal to energy bill savings, or more than energy bill savings? If the latter, how much more?"

The NEIs for respondents who still could not provide an answer are treated as missing in the calculation of average NEI values.

After providing values for the individual NEIs, respondents were asked to assign an annual value to the total impact of all the NEIs together (except for any changes in property value). We scaled each respondent's individual NEI values in proportion to the respondent's valuation of the total impact of all the NEIs in order to account for any overlap in NEIs or over-estimation of the individual NEIs. This scaling of individual NEI values occurred in the following way: Each NEI value was represented as a proportion of the sum of that respondent's individual NEI values. This proportion was then applied to the respondent's reported valuation of the total impact of all the NEIs, yielding the scaled value for each NEI. As with the occupant NEIs, the scaling factor is specific to each respondent and varies widely throughout the sample. For example, if a respondent said their total NEI value was $1,000 while reporting that reduced costs associated with lighting maintenance was worth $1,000 and the value of increased durability of their building was worth $500, the scaled NEI values for the respondent would be $667 for reduced costs for lighting maintenance and $333 for increased durability. A more detailed discussion of the scaling of NEI values can be found in section 9.3. NEI Value Calculation and in Appendix A.2 (Scaling of NEI Values).

It should be noted that the individual NEI values do not sum to equal the mean "Sum of NEIs" value presented in the table because the individual NEIs were based on respondents who expressed a value for a given NEI whereas the Sum of NEIs was estimated for all respondents. For example, lighting maintenance was only estimated for respondents who had installed energy efficient lighting through the

[165] The NEI of property value as asked in terms of a one-time change in value

[166] A discussion of the various methods used to estimate NEIs in the literature is found in the section 5.1: Methods Used to Measure Participant NEIs.

PAs' programs and estimated a value for reduced maintenance costs (12 buildings).Therefore, the number of NEIs that contribute to the Sum of NEIs varies from respondent to respondent.

NEI values of owners and managers of low-income rental housing are reported on a per building basis in Table 10-8 and on a per housing unit basis in Table 10-9. It should be noted that when the NEI values are converted from a per building to a per housing unit basis, the number of housing units used to calculate the average varies from NEI to NEI and is based on the number of housing units reported by the respondents who experienced the individual NEI. For example, the NEI of marketing is based on housing units for 21 respondents while the NEI of lighting maintenance is based on housing units for 12 respondents.

Two mean values are presented for each NEI—the first reflects reported NEI values (shown in dollars as well as in terms of mean percent of bill savings), while the second reflects respondents' reported values scaled in proportion to the total NEI value provided by respondents. Table 10-8 reports upper and lower bounds of values, calculated at a 90% confidence interval; the central estimate may be considered for planning purposes.

The most highly valued NEI by the owners and managers of low-income rental housing was reduced costs associated with lighting maintenance with a mean annual value of $2,927 per building and $66.73 per housing unit, followed by increased durability of their building or property, with a mean annual value of $1,065 per building and $36.85 per housing unit. Improved marketing, equipment maintenance, property value (one-time benefit), and tenant complaints were all valued at $250 a year or less per building and under $20 per unit. One NEI, reduced tenant turnover, was valued at $0 for all respondents. In addition, five respondents provided values for an additional impact not discussed previously in the survey. These other NEIs included helping the "bottom line" because of lower energy bills, increasing tenants' awareness of energy efficiency, increased safety, and respect from the community; these other NEIs had a mean annual value $3,439.

Table 10-8. Mean NEI Values from Survey[1]: Owners and Managers of Low-income Rental Housing, Per Building

	Value per year	Marketing		Equipment maintenance[3]		Lighting Maintenance[4]		Property Value[2]	Durability		Tenant Complaints		Other		Sum of NEIs[5]	Total Scaled[6] NEI Value
		Value	Scaled value	Value	Scaled value	Value	Scaled value	Value	Value	Scaled Value	Value	Scaled value	Value	Scaled value	Total**	Total***
Sample size		23		4		12		24	24		22		5		23	
Overall	Dollars	$104	$113	$500	$250	$2,997	$2,927	$245	$913	$1,065	$344	$221	$3,464	$3,439	$3,741	$3,280
	% Bill Savings	8%	8%	3%	2%	36%	28%	NA[7]	11%	10%	6%	4%	29%	18%	31%	36%
Lower Bound NEI Value	Dollars	$-16	$-19	$-342	$-171	$1,618	$1,144	$32	$225	$257	$-145	$-27	$-1,976	$-2,002	$1,792	$1,533
	% Bill Savings	-1%	-1%	-2%	-1%	18%	12%	NA	4%	3%	-1%	1%	-12%	8%	20%	24%
Upper Bound NEI Value	Dollars	$224	$244	$1,342	$671	$4,376	$4,710	$459	$1,601	$1,873	$833	$470	$8,904	$8,882	$5,689	$5,027
	% Bill Savings	16%	17%	9%	5%	54%	44%	NA	19%	17%	14%	7%	71%	29%	43%	49%

[1]The table does not report values for "reduced tenant turnover." All respondents valued reduced tenant turnover at $0.

[2]Property Value was not scaled because, as a one-time NEI value, it was excluded from the survey question about total annual value of NEIs.

[3]Equipment maintenance was only asked of respondents who installed heating or cooling equipment (programmable thermostats).

[4]Lighting was only asked of respondents who installed energy efficient lighting.

[5] Sum of NEIs is equal to the sum of the unscaled values of the individual annual NEIs (i.e., excluding property value).

[6] Total Scaled NEI Value is the value provided by respondents when asked for the total value of all NEIs, excluding property value.

[7]Percent of annual bill savings is not shown for Property Value because it is a one-time impact.

Table 10-9. Mean NEI Values from Survey[1]: Owners and Managers of Low-income Rental Housing, Per Housing Unit

	Value per year	Marketing		Equipment maintenance[3]		Lighting Maintenance[4]		Property Value [2]	Durability		Tenant Complaints		Other		Sum of NEIs[5]	Total Scaled[6] NEI Value
		Value	Scaled value	Value	Scaled value	Value	Scaled value	Value	Total	Total	Value	Scaled value	Value	Scaled value	Total	Total
*Sample size**		21		4		12		22	22		20		3		23	
Overall	Dollars	$0.90	$0.96	$7.81	$3.91	$97.56	$66.73	$17.03	$25.38	$36.85	$31.20	$19.61	$84.30	$86.61	$95.51	$94.28
	% Bill Savings	0.70%	0.08%	0.05%	0.03%	1.71%	1.21%	0.36%	0.42%	0.58%	0.20%	0.19%	0.10%	0.16%	1.04%	1.36%

[1]The table does not report values for "reduced tenant turnover." All respondents valued reduced tenant turnover at $0.

[2]Property Value was not scaled because, as a one-time NEI value, it was excluded from the survey question about total annual value of NEIs.

[3]Equipment maintenance was only asked of respondents who installed heating or cooling equipment (programmable thermostats).

[4]Lighting was only asked of respondents who installed energy efficient lighting.

[5] Sum of NEIs is equal to the sum of the unscaled values of the individual annual NEIs (i.e., excluding property value).

[6] Total Scaled NEI Value is the value provided by respondents when asked for the total value of all NEIs, excluding property value.

[7]Percent of annual bill savings is not shown for Property Value because it is a one-time impact.

10.2.2 Association between NEI Values and Installed Measures

As with the occupant NEIs, to estimate NEIs at the measure level, NMR assigned a portion of a given NEI value to an individual measure based on the average energy bill savings for which the measure is responsible. This method has also been used for the *2001 California Low Income Public Purpose Test (LIPPT) report for the Reporting Requirements Manual (RRM) Working Group Cost Effectiveness Committee* (TecMarket Works, SERA, and Megdal Associates, 2001). The team also ran a number of regression models in an attempt to quantify the relationship between each NEI category and specific measures installed by the owners and managers of low-income rental housing, but we were unable to find any significant relationships between measures and NEIs.

Table 10-10 reports the attribution of NEIs to individual measures for owners and managers of low-income rental housing on a per building basis and Table 10-11 reports the NEI values on a per housing unit basis. Compared to the occupant sample, the sample of owners and managers of multi-family rental housing had fewer types of measures installed: refrigerators and freezers, hot water systems and other water saving measures, lighting, programmable thermostats, and air sealing. Not surprisingly, with fewer types of measures installed, the total value of NEIs to owners and managers was a much smaller percentage of bill savings (36%) than for occupants—62% for low-income and 57% for others. As illustrated in the tables, energy efficient lighting has the greatest percentage contribution to the NEIs for owners and managers, at 46% of estimated energy savings and in turn 46% of each individual NEI (except for reduced lighting maintenance). Refrigerators and freezers provide the second largest percentage contribution to multi-family owner NEIs, at 35% of estimated bill savings.

Table 10-10. Attribution of NEI Values to Energy Efficiency Measures, Multi Family Owners, Per Building

	Marketing		Reduced Tenant Turnover		Increased Property Value		Equipment Maintenance and Reliability		Reduced Lighting Maintenance		Durability		Tenant Complaints	
	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$
Sample size	*27*	*23*	*27*	*25*	*27*	*24*	*0*	*4*	*19*	*5*	*27*	*23*	*27*	*22*
Refrigerators or Freezers	35%	$40	35%	$0	35%	$86	-	-	-	-	35%	$373	35%	$78
Hot Water System or Water Saving Measures	1%	$1	1%	$0	1%	$2	-	-	-	-	1%	$11	1%	$2
Energy Efficient Lighting	46%	$52	46%	$0	46%	$113	-	-	100%	$2,927	46%	$490	46%	$102
Thermostats	11%	$12	11%	$0	11%	$27	100%	$250	-	-	11%	$117	11%	$13
Air Sealing	7%	$8	7%	$0	7%	$17	-	-	-	-	7%	$75	7%	$16
Total Value	100%	$113	100%	$0	100%	$245	100%	$250	100%	$2,927	100%	$1,065	100%	$221

Table 10-11. Attribution of NEI Values to Energy Efficiency Measures, Multi Family Owners, Per Housing Unit

	Marketing		Reduced Tenant Turnover		Increased Property Value		Equipment Maintenance and Reliability		Reduced Lighting Maintenance		Durability		Tenant Complaints	
	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$
Sample size	*27*	*21*	*27*	*25*	*27*	*22*	*0*	*4*	*19*	*12*	*27*	*22*	*27*	*20*
Refrigerators or Freezers	35%	$0.34	35%	$0	35%	$5.96	-	-	-	-	35%	$12.90	35%	$6.86
Hot Water System or Water Saving Measures	1%	$0.01	1%	$0	1%	$0.17	-	-	-	-	1%	$0.37	1%	$0.20
Energy Efficient Lighting	46%	$0.44	46%	$0	46%	$7.83	-	-	100%	$66.73	46%	$16.95	46%	$9.02
Thermostats	11%	$0.11	11%	$0	11%	$1.87	100%	$3.91	-	-	11%	$4.05	11%	$2.16
Air Sealing	7%	$0.07	7%	$0	7%	$1.19	-	-	-	-	7%	$2.58	7%	$1.37
Total Value	100%	$0.96	100%	$0	100%	$17.03	100%	$3.91	100%	$66.73	100%	$36.85	100%	$19.61

10.2.3 Multi-family Firmographics

Respondents were asked how many units were in the building for which they estimated the NEIs. Out of the twenty-five buildings for which the number of units were known, more than one-half (14 buildings) had fifty units or fewer, while five were large buildings with 100 or more units.

Table 10-12. Number of Units in Building for which Respondent Estimated NEIs

Number of units	Number of Buildings	Percentage of Buildings
20 or less	7	26%
21 to 50	7	26%
51 to 99	6	22%
100 or more	5	19%
Don't know	2	7%
Total	27	100%
Mean # of units	57	
Median # of units	40	

Respondents were also asked how many buildings they own and manage, how many they manage but do not own, and how many they own but do not manage. Of the respondents who were able to report on the number of buildings owned or managed, all respondents own or manage multiple buildings, ranging from two to 130 buildings. The right-most column shows that the majority of respondents (53%) own and/or manage between one and ten buildings.

Table 10-13. Number of Buildings Respondents Own and/or Manage

Number of Buildings	Own and Manage	Manage, but do not own	Own, but do not manage	Total (Own and/or Manage)
0	14%	38%	62%	0%
1 to 5	19%	24%	9%	24%
6 to 10	29%	0%	0%	29%
11 to 20	10%	0%	0%	14%
More than 20	10%	10%	0%	14%
Don't know	19%	29%	29%	19%
Total	100%	100%	100%	100%
Mean # of buildings	9	10	.3	19

Table 10-14 shows the number of units respondents own and/or manage. Overall, respondents own or manage large numbers of low-income rental units; the median number of units owned or managed is 670 (two respondents own or manage tens of thousands of units, so the median is a more meaningful measure of central tendency for the sample).

Table 10-14. Number of Units Respondents Own and/or Manage

Number of Units	Own and Manage	Manage, but do not own	Own, but do not manage	Total Units (Own and/or manage)
0	14%	38%	62%	0%
1 to 99	10%	19%	5%	14%
100 to 499	14%	5%	0%	19%
500 to 999	19%	10%	5%	14%
1,000 to 9,999	19%	5%	0%	33%
10,000 or more	10%	0%	0%	10%
Don't know	14%	24%	29%	10%
Total	100%	100%	100%	100%
Mean # of units	7,438	443	35	7,447
Median # units	508	11	0	670

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APPENDIX A: ADDITIONAL ANALYSIS OF NEI SURVEYS

This appendix provides additional analysis of the surveys of low-income and non-low-income program participants, providing supplemental analysis on the strata within each population.

A.1 PERCEPTION OF EFFICIENCY IMPROVEMENTS AND NEIS

Respondents were asked whether they thought their home, after the improvements, was more energy-efficient, less energy-efficient, or the same level of efficiency as before the improvements. Within the LI respondents, respondents who had only shell measures installed (i.e., the shell group) were slightly more likely than those who had heating and cooling measures installed (i.e., the heating & cooling group) to say that the home's energy efficiency improved (78% versus 74%). Surprisingly, respondents in the shell plus heating & cooling group were the least likely to regard their home as more efficient than before, with approximately seven out of ten (71%) of respondents in this group saying their home was more efficient; this group was also the most likely to say that the efficiency had not changed, with one out of four respondents with both types of measure giving this response (versus 14% and 17% in the shell group and the heating & cooling groups, respectively).

The NLI respondents' responses were less surprising. While slightly fewer than nine out of ten respondents in the shell group and the heating & cooling group indicated that their home's efficiency had improved (89% and 87%, respectively), slightly more than nine out of ten (93%) among those who had both types of installments gave this indication. This latter group was also somewhat less likely than the others to say that the efficiency of their home had not changed (4%, versus 11% and 6% for the shell group and heating & cooling groups, respectively.

Table A-1. Perception of Energy-Efficiency after Improvements

	Low-Income				Non Low-Income			
Efficiency	Shell	Heating & Cooling	Shell Plus Heating & Cooling	Total	Shell	Heating & Cooling	Shell Plus Heating & Cooling	Total
Sample size	*72*	*72*	*69*	*213*	*70*	*68*	*71*	*209*
More efficient	78%	74%	71%	74%	89%	87%	93%	90%
Less efficient	1%	3%	3%	2%	0%	0%	0%	0%
Same efficiency	14%	17%	25%	18%	11%	6%	4%	7%
DK/Refused	7%	7%	1%	5%	0%	7%	3%	3%

For each NEI, respondents reported whether it was a positive impact, a negative impact, or had no effect. The results are shown in Table A-2 (for LI respondents) and Table A-3 (for NLI respondents) by the type of measures they had installed.

Among the LI respondents, those who had shell measures installed (i.e., the shell group) were somewhat more likely than the heating & cooling group to give positive ratings to several of the NEIs, including thermal comfort (shell group: 68%; heating & cooling group: 58%), noise (shell: 29%; heating & cooling: 15%), health impacts (shell: 21%; heating & cooling: 13%), and property value (shell: 71%; heating & cooling: 44%). However, while about two out of three respondents (66%) in the heating & cooling group regarded the lighting quality and lifetime as a positive impact, fewer than three out of five (57%) in the shell group did so. Approximately four out of five in both groups (shell: 82%; heating & cooling: 78%) said that the overall impact of the NEIs (not including property value) was positive. Respondents who had both shell measures and heating & cooling measures installed were somewhat more likely than the other groups to report that thermal comfort, noise, health, and lighting were positive impacts. The proportion of the shell plus heating & cooling group who said that the overall impact of the NEIs was positive (81%) was similar to that in the other two groups.

Among the NLI respondents, the shell group was again somewhat more likely than the heating & cooling group to say that several of the NEIs were positive, including thermal comfort (shell: 83%; heating & cooling: 65%), noise (shell: 34%; heating & cooling: 19%), and lighting quality and lifetime (shell: 55%; heating & cooling: 46%). However the shell group was somewhat less likely than the heating & cooling group to say that property value and durability of the home were positive impacts. Slightly less than nine out of ten (87%) in the shell group, and slightly more than nine out of ten in the heating & cooling group (93%) considered the total impact of the NEIs (not including property value) to be positive.

The shell plus heating & cooling group was somewhat more likely than both of the other groups to report property value, lighting, and durability of the home as positive impacts, and this group was the most likely of all the groups to say that the total impact of the NEIs was positive (96%).

.

Table A-2. Low-Income Respondents who Say Home Provides NEIs, by Measure Type

NEI	Shell				Heating & Cooling				Shell Plus Heating & Cooling			
	n	Pos	Neg	No diff	*n*	Pos	Neg	No diff	*n*	Pos	Neg	No diff
Thermal comfort	72	68%	3%	25%	72	58%	0%	39%	69	70%	1%	28%
Noise (from equipment or outside home)	72	29%	0%	69%	72	15%	1%	82%	69	32%	1%	64%
Health (colds/flus/asthma)	72	21%	4%	71%	72	13%	3%	82%	69	26%	4%	67%
Property value (homeowners only)	69	71%	0%	26%	59	44%	3%	42%	48	52%	0%	48%
Equipment reliability/maintenance	0	NA	NA	NA	72	54%	1%	39%	69	32%	10%	55%
Lighting quality and lifetime	14	57%	14%	21%	32	66%	9%	22%	62	71%	10%	19%
Durability of home	72	35%	0%	63%	72	39%	3%	51%	69	28%	3%	67%
Overall impact of NEIs*	72	82%	1%	13%	72	78%	3%	15%	69	81%	1%	13%

*Does not include property value.

Table A-3. Non-low-Income Respondents who Say Home Provides NEIs, by Measure Type

NEI	Shell				Heating & Cooling				Shell Plus Heating & Cooling			
	n	Pos	Neg	No diff	*n*	Pos	Neg	No diff	*n*	Pos	Neg	No diff
Thermal comfort	*70*	83%	0%	14%	*68*	65%	2%	28%	*71*	80%	0%	17%
Noise (from equipment or outside home)	*70*	34%	0%	63%	*68*	19%	4%	72%	*71*	35%	1%	59%
Health (colds/flus/asthma)	*70*	17%	1%	76%	*68*	18%	2%	74%	*71*	24%	1%	68%
Property value (homeowners only)	*68*	66%	0%	24%	*68*	79%	0%	18%	*71*	93%	0%	4%
Equipment reliability/maintenance	*0*	NA	NA	NA	*68*	72%	2%	25%	*71*	75%	4%	17%
Lighting quality and lifetime	*11*	55%	18%	27%	*13*	46%	0%	46%	*23*	91%	4%	4%
Durability of home	*70*	29%	1%	64%	*68*	41%	0%	57%	*71*	61%	0%	34%
Overall impact of NEIs*	*70*	87%	0%	11%	*68*	93%	2%	6%	*71*	96%	0%	4%

*Does not include property value.

A.2 SCALING OF NEI VALUES

This section is meant to provide a more detailed explanation of how a respondent's individual NEI values were scaled to their total NEI value, as presented in section 9.3: NEI Value Calculation. Table A-4 represents an abbreviated data set and demonstrates the scaling and summing method employed in this report.

In order to not overestimate the value of individual NEIs, the individual NEI values provided by the respondent were scaled to the total NEI value provided by the respondent. In cases when the respondent did not provide a total NEI value, the sum of the respondent's reported NEIs was used for scaling (see Table A-4 row D for an example).

Table A-4 illustrates that the number of NEIs that contribute to the total NEIs and the sum of the individual NEIs varies from respondent to respondent. In some cases, the respondent was not able to provide a value for an NEI (for example, "comfort" in row D). In other cases, respondents were not asked about individual NEIs. Respondents were only asked to provide NEI values for NEIs they could logically experience based on the measures installed by the PAs' programs. For example, if a respondent did not install lighting through the program, they were not asked about lighting quality and lifetime. Similarly, if the respondent did not install heating and cooling equipment through the program, they were not asked about equipment maintenance.

Rows B through G provide examples of respondents who could not provide NEI values or were not asked about several individual NEIs. Row H shows the sample size for the mean values, the mean values are based on all relevant cases reported in the table (i.e. the number of respondents for a given NEI). The number of relevant cases varies by NEI and the only mean value that encompasses the entire sample is the sum NEI. Because the scaled value is based on the relationship between the individual NEI values and the total NEI value provided by each respondent, there is a high level of variation in the scaling. For example, row A shows a respondent who valued their health NEI at $2,166 while assigning their overall value of total NEI $1,083 meaning that their scaled health NEI is $1,833 less than the value they assigned.

.

Table A-4. Example of NEI Scaling, Unweighted

	Respondent reported NEI Values						Sum of Reported NEIs	Reported Total value of NEIs						
Row label	Comfort	Noise	Health	Equipment	Light	Durability	SUM NEI	Total NEI	Comfort Scaled	Noise Scaled	Health Scaled	Equipment Scaled	Light Scaled	Durability Scaled
A	1,083	1,083	2,166	1,083	1,083	542	7,040	1,083	167	167	333	167	167	83
B	1,200	500	1,200	-	-	0	2,900	2,500	1,034	431	1,034	-	-	0
C	143	285	143	-	-	-	570	285	71	143	71	-	-	-
D	-	28	141	-	-	-	169	-	-	28	141	-	-	-
E	0	0	132	-	-	-	132	132	0	0	132	-	-	-
F	425	0	106	213	-	106	851	425	213	0	53	106	-	53
G	102	0	102	-	-	142	345	102	30	0	30	-	-	42
	Mean Values based on the number of valid observations in the preceding rows.													
H	n=6	n=7	n=7	n=2	n=1	n=4	n=7	n=7	n=6	n=7	n=7	n=2	n=1	n=4
I	492	271	570	648	1,083	198	1,715	755	253	110	256	137	167	45

A.3 NEI VALUES FOR INDIVIDUAL SAMPLE STRATA

The following set of tables (Table A-5, Table A-6, Table A-7) break out the mean NEI value by strata and income group. Among the shell sample (Table A-5) the LI and NLI groups attribute similar values to their NEIs except for property value where the NLI group mean is just over $400 higher than the LI group. Within the heating and cooling shell (Table A-6) the NLI group's mean valuation of thermal comfort is $100 higher than the LI group and their mean valuation of property value in nearly $800 higher than the LI group. There is much less uniformity of NEI means between income groups in the shell; plus heating and cooling combination strata (Table A-7) than there is in the other strata. The NLI NEI means for thermal comfort, property value, lighting life/quality, and equipment maintenance are hundreds of dollars more than their LI counterparts in the combination strata.

It should be noted that the individual NEI values do not sum to equal the mean “Sum of NEIs” and “Total NEI” values presented in the tables, because the individual NEIs were based on respondents who expressed a value for a given NEI, whereas the Sum of NEIs and Total NEI values were estimated for all respondents.

Table A-5. Mean NEI Values from Survey: Shell Sample[1]

	Value per year	Thermal comfort: Value	Thermal comfort: Scaled value	Noise reduction: Value	Noise reduction: Scaled value	Health impacts: Value	Health impacts: Scaled value	Property Value[2]: Value	Equipment maintenance[3]: Value	Equipment maintenance[3]: Scaled value	Lighting life/quality[4]: Value	Lighting life/quality[4]: Scaled value	Durability of home: Value	Durability of home: Scaled value	Sum of NEIs[5]: Value	Total NEI Value[6]: Scaled value
Sample size		50		61		58		44	-		9		54		63	
Non-LI Shell Sample	Dollars	$204	$130	$51	$22	$19	$9	$973	-	-	$94	$47	$21	$18	$260	$170
	% Bill Savings	63%	40%	18%	7%	-7%	3%	452%	-	-	<1%	7%	8%	6%	98%	52%
Sample size		58		67		63		59	-		9		65		71	
LI Shell Sample	Dollars	$225	$190	$99	$65	$19	$31	$568	-	-	$117	$64	$71	$55	$374	$341
	% Bill Savings	43%	32%	10%	7%	8%	4%	84%	-	-	11%	5%	13%	10%	59%	58%

[1]Cases that are three times the standard deviation of percent bill savings of the total scaled NEI value are excluded.

[2]Property Value was not scaled because, as a one-time NEI value, it was excluded from the survey question about total annual value of NEIs. Property value was limited to respondents who own their home.

[3]Equipment maintenance was only asked of respondents who installed heating or cooling equipment.

[4]Lighting was only asked of respondents who installed energy efficient lighting through the PAs' programs.

[5] Sum of NEIs is equal to the sum of the unscaled values of the individual annual NEIs (i.e., excluding property value)

[6] Total NEI Value is the value provided by respondents when asked for the total value of all NEIs, excluding property value.

Table A-6. Mean NEI Values from Survey: Heating and Cooling Sample[1]

		Thermal comfort		Noise reduction		Health impacts		Property Value[2]	Equipment maintenance[3]		Lighting life/quality[4]		Durability of home		Sum of NEIs[5]	Total NEI Value[6]
	Value per year	Value	Scaled value	Value	Scaled value	Value	Scaled value	Value	Value	Scaled value	Value	Scaled value	Value	Scaled value	Value	Scaled value
Sample size		57		59		58		56	57		11		59		63	
Non-LI Heating & Cooling Sample	Dollars	$204	$284	$103	$44	$35	$49	$-2	$2,534	$157	$120	$62	$34	$70	$64	$562
	% Bill Savings	63%	37%	35%	6%	13%	5%	2%	1,885%	34%	37%	7%	7%	10%	16%	167%
Sample size		59		64		68		43	60		23		57		70	
LI Heating & Cooling Sample	Dollars	$185	$69	$28	$11	$19	$11	$1,740	$167	$79	$67	$80	$82	$18	$415	$213
	% Bill Savings	31%	17%	4%	3%	1%	3%	479%	21%	17%	42%	23%	17%	4%	205%	54%

[1]Cases that are three times the standard deviation of percent bill savings of the total scaled NEI value are excluded.

[2]Property Value was not scaled because, as a one-time NEI value, it was excluded from the survey question about total annual value of NEIs. Property value was limited to respondents who own their home.

[3]Equipment maintenance was only asked of respondents who installed heating or cooling equipment.

[4]Lighting was only asked of respondents who installed energy efficient lighting through the PAs' programs.

[5] Sum of NEIs is equal to the sum of the unscaled values of the individual annual NEIs (i.e., excluding property value)

[6] Total Scaled NEI Value is the value provided by respondents when asked for the total value of all NEIs, excluding property value.

Table A-7. Mean NEI Values from Survey: Shell plus Heating and Cooling Combination Sample[1]

		Thermal comfort		Noise reduction		Health impacts		Property Value[2]	Equipment maintenance[3]		Lighting life/quality[4]		Durability of home		Sum of NEIs[5]	Total NEI Value[6]
	Value per year	Value	Scaled value	Value	Scaled value	Value	Scaled value	Value	Value	Scaled value	Value	Scaled value	Value	Scaled value	Value	Scaled value
Sample size		58		63		60		57	60		20		60		68	
Non-LI Shell Plus Heating & Cooling Sample	Dollars	$872	$384	$197	$86	$186	$38	$4,929	$423	$183	$494	$186	$312	$192	$1,886	$864
	% Bill Savings	39%	44%	13%	19%	7%	2%	825%	17%	9%	15%	10%	18%	19%	185%	89%
Sample size		55		62		64		41	62		56		63		67	
LI Shell Plus Heating & Cooling Sample	Dollars	$211	$40	$68	$13	$56	$17	$343	$69	$17	$122	$39	$80	$32	$531	$159
	% Bill Savings	25%	10%	7%	3%	8%	4%	132%	8%	4%	29%	11%	16%	11%	110%	42%

[1]Cases that are three times the standard deviation of percent bill savings of the total scaled NEI value are excluded.

[2]Property Value was not scaled because, as a one-time NEI value, it was excluded from the survey question about total annual value of NEIs. Property value was limited to respondents who own their home.

[3]Equipment maintenance was only asked of respondents who installed heating or cooling equipment.

[4]Lighting was only asked of respondents who installed energy efficient lighting through the PAs' programs.

[5] Sum of NEIs is equal to the sum of the unscaled values of the individual annual NEIs (i.e., excluding property value)

[6] Total Scaled NEI Value is the value provided by respondents when asked for the total value of all NEIs, excluding property value.

A.4 ASSOCIATION BETWEEN NEI VALUES AND BILL SAVINGS

Table A-8 displays the estimated average annual energy bill savings for the survey respondents, by population and strata. Overall, low-income respondents are expected to save $473 annually and non-low-income respondents are expected to save $673 annually. For the low-income respondents, the shell stratum has the highest average annual energy savings ($583) while for the non-low-income respondents the shell plus heating and cooling stratum has the highest average annual energy savings ($1,275).[167]

Table A-8. Mean NEI Values from Survey: Shell plus Heating and Cooling Combination Sample[1]

Strata	Low-income	Non-low-income
Sample size	**213**	**209**
Shell	$583	$380
Heating and Cooling	$392	$347
Shell plus Heating and Cooling	$445	$1,275
Overall Population	$473	$673

Table A-9 displays the results of a series of bivariate Ordinary Least Squares (OLS) regressions for which the value of a specific NEI is the dependent variable and total bill savings is the independent variable. We report results for the LI and NLI populations separately. These regression analyses are useful in gauging the magnitude of effect of bill savings on the value of individual NEIs. For example, every dollar increase in bill savings results in a $2.08 in the value of Thermal Comfort among the LI population. Total bill savings had the largest impact on Lighting among the LI and NLI groups and had the smallest impact on the Health NEI for the LI population and Noise Reduction for the NLI population. The value attributed to the relationship between bill savings and NEIs is fairly consistent between the LI and NLI groups, except for Noise Reduction and Property Value. The discrepancy between the income groups could be due to the difference in housing characteristics, as 23% of the low-income respondents live in multifamily homes (*i.e.* not a single-family, detached home) in which noise reduction would be a more noticeable NEI, while only 12% of the NLI sample lives in multifamily structures. Moreover, more NLI respondents than LI respondents own their homes, increasing the importance of property value to the NLI sample.

It is important to note that, by breaking out the individual NEIs in these bivariate regression models[168], we are showing a real relationship, but the context of the relationship (that a single NEI is not the only one experiencing an impact) is missing and therefore the relationship between bill savings and specific NEI should be interpreted with caution. Even though the analysis is a series of bivariate regressions they are not additive for a total effect. The bivariate regression for specific NEIs are based on respondents who experienced and provided a value for a specific NEI, whereas the bivariate regression for total NEIs is for the entire relevant sample. For a more accurate picture of how bill savings impacts overall NEI values, it would be best to consider the relationship between bill savings

[167] Estimated annual bill savings ranged from a low of $13.93 to a high of $4,910.74 for non-low-income respondents and from a low of $3.15 to a high of $2,150.81 for low-income respondents.

[168] Bivariate means that only the single dependent and independent variables entered the model; it is often called "simple" regression.

and the Total NEI Value. For example, a dollar increase in bill savings increases the reported value of NEIs by $0.48 among the LI group and $0.46 among the NLI group.

Table A-9. Mean NEI Values from Survey: Shell plus Heating and Cooling Combination Sample[1]

	Thermal Comfort	Noise Reduction	Health Impacts	Property Value	Equipment Maintenance	Lighting	Durability of Home	Total NEI Value
Low-income	2.08	1.23	0.83	1.00	5.74	7.60	1.48	0.48
Non-low-income	1.92	0.62	0.95	2.67	5.93	8.69	1.11	0.46

*These regressions were weighted by strata and income group. All values are significant at the .05 level. The constant was set to zero.

A.5 ASSOCIATION BETWEEN NEI VALUES AND INSTALLED MEASURES: ORDINARY LEAST SQUARES (OLS) REGRESSION

Table A-10 and Table A-11 show the results of the OLS regression models computed with the NEI value as the dependent variable and related energy efficiency measures (all transformed to dummy variables) as the dependent variables. Table A-10 shows the results for the LI sample, while Table A-11 shows the results for the NLI sample. We ran a separate model for each individual NEI. The models were weighted by strata and income group.[169] Performing a regression on these data allows us to determine the monetary relationship between the energy efficient measure and the NEI. For example, the results indicate that installing Air Sealing in low-income households increased the value of the Noise NEI by $784 compared to those without Air Sealing. A dash in the table indicates that the measure did not have a significant relationship with the individual NEI; for example, Air Sealing appears to be significantly related to Noise and Health, but not to Comfort, Property Value, Equipment Maintenance and Durability for the low-income respondents.

Among the LI sample, Air Sealing and Service to Heating and Cooling systems have the most consistent effect among the NEIs. Air Sealing serves to increase the value of Noise, Health, and Total NEIs while Service Heating and Equipment does the same for Comfort, Equipment, and Durability of the Home. In contrast, programmable thermostats and new windows appear to negatively affect a number of NEIs.

[169] We also forced the constant to be equal to zero, which mean the regression crosses the y axis at zero. This eases interpretation so we can easily identify the amount of savings rather than having to calculate the change in savings.

Table A-10. Dollar Relationship between Measures and NEIs*—Low-income

	Comfort	Noise	Health	Property Value	Equipment	Lighting	Durability	Total NEIs
Air Sealing**	-	784	438	-	-	-	-	143
Heating	-	-	-	2,088	2,972	-	1,908	205
Hot Water	-	-	-	-	-	-	-	-201
Insulation	1,826	-	879	-	-	-	-	-
Lighting	-	-	-	-	-	1,829	-	134
Service Heating and Cooling	1,792	-	-	-	1,073	-	771	-
Thermostat	-	-	-780	-1,926	-	-	-	-
Window	-2,941	-754	-982	-	-	-	-777	-

*All coefficients in this model are significant at the .1 level and most are significant at the .05 level.
**The significant measures reported in Table 1 and 2 do not represent every measure that was tried in the model. All measures from the following list, Aerator, Air Sealing, Appliance (Refrigerators and Freezers), Cooling, Door, Duct Sealing, Heating and Cooling, Heating and Hot Water, Heating, Heating Controls, Hot Water, Insulation, Lighting, Pipe Wrap, Rebate, Service Heating Cooling, Showerhead, System Sizing, thermostat, Pool Timer, Tank Wrap, Window, that were logically linked to each specific NEI was attempted in the model though we made the choice to adopt a parsimonious method and only left significant measures in the model.

Among the NLI sample, Heating systems and Insulation have the most consistent positive impact across NEIs. Heating systems positively impacts the values of the Comfort, Health, Property Value, Equipment, Durability and Total NEIs while Insulation positively impacts the Comfort, Noise, Health, Property Value, and Total NEIs. In contrast, pipe wrap, programmable thermostats, and new windows appear to negatively affect a number of NEIs.

Table A-11. Dollar Relationship between Measures and NEIs*—Non-low-income

	Comfort	Noise	Health	Property Value	Equipment	Lighting	Durability	Total NEIs
Aerator**	-	-	-	-3,698	-	-	-	3,522
Air Sealing	-	-	-	-	-	-	1,444	-
Appliance	-	-	-	-	-	-	-	-466
Duct Sealing	-1,599	-	-	18,872	-	-	-	-68
Heating	1,100	-	656	2,654	1,093	-	597	372
Heating and Hot Water	-	-	-	-	-	-	-	344
Insulation	2,467	416	927	1,350	-	-	-	211
Lighting	-	-	-	-	-	1,307	-	-
Pipe Wrap	-2,452	-	-903	-1,313	-	-	-	-115
Thermostat	-1,163	-	-669		-	-	-	-
Window	-	-	-	-1,526	-	-	-	-168

*All coefficients in this model are significant at the .1 level and most are significant at the .05 level.
**The significant measures reported in Table 1 and 2 do not represent every measure that was tried in the model. All of the following measures—Aerator, Air Sealing, Appliance (Refrigerators and Freezers), Cooling, Door, Duct Sealing, Heating and Cooling, Heating and Hot Water, Heating, Heating Controls, Hot Water, Insulation, Lighting, Pipe Wrap, Rebate, Service Heating Cooling, Showerhead, System Sizing, thermostat, Pool Timer, Tank Wrap, Window—that were logically linked to each specific NEI were attempted in the model, although we chose to adopt the parsimonious method of leaving only significant measures in the model.

Comparing Table A-10 for the LI sample and Table A-11 for the NLI sample demonstrates that there is little consistency between the measures that increase NEI values among the two groups. The only significant relationships found in both samples include the following:

- Positive impact of insulation on comfort
- Positive impact of insulation on health
- Negative impact of programmable thermostat on health
- Positive impact of heating systems on property values
- Positive impact of heating systems on equipment maintenance
- Positive impact of lighting measures on lighting quality
- Positive impact of heating systems on the durability of the system

Interpreting the results of all of these OLS regression is difficult in part because this method seeks to isolate the impact of individual measures, but, in reality, their combination when installed in homes contributes greatly to the production of a given NEI. While the results may help identify some of the key measures for an individual NEI, NMR does not recommend using these values for individual measures.

A.6 OTHER PARTICIPANT PERSPECTIVE HEALTH IMPACTS

This section reports on an alternative method to estimating participant perspective health benefits via reductions in sick days attributed to energy efficiency measures installed by the programs. Because of the extremely small number of respondents reporting program induced changes in health, NMR does not recommend using the NEI values reported in this section but we do present them in the interest of providing information to inform further discussion and future exploration into this issue.

Energy efficiency programs may have direct impacts on health through improved home environments, reduced exposure to hypothermia or hyperthermia—particularly during heat waves and cold spells—improved indoor air quality, and potential reductions in moisture and mold, leading to amelioration of asthma triggers and other respiratory ailments. Therefore, participants in energy efficiency programs may realize a number of health related improvements due to installed measures, resulting in fewer days off work due to illness.

Respondents were asked to report the number of sick days they or a household member had taken after the energy-efficient improvements and during a period of a year before the improvements. Those whose number of sick days had changed since the improvements were further asked whether they thought the change in sick days was related to the improvements. The evaluation team estimated the value of the participant health benefits based on changes in self reported sick days that respondents attributed to the installations and associated changes in lost wages.

It should be noted that the recommended (NEI) values for all of the health-related impacts represent conservative estimates. Importantly, any reported changes in sick days or the number of times a participant sought medical care for heat stress and other conditions that were not attributed to the improvements were not included in the value estimates. Rather, value estimates were solely based on those participants who attributed changes in number of sick days or medical visits to the efficiency improvements; the value for all other respondents (including those who had no changes or who considered their changes to be unrelated to the improvements) was set to zero. In addition, conclusions are interpreted cautiously because some of the sub-samples are extremely small, in some cases only one respondent.

The number of reported sick days before and after the improvements is illustrated in Table A-11 (for NLI respondents) and Table A-13 (for LI respondents). Each table also shows sick days before and after the improvements for the subset of respondents who 1) had a change in sick days from before to after the improvements, and 2) said the change in sick days was related to the improvements. Again, this subset was used for estimating the total reduction in lost wages.

Table A-11 shows the change in sick days for all respondents who gave a valid response to the question (i.e., did not say “don’t know” or “refuse”), as well as for the sub-sample of NLI participants who attributed their change in sick days to the improvements. The two right-most columns show that, among the eleven respondents who attributed their change in sick days to the improvements, only 10% had no sick days before the improvements, while close to one-half (45%) had no sick days after. Also, whereas about one out of three respondents who attributed changes in sick days to the improvements (34%) missed at least six days before the improvements, only 10% missed that many after.

For the LI respondents, the mean number of sick days after the improvements decreased from a mean of 2.0 to 1.7 (Table A-13). Among the six LI respondents who attributed their change in sick days to the improvements, the number of sick days was reduced from 4.1 to 0. All of these respondents had one to five sick days before the improvements, whereas none had any sick days after.

Table A-12. Sick Days Before and After Improvements, Non-low- income

Non-low Income	Reported sick days, all respondents		Reported sick days, respondents who attributed change in sick days to improvements	
	Sick days before	Sick days after	Sick days before	Sick days after
Sample size	*173*	*202*	*11*	*11*
0 sick days	66%	77%	10%	45%
1 to 5 sick days	21%	17%	56%	45%
6 to 10 sick days	9%	3%	23%	10%
11 to 20 sick days	2%	2%	11%	0%
More than 20 sick days	2%	2%	0%	0%
Mean sick days	2.4	1.3	4.4	2.4

Table A-13. Sick Days Before and After Improvements, Low-income

Low-income	Reported sick days, all respondents		Reported sick days, respondents who attributed change in sick days to improvements	
	Sick days before	Sick days after	Sick days before	Sick days after
Sample size	*185*	*206*	*6*	*6*
0 sick days	76%	83%	0%	100%
1 to 5 sick days	15%	8%	100%	0%
6 to 10 sick days	6%	6%	0%	0%
11 to 20 sick days	2%	1%	0%	0%
More than 20 sick days	1%	1%	0%	0%
Mean sick days	2.0	1.7	4.1	0.0

Table A-14 (NLI) and Table A-15(LI) illustrate how we estimated the NEI value per participant for reduction in sick days. First, we estimated lost wages by multiplying the number of sick days before and after the improvements by the respondent's daily wage rate, for the subset of respondents who attributed their changes in sick days to the improvements (i.e., the attribution group), and then applying the strata weights.[170] We calculated total lost wages before and after the improvements for the attribution group by summing the lost wages for the respondents in the attribution group reporting missed days before and after the improvements (again, applying the strata weights). Total reduction in lost wages was derived by subtracting lost wages after from lost wages before. Finally, this number, representing the reduction in lost wages for the attribution group, was divided by the total number of respondents in each income group, as we did not consider there to be a reduction in lost wages for the participants who did not attribute their change in sick days to the improvements. The resulting

[170] Daily wage rates were estimated as follows. An annual salary was estimated as the median of the salary range reported by the participant. If the participant did not report a salary range, the average of each population (i.e. low-income and non-low-income) was used. The annual wage rate was divided by 245 work days, assumed to be the annual number of work days.

reduction in lost wages was calculated to be $58 per participant for NLI respondents and $12 per participant for the LI respondents.

Table A-14. Reduction in Lost Wages Due to Sick Days, Non Low- Income

	Before improvements	After improvements
Sample size (Number of respondents in attribution group with any sick days before/after improvements)	*10*	*6*
Mean sick days	4.4	2.4
Total lost wages	$21,952	$9,788
Total reduction in lost wages	$12,164	
Average reduction in lost wages (total reduction in lost wages divided by all 209 NLI respondents)	58	

Table A-15. Reduction in Lost Wages Due to Sick Days, Low-income

	Before improvements	After improvements
Sample size (Number of respondents in attribution group with any sick days before/after improvements)	*6*	*0*
Mean sick days	4.1	0.0
Total lost wages	$2,648	$0
Total reduction in lost wages	$2,648	
Average reduction in lost wages (total reduction in lost wages divided by all 209 NLI respondents)	$12	

A.7 SOCIETAL PERSPECTIVE HEALTH IMPACTS

This section reports on potential societal health-related benefits estimated via reduced medical costs due to reductions in incidences of heat stress, hypothermia, and asthma. Because of the extremely small number of respondents reporting program induced changes in health, NMR does not recommend using the NEI values reported in this section but we do present them in the interest of providing information to inform further discussion and future exploration into this issue.

Energy efficiency programs may have direct impacts on health through improved home environments, reduced exposure to hypothermia or hyperthermia—particularly during heat waves and cold spells—improved indoor air quality, and potential reductions in moisture and mold, leading to amelioration of asthma triggers and other respiratory ailments. Therefore, participants in energy efficiency programs may realize a number of health related improvements due to installed measures, resulting in fewer days off work due to illness. In addition, society at large benefits because of reduced medical costs due to reductions in the incidence of symptoms or occurrences of specific health problems (such as asthma or other respiratory problems, heat stress and hypothermia).

Energy efficiency programs may have direct impacts on health through improved home environments, such as reduced risks of heat stress and hypothermia as well as improved indoor air quality and potential reductions in moisture and mold, leading to amelioration of asthma triggers and other respiratory ailments. Society at large benefits because of lower medical costs due to reductions in the incidence of symptoms or occurrences of specific health problems (such as asthma or other respiratory problems, heat stress and hypothermia).

Respondents were asked to report the number of visits made to a hospital, emergency room, or urgent care facility for heat stress, overexposure to cold, and asthma after the energy-efficient improvements and during a period of a year before the improvements. They were further asked whether they thought any changes in the number of times they sought care for these conditions was related to the improvements. The evaluation team estimated the value of the societal health benefits based on changes in the number of times care was sought—specifically, changes that respondents attributed to the installations—and associated changes in costs for medical care. Based on a review of the medical literature, the average cost for a visit to a medical center for heat stress and overexposure to cold adjusted for inflation is approximately $1,470 per visit.[171] The average cost of treating asthma at an emergency room, adjusted for inflation, is approximately $738.[172] These values multiplied by the reduction in number of care visits sought as reported by the respondents yield the recommended respective NEI value.

A.7.1 Heat Stress

None of the NLI respondents reported seeking care for heat stress either before or after the improvements (Table A-16). Among the LI respondents, there was a slight reduction in heat stress incidents—while 4% sought care before the improvements, 2% sought care after. However, only one of these respondents reported that the change in the number of times seeking medical care for heat stress was related to the energy efficiency improvements. This participant reported that medical care was sought for heat stress twice prior to improvements and five times since, exhibiting an increase in the number of times care was sought for heat stress (Table A-17).

[171] Centers for Disease Control and Prevention, 2011. Treatment for heat stress and overexposure to cold is considered a "general injury" by the CDC: "According to the Injury Surveillance Guidelines, an injury is the physical damage that results when a human body is suddenly or briefly subjected to intolerable levels of energy. Injury can … be an impairment of function resulting from a lack of one or more vital elements (i.e., air, water, or warmth), as in strangulation, drowning, or freezing.… The energy causing an injury may be … thermal (e.g., air or water that is too hot or too cold)."

[172] Agency for Healthcare Research and Quality, 2008.

Table A-16. Medical Care Visits for Heat Stress Before and After Improvements, Non-low Income

Non-low Income	Reported number of times sought care, all respondents		Reported number of times sought care, respondents who attributed change to improvements	
	Before	After	Before	After
Sample size	*198*	*209*	*0*	*0*
0 times sought	100%	100%	0%	0%
1 to 5 times sought	0%	0%	0%	0%
6 to 10 times sought	0%	0%	0%	0%
11 to 20 times sought	0%	0%	0%	0%
More than 20 sought	0%	0%	0%	0%
Mean times care sought	0.0	0. 0	0.0	0.0

Table A-17. Medical Care Visits for Heat Stress before and After Improvements, Low-income

Low-income	Reported number of times sought care, all respondents		Reported number of times sought care, respondents who attributed change to improvements	
	Before	After	Before	After
Sample size	*188*	*210*	*1*	*1*
0 times sought	96%	98%	0%	0%
1 to 5 times sought	3%	2%	100%	100%
6 to 10 times sought	1%	0%	0%	0%
11 to 20 times sought	0%	0%	0%	0%
More than 20 sought	0%	0%	0%	0%
Mean times care sought	0.1	0.1	2.0	5.0

None of the NLI respondents attributed changes in incidents of heat stress to the energy efficiency improvements, so the value for NLI respondents is $0. Table A-18(LI) illustrates how we estimated the annual NEI value per participant for changes in heat stress incidents. First, health care cost for heat stress was estimated by multiplying the number of times care was sought for heat stress before and after the improvements, for the subset of respondents who attributed their changes in sick days to the improvements (i.e., the attribution group), by the average cost for a visit to a medical center for heat stress ($1,470 per visit) and applying the strata weights.[173][174] Total health care costs before and after the improvements for the attribution group were then calculated by summing the health care costs for the respondents in the attribution group reporting medical visits for heat stress before and after the improvements (again, applying the strata weights). The total change in health care costs for heat stress was derived by subtracting health care costs after from health care costs before. Finally, this number, representing the change in health care costs for the attribution group, was divided by the total number of respondents in each income group, as there was considered to be no change in health care costs for the participants who had not attributed their change in number of medical visits for heat stress to the improvements. The resulting change in health care costs for heat stress was calculated to be $0 per participant for NLI respondents and a negative benefit of $26 per participant for the LI respondents.

Measuring changes in heat stress depends upon the occurrence of a severe heat wave that triggers heat stress among members of the population. It may be that our sample size was too small to measure incidences of heat stress during a heat wave, or the time period of the study may not have included a severe heat wave in Massachusetts. Changes in incidence rates of heat stress are also being examined in the upcoming evaluation of the national WAP; values might be able to be derived from these findings (Ternes et al., 2007).

[173] Centers for Disease Control and Prevention, 2011. Treatment for heat stress and overexposure to cold is considered a "general injury by the CDC: "According to the Injury Surveillance Guidelines, an injury is the physical damage that results when a human body is suddenly or briefly subjected to intolerable levels of energy. Injury can … be an impairment of function resulting from a lack of one or more vital elements (i.e., air, water, or warmth), as in strangulation, drowning, or freezing.… The energy causing an injury may be … thermal (e.g., air or water that is too hot or too cold…"

[174] Total reductions in lost wages were weighted to strata and income group.

Table A-18. Change in Medical Care Cost for Heat Stress before and After Improvements, Low-income

Low-Income	Reported number of times sought care, respondents who attributed change to improvements: Before	After
Sample size (Number of respondents in attribution group who sought care before/after improvements)	*1*	*1*
Mean number of medical care visits	2	5
Total health care costs	$3,597	$8,992
Total reduction in health care costs	$-5,395	
Average reduction in health care costs, heat stress (total change in health care costs divided by all 213 respondents)	$-26	

A.7.2 Hypothermia

Among the NLI respondents (Table A-19), one respondent (fewer than one out of one hundred) reported seeking care for hypothermia twice before the improvements, and none sought care for hypothermia after. This respondent attributed the change to the energy-efficiency improvements that were installed. Among the LI respondents (Table A-20), there was a slight reduction in hypothermia incidents—while 4% sought care before the improvements (with a mean of 3.1 visits for these respondents), 3% sought care after (with a mean of 2.7 visits). However, only one of these respondents reported that the change in the number of times seeking medical care for hypothermia was related to the energy efficiency improvements. This participant reported that medical care was sought for hypothermia three times prior to improvements and one time since, exhibiting a decrease in the number of times care was sought for hypothermia.

Table A-19. Medical Care Visits for Hypothermia before and After Improvements, Non-low-income

	Reported number of times sought care, all respondents		Reported number of times sought care, respondents who attributed change to improvements	
Non-low-income	Before	After	Before	After
Sample size	*197*	*209*	*1*	*1*
0 times sought	100%	100%	0%	100%
1 to 5 times sought	<1%	0%	100%	0%
6 to 10 times sought	0%	0%	0%	0%
11 to 20 times sought	0%	0%	0%	0%
More than 20 sought	0%	0%	0%	0%
Mean times care sought	2.0	0.0	2.0	0.0

Table A-20. Medical Care Visits for Hypothermia before and After Improvements, Low-income

Low-income	Reported number of times sought care, all respondents		Reported number of times sought care, respondents who attributed change to improvements	
	Before	After	Before	After
Sample size	*190*	*212*	*1*	*1*
0 times sought	96%	98%	0%	0%
1 to 5 times sought	3%	2%	100%	100%
6 to 10 times sought	1%	1%	0%	0%
11 to 20 times sought	0%	0%	0%	0%
More than 20 sought	0%	0%	0%	0%
Mean times care sought	3.1	2.7	3.0	1.0

Table A-21 (NLI) and Table A-22 (LI) illustrate how the annual NEI value per participant for changes in hypothermia incidents was estimated. First, the health care cost for hypothermia was estimated by multiplying the number of times care was sought for hypothermia before and after the improvements, for the subset of respondents who attributed their changes in hypothermia to the improvements (i.e., the attribution group), by the average cost for a visit to a medical center for hypothermia ($1,470 per visit) and applying the strata weights. Total health care costs before and after the improvements for the attribution group were then calculated by summing the health care costs for the respondents in the attribution group reporting medical visits for hypothermia before and after the improvements (again, applying the strata weights). The total change in health care costs for hypothermia was derived by subtracting health care costs after from health care costs before. Finally, this number, representing the change in health care costs for the attribution group, was divided by the total number of respondents in each income group, as there was considered to be no change in health care costs for the participants who had not attributed their change in number of medical visits for hypothermia to the improvements. The resulting change in health care costs for hypothermia was calculated to be $1.41 per participant for NLI respondents and $14 per participant for the LI respondents.

Table A-21. Change in Medical Care Cost for Hypothermia Before and After Improvements, Non-low-income

Non-low-income	Reported number of times sought care, respondents who attributed change to improvements	
	Before	After
Sample size (Number of respondents in attribution group who sought care before/after improvements)	*1*	*0*
Mean number of medical care visits	2	0
Total health care costs	$294	$0
Total reduction in health care costs	$294	
Average reduction in health care costs, heat stress (total change in health care costs divided by all 209 respondents)	$1.41	

Table A-22. Change in Medical Care Cost for Hypothermia Before and After Improvements, Low-income

Low-income	Reported number of times sought care, respondents who attributed change to improvements	
	Before	After
Sample size (Number of respondents in attribution group who sought care before/after improvements)	*1*	*1*
Mean number of medical care visits	3	1
Total health care costs	$4,409	$1,470
Total reduction in health care costs	$2,939	
Average reduction in health care costs, heat stress (total change in health care costs divided by all 213 respondents)	$14	

A.7.3 Asthma

Among the NLI respondents (Table A-23), about one-third (31%) reported seeking care for asthma between one and five times before the improvements, and fewer than one out of five (17%) sought care for asthma between one and five times after. In addition, a few respondents (3%) sought care between six and ten times after the improvements. There was an overall increase in asthma incidents, from a mean of 2.1 to a mean of 3.3, for respondents who had any asthma incidents. For the two respondents who attributed the change in asthma incidents to the energy-efficiency improvements that were installed, the mean number of incidents increased from 2.5 to 3.0. Among the LI respondents (Table A-23), there was a reduction in asthma incidents—while 38% sought care before the improvements (with a mean of 5 visits for these respondents), 25% sought care after (with a mean of

3.5 visits). However, among the three LI respondents who said that the change in the number of times seeking medical care for asthma was related to the energy efficiency improvements, there was an overall increase in asthma incidents, from a mean of 4.5 to 6.9 visits to a medical facility for asthma.

Table A-23. Medical Care Visits for Asthma before and After Improvements, Non-low-income

	Reported number of times sought care, all respondents		Reported number of times sought care, respondents who attributed change to improvements	
Non-low-income	**Before**	**After**	**Before**	**After**
Sample size	*45*	*48*	*2*	*2*
0 times sought	69%	80%	0%	52%
1 to 5 times sought	31%	17%	100%	48%
6 to 10 times sought	0%	3%	0%	0%
11 to 20 times sought	0%	0%	0%	0%
More than 20 sought	0%	0%	0%	0%
Mean times care sought	2.1	3.3	2.5	3.0

Table A-24. Medical Care Visits for Asthma before and After Improvements, Low-income

	Reported number of times sought care, all respondents		Reported number of times sought care, respondents who attributed change to improvements	
Low-income	**Before**	**After**	**Before**	**After**
Sample size	*61*	*70*	*3*	*3*
0 times sought	62%	75%	0%	33%
1 to 5 times sought	26%	21%	59%	26%
6 to 10 times sought	7%	4%	41%	41%
11 to 20 times sought	5%	0%	0%	0%
More than 20 sought	0%	0%	0%	0%
Mean times care sought	5.0	3.5	4.5	6.9

Table A-25 (NLI) and Table A-26 (LI) illustrate how the annual NEI value per participant for changes in asthma incidents was estimated. First, the health care cost for asthma was estimated by multiplying the number of times care was sought for asthma before and after the improvements, for the subset of respondents who attributed their changes in asthma to the improvements (i.e., the attribution group), by the average cost for a visit to a medical center for asthma ($737.74 per visit), applying the strata weights. Total health care costs before and after the improvements for the attribution group were then calculated by summing the health care costs for the respondents in the attribution group reporting medical visits for asthma before and after the improvements (again, applying the strata weights). The total change in health care costs for asthma was derived by subtracting health care costs after from health care costs before. Finally, this number, representing the change in health care costs for the attribution group, was divided by the total number of respondents in each income group, as there was considered to be no change in health care costs for the participants who had not attributed their change in number of medical visits for asthma to the improvements. The resulting reduction in health care costs for asthma was calculated to be $11 per participant for NLI respondents and $14 per participant for the LI respondents.

Table A-25. Change in Medical Care Cost for Asthma Before and After Improvements, Non-low-income

Non-low-income	Reported number of times sought care, respondents who said change is related to improvements	
	Before	After
Sample size (Number of respondents in attribution group who sought care before/after improvements)	2	2
Mean number of medical care visits	2.5	3
Total health care costs	$5,347	$3,097
Total reduction in health care costs	$2,250	
Average reduction in health care costs, heat stress (total change in health care costs divided by all 209 respondents)	$11	

Table A-26. Change in Medical Care Cost for Asthma Before and After Improvements, Low-income

Low-income	Reported number of times sought care, respondents who said change is related to improvements	
	Before	After
Sample size (Number of respondents in attribution group who sought care before/after improvements)	3	2
Mean number of medical care visits	3	1
Total health care costs	$4,409	$1,470
Total reduction in health care costs	$2,939	
Average reduction in health care costs, heat stress (total change in health care costs divided by all 213 respondents)	$14	

APPENDIX B: MASS SAVE NEIS

In the fall of 2010 Cadmus and Opinion Dynamics Corporation (ODC) conducted surveys with 1,202 customers who participated in the 2010 Mass Save® Residential Single Family Retrofit (Mass Save) Program.[175] Mass Save is a program that provides energy efficiency audits at no cost to customers, as well as free installation of measures such as CFLs, programmable thermostats, and low-flow showerheads, as needed. The audit also provides recommendations for improving the overall energy efficiency of the home and provides incentives to install measures such as insulation/weatherization, heating equipment, and energy efficient appliances.

The survey included questions about potential non-energy impacts that participants may have experienced as a result of their participation in the Mass Save program. The NEI questions focused on the perceived changes in thermal comfort, outside noise, sick days, chronic health conditions (asthma), colds and flu, and the ability to sell or rent the home after measures were installed. Respondents were only asked individual NEI questions if they had installed measures that were determined to reasonably contribute to the individual NEB of interest. For example, respondents who installed windows, insulation, air conditioner or a heating system, programmable thermostats, air sealing or sealing of heating and cooling ducts were asked about changes in the thermal comfort of their home.

Table B–1 summarizes the Mass Save participants' perceived changes in several NEIs commonly reported to result from energy efficiency improvements. Participants were asked if they noticed potential positive or negative changes in their household associated with the specific NEI. Almost two out of three respondents reported a positive change in thermal comfort (63%) after measures were installed, while one out of three (33%) reported no change.[176] One out of three (33%) participants noticed a positive change in the reduction of outside noise associated with installed measures while more than two out of three experienced no change (65%).[177]

Respondents were also asked about changes in sick days or health.[178] A change in sick days attributed to installed measures elicited a modest noticeable change. Only 4% of respondents noticed a positive change, less than 1% a negative change and the vast majority reported no noticeable changes (93%). Respondents asked whether they noticed any changes in the frequency or intensity of chronic health conditions such as asthma reported similar results as changes in sick days, 4% a positive change, 1% a negative change, and 95% reporting no changes. Those asked if they noticed any changes in the frequency or intensity of other illnesses such as colds or flu, again reported results similar to sick days and asthma, mentioning that 7% noticed a positive change, whereas 90% reported no changes.

Lastly, respondents were asked if they believed it would be easier to sell or rent their home because of the installed improvements or conversely more difficult to sell or rent their home.[179] Almost one out of three (31%) eligible respondents affirmed that the installed measures would positively impact the ability to sell or rent the home. Less than one percent reported the measures would negatively impact the ability, while 64% reported the installed measures made no difference in the ability to sell or rent the home.

[175] Surveyed participants were customers for one of four Program Administrators (PAs): National Grid, NSTAR, Cape Light Compact and WMECO.

[176] Respondents who installed windows, insulation, air conditioner or a heating system, programmable thermostat, air sealing or sealing of heating and cooling ducts were asked about changes in the thermal comfort of their home.

[177] Respondents who installed windows or insulation were asked about changes in the level of outside noise heard in the home.

[178] Respondents who installed windows, insulation, air conditioner or a heating system, programmable thermostat, air sealing or sealing of heating and cooling ducts were asked about changes in sick days or health.

[179] Respondents who installed either a new air conditioner, heating system, water heater, windows, or insulation or had purchased a new refrigerator were asked about changes in their ability to sell or rent their home.

B: Mass Save NEIs

Table B-1Summary of Non Energy Impacts, Mass Save Participants

NEI	*Sample size*	Positive	Negative	No difference
Thermal comfort	554	63%	2%	33%
Noise (from equipment or outside home)	239	33%	<1%	65%
Number of sick days	551	4%	<1%	93%
Chronic health/asthma	551	22%	5%	95%
Health (colds and flus)	551	7%	1%	90%
Ability to sell or rent home	359	31%	<1%	64%
Durability of home	213	34%	2%	60%
Overall impact of NEIs*	213	80%	2%	14%

APPENDIX C: ADDITIONAL LITERATURE REVIEWED FOR SELECT NEIs

This appendix provides a summary of additional literature reviewed for this study.

C.1 UTILITY-PERSPECTIVE NEIS

C.1.1 Transmission and Distribution Savings

Avoided transmission and distribution losses are already accounted for in the TRC benefit-cost test for the PAs' electric energy efficiency plan (National Grid et al. (2009); NSTAR et al. (2009). A brief review of other studies that have estimated the value of transmission and distribution losses may be useful.

Skumatz and Dickerson (1997, 1999)

Skumatz and Dickerson (1997, 1999) estimated the value of transmission and distribution savings for a variety of programs, including low-income weatherization, the VPP program, and refrigerator and air conditioner rebate programs. The NEI values were estimated by applying a combined T&D line loss and deferral estimate of 10% to each program's savings in avoided cost terms. The resulting annual utility savings per participant ranged from $0.92 for the refrigerator rebate program to $4.33 for the VPP program. The authors noted, however, that whether the non-energy benefit applied to a specific utility depended on whether the utility was in a competitive environment.

Skumatz and Gardner (2005)

An annual NEI value of $2.59 per household was estimated for the distribution-only portion of the non-energy benefits associated with Wisconsin's low-income WAP in a 2005 report (Skumatz and Gardner, 2005). This value assumed a line loss reduction of 6.5% and an estimated avoided cost per kWh of $0.05.

Ternes et al. (2007)

In the upcoming national WAP evaluation, the evaluators at Oak Ridge National Laboratory (ORNL) plan to calculate a monetized value of savings to utilities from reduced transmission and distribution losses, by multiplying the electricity savings in weatherized households in kWh by the average amount of electricity lost in transmission and distribution per kWh sold (Ternes et al., 2007). Relative to all other NEIs that the national WAP evaluators plan to measure in the upcoming WAP evaluation, the evaluators anticipate both the magnitude and uncertainty surrounding the monetized value to be low.

C.2 PARTICIPANT-PERSPECTIVE NEIS

C.2.1 Improved Sense of Environmental Responsibility

While the environmental benefits of the PAs' programs have been estimated in the *Avoided Energy Supply Costs in New England: 2011 Report* (Hornby et al, 2011) and included in the PAs' three year energy efficiency plans (National Grid et al., 2009; NSTAR et al., 2009), a brief review of other studies that have estimated how program participants value environmental benefits may be useful.

As participants are generally aware that reducing their own energy consumption has a positive effect on the environment, programs that increase the energy efficiency of their homes can result in a sense of satisfaction from being environmentally responsible. Although sense of environmental responsibility (or, as expressed in some surveys, participants' perceptions of the value of the "environmental impact" of their participation in the program) is not included in NEI studies as frequently as is thermal comfort, when it is included, it tends to be one of the most highly valued participant NEIs for both all-income and low-income whole-house programs, possibly second only to comfort.

a. NON-LOW-INCOME PROGRAMS

Myers and Skumatz (2006)

Myers and Skumatz' analysis of NEI studies from several multi-family retrofit programs (2006) yielded an estimated average value for sense of environmental responsibility of 16% of the value of all Participant NEIs combined, only slightly lower than the value for thermal comfort (19%).

NMR and Conant (2009)

The NEI evaluations of new construction programs we reviewed did not include environmental responsibility in their surveys; however, in response to an open-ended item in the survey used in NMR's evaluation of the Massachusetts New Homes with ENERGY STAR program, participants were asked to identify any additional NEIs that had not been mentioned in the survey, and five participants identified having a positive impact on the environment (NMR and Conant, 2009). The average value for this NEI given by these respondents was 60% of bill savings, or $220. Again, although this value was not scaled relative to overall NEI values, the fact that participants valued environmental responsibility nearly as much as they did thermal comfort (70% of bill savings) is notable.

b. LOW-INCOME PROGRAMS

Myers and Skumatz (2006)

For the low-income multifamily retrofit programs included in the analysis noted above (Myers and Skumatz, 2006), the estimated value for environmental responsibility across studies was even higher than that for the all-income programs, at 27% of the total value for the Participant NEIs combined.

Skumatz and Dickerson (1999)

In Skumatz and Dickerson's analysis of NEI results from various low-income weatherization programs (1999), environmental impact was rated as the second most important NEI for programs with insulation.

Skumatz and Nordeen (2001)

The NEI evaluation of the CT Weatherization Residential Assistance Programs (Skumatz and Nordeen, 2001) found that 17% of those who experienced an increased sense of environmental responsibility from the program said that environmental responsibility was of greater value than their bill savings, and that this NEI had the second highest value out of those included in the survey, but specific NEI values were not reported.

Sense of environmental responsibility tends to be one of the most highly valued participant NEIs for both all-income low-income whole-house programs, possibly second only to comfort. Participants in a variety of programs are aware that that reducing their own energy consumption has a positive effect on the environment and can result in a sense of satisfaction from being environmentally responsible.

C.3 BUFFERS ENERGY PRICE INCREASES

Only one study in the literature quantified the NEI value of buffering energy price increases. The value of this participant NEI was measured in the 2008 Evaluation of the Massachusetts New Homes with ENERGY STAR Program through participant surveys (NMR and Conant, 2009). A relative valuation method was employed in which respondents were asked if they believed their new home, because it was an ENERGY STAR home, buffered against future energy price increases. Ninety-four percent of surveyed respondents believed that their ENERGY STAR home buffered against energy bill increases (n=70). Respondents were then asked to value this NEI as a percentage of their estimated annual energy savings of $400. The mean NEI value estimated in this report was 97% of bill savings, or $386 per participant per year. Upper and lower bounds calculated at the 90% confidence level for this survey were 40% and 153% of bill savings. This was the highest value for the seven NEIs examined in this study.

C.4 REDUCED NEED TO MOVE AND COSTS OF MOVING, INCLUDING HOMELESSNESS

A number of studies have examined the benefits associated with reducing energy costs and reducing mobility and homelessness. For example, in the 1993 evaluation of the national WAP, Brown et al. cited a study concluding that 2.5% of the 1974-1975 mortgage failures were attributable to energy price increases (Metrostudy Corporation, 1976). Also cited in Brown et al. (1993) is a survey of homeless persons and emergency shelter providers by Robinson (1991), which found that among the housing-related reasons for homelessness in Pennsylvania, utility terminations were identified as the cause 7.9% of the time. Robinson also reported that 32% of homes were abandoned within one year of electric service termination and 22% of homes were abandoned within one year of gas service termination. The 1999 Evaluation of the Energy and Non-energy Impacts of Vermont's Weatherization Assistance (Riggert et al.) cited additional findings linking energy costs with mobility, including a report that 42% of homes in Maine were vacated from one to eleven months after service termination between 1986 and 1987 (Colton, 1994), and that 42% of the "most recent five year frequent movers" in a Missouri telephone survey stated that energy bills were "very important" in their move (Colton, 1995). A recent survey of national Low Income Home Energy Assistance Program (LIHEAP) participants reported that due at least in part to their energy bills, in the previous five years 5% of respondents had been evicted from their home or apartment, 4% had had a foreclosure on their mortgage, 12% had moved in with friends or family, and 3% had moved into a shelter or became homeless (Berger and Yan, 2010). In addition, 12% of respondents had had their electric or gas service terminated in the past year due to nonpayment, and 53% those who did not have either service terminated said that they would have if they had not received LIHEAP support. This body of research suggests that the ability to pay energy bills is one of the factors associated with mobility.

Brown et al (1993)

An estimate of the impact of the national WAP on low-income mobility is provided in the 1993 evaluation (Brown et al., 1993). A pre/post treatment/control analysis conducted of approximately 5,000 weatherized and 5,000 controlled dwellings revealed that dwellings experienced significantly less mobility after weatherization: 11 occupancy changes per 100 dwellings before weatherization versus nine occupancy changes per 100 dwellings after weatherization. Over the same time period, occupancy changes for the control group actually increased from 12 occupancy changes per 100 dwellings to 18. Brown et al. (1993) performed a rough calculation of the per participant NEI associated with the 4,000 avoided moves from the program based on the mobility impact analysis, reporting the benefit to be less than $1.00 per weatherized dwelling. Due to the uncertainty about the underlying assumptions and the relatively small magnitude of this monetized figure, the monetized value was not included in the benefit/cost calculations and the estimation formula was not reported in the evaluation.

Skumatz and Dickerson (1997)

One of the first monetized values of reduced forced moves attributable to weatherization programs is provided in Skumatz and Dickerson (1997), based on the Venture Pilot Program, a low-income weatherization and education program in California. An NEI range of $0.00-$100.00 per participant annually was reported, based on the estimated program impact on mobility taken from Brown et al. (1993), estimates of change in expected high school dropout rates, and the difference in lifetime earnings between graduates and dropouts. This NEI valuation did not include any direct moving expenses; only the indirect impact of reduced lifetime earnings, based on the premise that increased mobility is linked to increased dropout rates, was included.

Skumatz and Dickerson (1999)

An NEI value range of $0.00-$52.00 per participant per year was estimated in a similar manner for another California low-income weatherization program (Skumatz and Dickerson, 1999).

Skumatz (2002)

Although participant-reported survey results were not used in the computation of the NEI value associated with this program, a survey of the California low-income weatherization program participants indicates that 16% of respondents reported that the program definitely helped them avoid a move (Skumatz, 2002).

Riggert et al. (1999) & Dalhoff (2007)

The midpoint of $50.00 from the range estimated by Skumatz and Dickerson for the VPP program was applied as the NEI value of reduced mobility rates for the 1999 Vermont WAP analysis (Riggert et al., 1999). For the 2007 update to the Vermont WAP analysis, the same estimation method (i.e. the midpoint of the Skumatz and Dickerson VPP range) was employed, but was adjusted for inflation, resulting in an NEI value of $62.00 (Dalhoff, 2007).

Oppenheim & MacGregor (2002)

The annual NEI estimate for reduced forced moves of $10.10 per participant presented in Oppenheim and MacGregor (2002) includes both direct and indirect costs of moving. The direct cost component of the NEI was computed by multiplying an estimated 6% of avoided service terminations by 32% of terminations resulting in forced mobility (taken from Robinson, 1991) by an estimated $500 in moving costs. Additionally, an estimated $26.06 was added to account for the decreased earning power of children who lose education due to homelessness. The 6% figure for avoided service terminations assumes that all low-income service terminations are avoided.

TecMarket Works, SERA, and Megdal Associates (2001)

Unlike the VPP, California weatherization program, Oppenheim and MacGregor, and Vermont WAP estimates, the NEI calculation for the California LIPPT report was based only on the direct costs of moving; it excluded any indirect costs. An annual NEI value of $1.30 per participant was estimated for the LIPPT report, based on an estimated rate of 0.6% avoided moves per participant, taken from Blasnik (1997), an estimated number of hours spent per move, minimum wage, and an estimate of one month's rent (TecMarket Works, SERA and Megdal Associates, 2001). The LIPPT report authors noted that Blasnik's 0.6% estimate of avoided moves was based on a pre/post analysis of turnover in new party meters, with a control group, and that the program on which it was based had a low percentage of renters (only 16%).

Skumatz & Nordeen (2002)

The annual NEI value of $0.65 per participant for the Connecticut WRAP program was estimated via the same method as for the California LIPPT report, except that one month's rental costs were excluded from the calculation (Skumatz and Nordeen, 2002). A survey of Connecticut WRAP participants revealed that 16% of respondents indicated that the program helped them avoid a move; however, the more conservative rate of 0.6% avoided moves from Blasnik (1997) was considered more reliable than the self-reported figure, and therefore was used in the NEI estimation formula instead of the self-reported 16%.

Skumatz & Gardner (2005)

The NEI value for reduced mobility was estimated for the 2005 report on Wisconsin's low-income weatherization program (Skumatz and Gardner, 2005) via the relative valuation survey method. First, respondents were asked to report whether they experienced positive, negative, or no effects as a result of their participation in the program. Ninety-five percent of respondents reported no effect on the likelihood of moving because of energy costs, while 3% of respondents reported a positive change and 2% reported a negative change. An annual NEI value of $1.00 per participant was presented in this report. In addition to the NEI relative valuation questions, respondents were asked which of the NEI categories was most important to them. Two percent of respondents reported "likelihood of moving because of energy costs" to be the most important NEI to them out of the 21 NEIs included in the survey.

Ternes et al. (2007)

The national WAP evaluators at ORNL plan to calculate a monetized value of the NEI of reduced mobility in the upcoming national WAP evaluation (Ternes et al., 2007). The proposed estimation method involves calculating the average reduction in number of moves per weatherized household and the average cost per move. The decision to collect new data for quantifying NEIs for this evaluation is based on several factors, including the uncertainty surrounding performance metrics (i.e. impact values), the uncertainty surrounding monetized metrics, and the potential magnitude of the monetized NEI value. The decision process involves rating the aforementioned factors as either "low," "medium," or "high." Ternes et al. find the uncertainty regarding the average reduction in number of moves per weatherized household to be "high," the uncertainty regarding the average cost per move to be "medium," and the potential magnitude of the monetized value to be "medium." In order to determine the average number of moves, billing data will be examined for both a treatment and a control group for the year following weatherization. If, however, billing data does not indicate when the occupants of a dwelling move, then a telephone survey will be employed in order to determine the number of moves during the year following weatherization. While the NEI of reduced mobility will be measured in the upcoming national WAP evaluation, there is no plan to estimate the program impact on homelessness or the value of avoided homelessness.

The participant-perspective NEI of reduced mobility has been measured via numerous methods and formulas in the literature for low-income households. Some of the monetized NEI valuations address the issue of homelessness, although, the majority do not. Most NEI value estimations consist of an algorithm, including an assumed percentage reduction in moves and the avoided direct and/or indirect costs associated with moving. For most NEI values estimated in this way, the percentage reduction in mobility was taken either from Brown et al. (1993) or from Blasnik (1997). The direct and indirect costs of forced moves and homelessness vary considerably with regard to which costs are included in the NEI valuation. The earlier NEI valuations in the literature tended to be high, accounting for lost lifetime earning potential, based on an assumed rate of high school dropouts resulting from increased mobility and/or homelessness during childhood. More recent NEI valuations are more conservative and exclude the indirect costs of decreased educational attainment. The formulas for estimating the avoided moving costs are not provided in the literature; therefore, it is not possible to assess the reliability of these avoided cost assumptions. One NEI value found in the literature was estimated by a different method than all of the other estimates. This value was estimated via the relative valuation survey method; it was extremely low, because only 5% of respondents indicated that the program had any effect on their "likelihood of moving because of energy costs," and 40% of those 5% of respondents actually indicated a negative effect.

C.5 MORE DURABLE HOME AND EQUIPMENT AND APPLIANCE MAINTENANCE REQUIREMENTS

Equipment maintenance has been examined in zero and low energy homes in New Zealand using the relative valuation survey method (Stoecklein and Skumatz, 2007). Sixty participants completed the online survey, in which each participant was required to complete the relative valuation questions for two of the following four measures: double glazing, super insulation, solar water heat, and solar design features (such as trombe walls). Respondents indicated that, on average, they had positive experiences with the maintenance requirements of the double glazing and super insulation, and negative experiences with the maintenance requirements of the solar water heat systems and the solar design features of their homes. The relative share of maintenance as compared to the other NEIs included in the survey was 1% for double glazing, 3% for super insulation, -30% for solar water heat, and -3% for solar design. Participants found the maintenance requirements of the solar water heat systems to be particularly burdensome, and, on average, valued the maintenance hassles associated with solar water heat systems at 30% of energy bill savings. Monetized NEI values were not presented in this report.

C.6 REDUCING ENERGY EXPENSES, MAKING MORE MONEY AVAILABLE FOR OTHER USES, SUCH AS HEALTH CARE

Energy efficiency programs can reduce energy costs and therefore allow participating households to spend more money on food, healthcare, or other household needs. However, because the energy savings from these programs are already counted as a benefit by the PAs, to count additional benefits from these energy savings would amount to double counting.

Clearly, low-income populations face a number of burdens related to energy costs and household budget tradeoffs. In order to pay energy costs, families often spend less on food, medications, and other necessities. Lower spending on food may lead to nutritional risk, which in turn can lead to poor growth, malnutrition, and cognitive and developmental deficits that affect school performance, while reduced spending on medications may exacerbate medical conditions. In addition, households may be limited in their ability to make repairs to existing homes or move out of risky homes, increasing the risks of pest infestations, water leaks that lead to mold, and exposure to lead paint. These risks in turn can lead to increased incidence and severity of asthma and other respiratory diseases, lead poisoning and other health risks (Child Health Impact Working Group, 2007).

Low-income families and recipients of Federal Low Income Home Energy Assistance Program (LIHEAP) often skip meals and reduce caloric intake during the winter, due to high energy bills. For example, low-income households have been found to reduce food expenditures by roughly the same amount as their increase in winter fuel expenditures, resulting in reduced caloric intake during the winter months (Bhattacharay et al., 2003).[180] Other studies have found similar relationships between reduced food expenditures and reduced caloric intake during winter heating months, with resulting higher risks of anemia, other vitamin deficiencies and at-risk for hunger (Child Health Impact Working Group, 2007). Children in families facing food insecurity in turn face a number of long-term risks, such as poor growth, poor health or chronic illness, increased risks of hospitalizations, lower measures of physical and psychosocial functioning, and deficits in cognitive and behavioral development that affects school performance (Child Health Impact Working Group, 2007).

Studies of LIHEAP participants have documented the risks faced by program participants. For example, in a survey of LIHEAP participants in 2005, participating households in the Northeast made the following home budget tradeoffs:[181]

- 73% of participating households reduced household expenses due to energy bills
- 20% of participating households went without food due to energy bills
- 28% of participating households went without medical or dental care due to energy bills
- 23% of participating households didn't pay rent/mortgage in full at least once

Similar budget trade-offs were found in the most recent study of national LIHEAP recipients, including (Berger and Yang, 2009):

- 26% of participating households kept their home at a temperature perceived to be unsafe or unhealthy
- 33% of participating households did not fill a prescription or took less than the prescribed dose
- 25% of participating households had someone in the house become sick due to a cold

[180] In one study, increased[180] Increased rates of vitamin deficiencies and anemia were observed among poor families in winter, but these increases were not statistically significant (Bhattacharya et al., 2003)

[181] Similar measures of risk have been found in studies of LIHEAP participants in other parts of the country. For example, a study of 2004 LIHEAP participants in Missouri found that 46% of participants paid energy bills instead of buying food, 45% skipped taking medications or took less than the prescribed amount of medication, 60% of respondents closed off a room to avoid heating it, and 54% of respondents used their ovens to heat their homes (Colton, 2004). See also Berger and Yang, 2009, for more details on 2009 LIHEAP participants.

In addition, the constraints of energy costs and substandard housing increase the likelihood that poor families will experience unhealthy housing conditions, such as pest infestations, mold, and lead paint. There is substantial evidence linking asthma to conditions such as excessive moisture and mold, infestations of roaches and rodents, and poor ventilation. Children exposed to these conditions experience more asthma symptoms, miss more days of school, and have more frequent emergency room visits and hospitalizations (Child Health Impact Working Group, 2007).

Programs that help reduce energy burdens for low-income families may help alleviate risks and provide health benefits. For example, a study examining potential impacts of LIHEAP on the nutritional and health risks among children less than three years old found that, among low-income families, children in families not receiving LIHEAP were 20% more likely to be at nutritional risk for growth problems than children in families that did receive LIHEAP. However, the study was not able to examine the potential long-term impacts of these differences in nutritional risks. In addition, children in families not receiving LIHEAP were 30% more likely to be admitted to the hospital for acute reasons, on the day of the study, than children in families that did receive LIHEAP. However, there were no differences in lifetime hospitalizations (Frank et al., 2006).

C.7 TERMINATION AND RECONNECTION

Participant valuation of avoided terminations and reconnections has been measured for several low-income programs. NEI estimates have been developed, based on surveys and/or computations of the value of participant time spent getting service restored, as well as the costs incurred by the participant to have service restored. Various assumptions have been made when data such as termination and reconnection rates, program-induced change in termination rates, and participant value of time were unavailable or difficult to measure

Skumatz & Dickerson (1997)

The NEI of reduced terminations and reconnections from the participant perspective was investigated for the California Venture Partners Pilot low-income program via several methods including a survey asking participants what they would be willing to pay to avoid service termination (Skumatz and Dickerson, 1997). The survey revealed that customers were willing to pay up to $50 per year to avoid a service termination. Additionally Moreover, participant cost to restart service (divide among all participants, not just those with terminations) was estimated to be up to $1.00 and lost rental value was estimated to be up to $0.15 per year for VPP program. The estimate to restart service was based on termination rates for qualified customers, an assumed percentage reduction in the rate of terminations based on the arrearage reduction from Magouirk (1995), the average balance to be paid in order to restore service, the reconnection fee, an assumption of credit card interest rates to represent the cost to borrow money for reconnection, and the value of an assumed four hours of participant time spent at minimum wage coordinating the reconnection. The estimate of lost rental value was based on the loss of value of one day of rent for a property and the assumed percentage reduction in the rate of terminations based on Magouirk (1995). This estimate was discounted by 25% to account for the fact that few properties would be turned off during the heating season and that a full day may not be lost for some participants.

Skumatz (2002); Skumatz and Dickerson (1999)

NEI value ranges for a California low-income weatherization program were estimated in a similar manner as for the VPP program. A survey of these program participants revealed that 14% of participants a noticed change in “shutoffs,” and of those reporting a change, 81% indicated that the change was for the better, while 19% indicated that the change was for the worse (Skumatz, 2002). Quantified NEI value ranges for the California weatherization program include $0.00-26.06 to avoid termination, $0.00-0.52 to restart service, and $0.00-0.08 in lost rental value (Skumatz and Dickerson, 1999).

TecMarket Works, SERA, and Megdal Associates (2001)

Another report estimating participant valuation of avoided terminations and reconnections is the 2001 California LIPPT report (TecMarket Works, SERA, and Megdal Associates, 2001). An annualized NEI value of $0.17 was estimated for avoided shutoffs, and a value of $0.08 was estimated for avoided reconnects. The shutoff NEI was computed based on average shutoffs per year per customer for the relevant California utilities, an estimated reduction in shutoffs of 23%, and an assumed eight hours spent at minimum wage getting power restored. The reconnection NEI was computed in a similar manner; it was based on average reconnections per year per customer for the relevant California utilities, an estimated percentage reduction in reconnections of 23%, the reconnection fee, and an interest rate component for borrowing the money to pay the reconnection fee. The benefit period for reduced terminations, used to compute the annualized value in this study, was assumed to be three years, while the benefit period for reduced reconnections was assumed to be ten years.

Ternes et al. (2007)

In their upcoming evaluation of the national WAP, the evaluators at ORNL intend to include a monetized value of avoided shut-offs and reconnections as a result of the program (Ternes et al., 2007). The proposed estimation method for this report is to multiply the average number of shut-offs and reconnections per weatherized household by the average cost to customers per shut-off, including "lost rent" and the reconnection fee. On a scale of "low," "medium," and "high," Ternes et al. (2007) anticipate the uncertainty regarding both the average reduction in shut-offs and reconnections and the average cost to customers per shut-off to be "low."

C.8 BILL-RELATED CALLS

Participant valuation of time spent on bill-related calls to the utility has been measured by relative valuation survey results, or by an algorithm including time spent on the phone and minimum wage as variables. The monetized NEI value produced from the survey method is more than an order of magnitude greater than the values produced by the algorithms. Of the algorithm-derived NEI values of participant-perspective bill-related calls, all are based on assumed impact values for payment-related behavior from the literature, rather than on data about program-induced changes in customer calls. No impact evaluations could be found in the literature supporting the assumption that energy efficiency programs do in fact lead to a reduction the number of customer calls to utilities.

TecMarket Works, SERA, and Megdal Associates (2001)

The NEI value of reduced bill-related calls from the participant perspective was estimated to be $0.18 annually per participant in the 2001 California LIPPT report (TecMarket Works, SERA, and Megdal Associates, 2001). This value was calculated based on the average number of customer calls per year, the average length per customer call, an assumed percentage reduction in bill-related calls, and minimum wage. Data on bill-related calls from low-income customers and program-induced reduction in customer calls was unavailable; therefore, proxy values were substituted in the formula for calculating this NEI value. For example, data on all customer calls (regardless of income) was used to calculate the average number of calls and average length per call. Additionally, the proxy value used in place of percent reduction in customer calls was a point estimate, based on an assortment of bill payment behavior and collection activity impact studies.

Skumatz and Nordeen (2002)

An annual participant NEI value of $0.29 was estimated for the Connecticut Weatherization Residential Assistance Partnership (WRAP) program via a similar method as the CA LIPPT (Skumatz and Nordeen, 2002).

Skumatz and Gardner (2005)

Participant valuation of reduced time spent on bill-related calls was measured via a participant survey for the Wisconsin low-income WAP (Skumatz and Gardner, 2005). Respondents were asked if they noticed any impact with regards to each NEI in the survey, and if so, whether the impact was negative or positive. Seven percent of respondents reported a positive impact for "change in number of calls to utility related to bills," while 1% reported a negative impact, and 91% reported no impact. Respondents who reported an impact were then asked whether the impact was much less valuable, somewhat less valuable, same value, somewhat more valuable, or much more valuable than the potential energy savings. These results were translated into average participant value relative to energy savings, which was then multiplied by annual estimated energy savings, in order to yield an NEI value range of $6.00-$8.00 per year.

C.9 EDUCATION

Energy education can be as basic as energy conservation tips and familiarization with energy efficiency measures, but some low-income programs reviewed in the literature have sizable education components, covering areas such as financial literacy and household budgeting.

Skumatz et al. (2009)

One such attempt to quantify the value of program-induced education is reported in Skumatz et al. (2000), although the results were based on a small sample. In this report, a survey for several residential programs—including central AC and lighting rebate programs, a financing program, the VPP and California low-income weatherization program—indicated that participants valued the education associated with measure programs at 10% of energy savings.

Skumatz (2002)

Another participant survey for the California low-income weatherization program indicated that 55% of participants reported receiving educational benefits and feeling more in control over bills as a result of the program (Skumatz, 2002). The average willingness to pay for the combined value of the educational benefits and feeling of control over bills was $93.88. Some programs, such as the VPP program, specifically include an educational component, while others do not.

For programs that do not include an educational component over and above a basic introduction to energy efficiency and measures, this NEI potentially overlaps with the participant NEI of reduced transaction costs. Unlike the reduced transaction costs NEI, education is not recognized as its own NEI and will not be investigated for the upcoming evaluation of the national WAP (Ternes et al., 2007).

C.10 SOCIETAL-PERSPECTIVE NEIs

C.10.1 Improved Health

Other studies on improved health indicators from energy efficiency measures have attempted to quantify the benefits resulting from improved environmental quality (IEQ) in office settings. While not directly comparable to studies of residential and low-income programs, these studies provide a context for the scale of the potential impacts. Improving ventilation and relative humidity in buildings can result in a reduction of colds, viruses, and allergy and asthma events. Fisk (2002) has demonstrated that there are significant societal benefits to IEQ on the order of several billion dollars in savings annually. Estimates of potential health and productivity gains from improved IEQ are $6-14 billion for reduced respiratory illness, $1-4 billion for reduced allergies and asthma, $10-30 billion for reduced sick building syndrome, and $20-60 billion for improved worker performance from changes in thermal environment and lighting.

APPENDIX D: UTILITY-PERSPECTIVE NEI VALUES DERIVED FROM THE LITERATURE

The utility-perspective NEIs for which NMR recommends deriving values from the literature include reductions in arrearage carrying costs, bad debt write-offs, terminations and reconnections, customer calls, notices, and safety-related emergency calls. NMR's review of the literature found eight reports containing utility-perspective NEI values based on programs comparable to the PAs' programs with respect to program components[182], energy efficient measures[183], and target populations[184]. These eight studies, published between 1997 and 2005, are displayed in Table D–1 along with the reported NEI values[185]. The table does not include NEI values from evaluations of programs that were not comparable to the PAs' programs. For example, the 2008 evaluations of the Oregon HEAT and REACH Programs (Drakos et al., 2008) and the 2005 evaluation of the Utah HELP program (Khawaja and Wiley, 2005) were excluded because these programs relied heavily or entirely on payment assistance, counseling, and educational components, program elements not included in the PAs' low-income programs.

182 The low-income energy efficiency programs in the literature incorporated different program elements, including different combinations of energy efficiency measures, educational and counseling components, and in some cases payment assistance. NMR considered programs comparable to the PAs' programs to be those relying primarily on energy efficiency measures. Programs relying primarily or entirely on education, counseling, or payment assistance components were not considered comparable to the PAs' programs.

183 In determining whether an NEI value from the literature was applicable to the PAs' programs, NMR reviewed the measures implemented by the programs in each study. Next, NMR compared the measures in the literature to measures implemented through the PAs' programs (the PAs provided lists of measures implemented through their programs). With the exception of low-income programs relying primarily on education, counseling, or payment assistance components, the majority of low-income weatherization and retrofit programs in the NEI literature offer similar measures as the PAs' low-income programs, such as insulation, air sealing, heating system repairs/replacements, lighting, and DHW measures.

184 NMR considers low-income programs that are open to all low-income customers to be comparable to the PAs' low-income programs. Studies of programs that targeted only a subset of low-income customers, such as high-arrearage low-income customers, were not considered comparable to the PAs' programs.

185 An empty cell in Table D-1 signifies one of two things: either an NEI value was not estimated for a particular study, or the NEI value reported was based on an NEI from another report included in the table. An example of the latter scenario is the NEI of reduced carrying cost on arrearages reported for the national low-income WAP (Schweitzer and Tonn, 2002), in which the NEI value was estimated by taking the midpoint of the values reported for the Venture Partners Pilot and CA low-income weatherization programs (Skumatz and Dickerson, 1997 and 1999).

Table D-1. Reported NEI Values (Dollars per Participant per Year)

Study	Reported NEI Value, $/year/participant					
	Carrying Cost on Arrearages	Bad Debt Write-Offs	Terminations and Reconnections	Customer Calls	Notices	Safety-Related Emergency Calls
WI Low-income Weatherization (Skumatz and Gardner, 2005)	1.37	--	0.13	0.43	0.30	--
National Low-income Weatherization NEBs Study (Schweitzer and Tonn, 2002)	--	6.09	0.55	--	--	6.91
MA Low-income Weatherization (Skumatz Economic Research) Associates, 2002)	1.71	3.62	--	0.59	--	0.40
CT Low-income Weatherization (Skumatz and Nordeen, 2002)	2.03	2.24	0.10	0.55	1.16	0.21
CA Low-income Public Purpose Test (TecMarket Works, Skumatz Economic Research Inc, and Megdal Associates, 2001)	3.76	0.48	0.07	1.58	1.49	0.07
VT Low-income Weatherization (Riggert et al., 1999)	--	--	7.00	--	--	15.58
CA Low-income Weatherization (Skumatz and Dickerson, 1999)	2.09	2.34	0.33	0.07	0.04	7.91
Venture Partners Pilot Program (Skumatz and Dickerson, 1997)	4.00	4.50	0.63	0.13	0.08	15.00

Recommended values for the utility-perspective NEIs of reductions in arrearage carrying costs, bad debt write-offs, terminations and reconnections, customer calls, notices, and safety-related emergency calls were calculated via a two-step process. First, NMR adjusted the reported values from the literature into 2010 dollars using an inflation rate of 2.5 percent per year, the same inflation rate used in the PAs' three-year plans (see National Grid et al., 2009; NSTAR et al., 2009). Next, we calculated the average (mean), median and midpoint of the inflation-adjusted NEI values. NMR recommends using the median value.[186] Each NEI value from the literature was given equal weight in the calculation of the average value. Table D–2 displays the reports from which NEI values of reduced arrearage carrying costs for programs comparable to the PAs' programs were obtained, the reported NEI values (the same as in Table D–1), and the inflation-adjusted values in 2010 dollars. The same information for the NEI values associated with bad debt write-offs, terminations and reconnections, customer calls, notices, and safety-related emergency calls, are presented in Tables D-3 through D-7.

[186] NMR recommends using the median value as the median helps moderate the impact of potential outlier values.

Table D-2. Inputs to Recommended Value for Carrying Cost on Arrearages

Carrying Cost on Arrearages ($/year/participant)		
Study	**Reported Value**	**Adjusted for Inflation (2010 dollars)**
WI Low-income Weatherization (Skumatz and Gardner, 2005)	$1.37	$1.55
MA Low-income Weatherization (Skumatz Economic Research Associates, 2002)	$1.71	$2.08
CT Low-income Weatherization (Skumatz and Nordeen, 2002)	$2.03	$2.47
CA Low-income Public Purpose Test (TecMarket Works, Skumatz Economic Research Inc, and Megdal Associates, 2001)	$3.76	$4.70
CA Low-income Weatherization (Skumatz and Dickerson, 1999)	$2.09	$2.74
Venture Partners Pilot Program (Skumatz and Dickerson, 1997)	$4.00	$5.51
Average of adjusted values	--	$3.18
Median of adjusted values	--	$2.61
Midpoint of adjusted values	--	$3.53

Table D-3. Inputs to Recommended Value for Bad Debt Write-offs

Bad Debt Write-Offs ($/year/participant)		
Study	**Reported Value**	**Adjusted for Inflation (2010 dollars)**
National Low-income Weatherization NEBs Study (Schweitzer and Tonn, 2002)	$6.09	$7.42
MA Low-income Weatherization (Skumatz Economic Research Associates, 2002)	$3.62	$4.41
CT Low-income Weatherization (Skumatz and Nordeen, 2002)	$2.24	$2.73
CA Low-income Public Purpose Test (TecMarket Works, Skumatz Economic Research Inc, and Megdal Associates, 2001)	$0.48	$0.60
CA Low-income Weatherization (Skumatz and Dickerson, 1999)	$2.34	$3.07
Venture Partners Pilot Program (Skumatz and Dickerson, 1997)	$4.50	$6.20
Average of adjusted values	--	$4.07
Median of adjusted values	--	$3.74
Midpoint of adjusted values	--	$4.01

Table D-4. Inputs to Recommended Value for Terminations and Reconnections

Terminations and Reconnections ($/year/participant)		
Study	**Reported Value**	**Adjusted for Inflation (2010 dollars)**
WI Low-income Weatherization (Skumatz and Gardner, 2005)	$0.13	$0.15
National Low-income Weatherization NEBs Study (Schweitzer and Tonn, 2002)	$0.55	$0.67
CT Low-income Weatherization (Skumatz and Nordeen, 2002)	$0.10	$0.12
CA Low-income Public Purpose Test (TecMarket Works, Skumatz Economic Research Inc, and Megdal Associates, 2001)	$0.07	$0.09
VT Low-income Weatherization (Riggert et al., 1999)	$7.00	$9.18
CA Low-income Weatherization (Skumatz and Dickerson, 1999)	$0.33	$0.43
Venture Partners Pilot Program (Skumatz and Dickerson, 1997)	$0.63	$0.86
Average of adjusted values	--	$1.64
Median of adjusted values	--	$0.43
Midpoint of adjusted values	--	$4.64

Table D-5. Inputs to Recommended Value for Customer Calls

Customer Calls ($/year/participant)		
Study	**Reported Value**	**Adjusted for Inflation (2010 dollars)**
WI Low-income Weatherization (Skumatz and Gardner, 2005)	$0.43	$0.49
MA Low-income Weatherization (Skumatz Economic Research Associates, 2002)	$0.59	$0.72
CT Low-income Weatherization (Skumatz and Nordeen, 2002)	$0.55	$0.67
CA Low-income Public Purpose Test (TecMarket Works, Skumatz Economic Research Inc, and Megdal Associates, 2001)	$1.58	$1.97
CA Low-income Weatherization (Skumatz and Dickerson, 1999)	$0.07	$0.09
Venture Partners Pilot Program (Skumatz and Dickerson, 1997)	$0.13	$0.17
Average of adjusted values	--	$0.68
Median of adjusted values	--	$0.58
Midpoint of adjusted values	--	$1.03

Table D-6. Inputs to Recommended Value for Notices

Notices ($/year/participant)		
Study	**Reported Value**	**Adjusted for Inflation (2010 dollars)**
WI Low-income Weatherization (Skumatz and Gardner, 2005)	$0.30	$0.34
CT Low-income Weatherization (Skumatz and Nordeen, 2002)	$1.16	$1.41
CA Low-income Public Purpose Test (TecMarket Works, Skumatz Economic Research Inc, and Megdal Associates, 2001)	$1.49	$1.86
CA Low-income Weatherization (Skumatz and Dickerson, 1999)	$0.04	$0.05
Venture Partners Pilot Program (Skumatz and Dickerson, 1997)	$0.08	$0.10
Average of adjusted values	--	$0.75
Median of adjusted values	--	$0.34
Midpoint of adjusted values	--	$0.96

Table D-7. Inputs to Recommended Value for Safety-related Emergency Calls

Safety-Related Emergency Calls ($/year/participant)		
Study	**Reported Value**	**Adjusted for Inflation (2010 dollars)**
National Low-income Weatherization NEBs Study (Schweitzer and Tonn, 2002)	$6.91	$8.43
MA Low-income Weatherization (Skumatz Economic Research Associates, 2002)	$0.40	$0.49
CT Low-income Weatherization (Skumatz and Nordeen, 2002)	$0.21	$0.26
CA Low-income Public Purpose Test (TecMarket Works, Skumatz Economic Research Inc, and Megdal Associates, 2001)	$0.07	$0.09
VT Low-income Weatherization (Riggert et al., 1999)	$15.58	$22.56
CA Low-income Weatherization (Skumatz and Dickerson, 1999)	$7.91	$10.37
Venture Partners Pilot Program (Skumatz and Dickerson, 1997)	$15.00	$20.68
Average of adjusted values	--	$8.98
Median of adjusted values	--	$8.43
Midpoint of adjusted values	--	$11.43

APPENDIX E: NEI SURVEY, OWNERS AND MANAGERS OF LOW-INCOME RENTALS

Owners of Low-income Housing — NEI Survey

CaseID

Respondent Data

- Name
- Phone

Utility Name

- Ex
- Ex
- Ex

Utility Program Name

- Ex
- Ex
- Ex

Measures received

- Ex
- Ex
- Ex
- Ex

Estimated Annual Savings

INTRODUCTION AND SCREENING

Hello, my name is ______, and I'm calling from Tetra Tech on behalf of Massachusetts utilities and energy efficiency organizations about some of the programs and services they offer, including the energy efficiency improvements you had done recently to your property through <PA NAME>'s energy efficiency programs.

I1 May I speak with [CONTACT NAME]?

1 Yes [GO TO I1a]
2 No [SKIP TO I3]

I1A The survey should take around 20 minutes and the information you provide will help the sponsors improve their programs and services. Your responses will be kept strictly confidential. For quality and training purposes, this call will be recorded.

I2 According to our records, energy efficiency improvements were made at your property at [ADDRESS] with the help of [PA NAME]'s [NAME OF PA'S PROGRAM] program sometime within the past 2 years. Are you the person who is most familiar with these energy efficiency improvements?

1 Yes [SKIP TO I4]
2 No [GO TO I3]
D DON'T KNOW [GO TO I3]
R REFUSED [THANK & TERMINATE]

I3 Is there someone else I could speak to now who has been involved with the energy efficiency improvements recently made to the property at [ADDRESS]

1 Yes [RE-READ INTRO AND START WITH I1a]
2 No [ASK TO SCHEDULE A TIME TO CALL BACK]
D Don't know [THANK & TERMINATE]
R Refused [THANK & TERMINATE]

I4 I would like to confirm that the following energy efficiency improvements were installed at your property at [ADDRESS] [LIST EFFICIENCY MEASURES FROM PROGRAM DATA]. Is this correct?

1 Yes [GO TO I5]
2 Yes, participated, but installed different efficiency measures
[RECORD EFFICIENCY MEASURES AND RE-SCHEDULE INTERVIEW]
3 No, did not participate in the program [THANK & TERMINATE]
D Don't know [THANK & TERMINATE]
R Refused [THANK & TERMINATE]

I5 Comparing your property now to before you had the energy efficiency improvements installed, would you say your property is more energy-efficient, less energy-efficient or about the same level of energy efficiency?

1 More energy-efficient
2 Less energy-efficient
3 Same level of efficiency
D Don't know
R Refused

I6 Since installing the energy efficiency measures, have you noticed any changes in your energy bills for the property at [ADDRESS]?

1 Yes, lower energy bills
2 No, higher energy bills
3 No change in bills
D Don't know
R Refused

I7 Are the tenants at [ADDRESS] responsible for paying their own energy bills, or are utilities included in the rent?

1 Tenants pay their bills [GO TO I8]
2 Energy bills included in rent [SKIP TO I9]
3 Tenants pay some bills, some included in rent [GO TO I8]
D Don't know [SKIP TO I9]
R Refused [SKIP TO I9]

I8 Since installing the energy efficiency measures for the property at [ADDRESS], have any tenants told you that they have seen changes in their energy bills? If so, what changes?

1 Yes, lower energy bills
2 Yes, higher energy bills
3 No change in bills
4 Have not heard anything from tenants about energy bills
D Don't know
R Refused

I9 Since installing the energy efficiency measures for the property at [ADDRESS], have any tenants commented on what they like or do not like about the energy efficiency improvements?
[IF YES: What are they?]
[PROBE: Is there anything else? RECORD UP TO THREE RESPONSES]

1 Lower energy bills
2 More comfortable
3 Improved reliability of heating and cooling equipment or appliances
4 Less noise from outside
5 Higher energy bills
6 Less comfortable
7 Decreased reliability of heating/cooling equipment or appliances
8 More noise from outside
9 Nothing
10 Other (SPECIFY)
11 Don't know
12 Refused

I10_int Properties such as yours, which have had energy efficiency improvements, typically are more energy efficient than comparable properties that have not had similar efficiency improvements made. As a result, properties such as yours use less energy for heating, cooling, and water heating and have lower energy bills.

I10 In addition to your energy savings, have you noticed any other positive impacts resulting from the energy efficiency improvements made to your property?
[IF YES: What are they?]
[PROBE: Is there anything else? RECORD UP TO THREE RESPONSES]

1 No benefits
2 Easier to lease or rent units; improved marketing of rental property
3 Improved reliability of heating and cooling equipment or appliances
4 Less maintenance of heating and cooling equipment or appliances
5 Less maintenance for lighting
6 Reduced tenant turnover
7 Other (SPECIFY)
D Don’t know/don’t remember
R Refused

I11 Have you noticed any negative impacts resulting from the energy efficiency improvements made to your property?
[IF YES: What are they?]
[PROBE: Is there anything else? RECORD UP TO THREE RESPONSES]

1 No negative impacts
2 More difficult to lease or rent units
3 Less reliable heating and cooling equipment or appliances
4 More maintenance of heating and cooling equipment or appliances
5 More maintenance for lighting
6 Increased tenant turnover
7 Higher energy bills
8 Other (SPECIFY)
D Don’t know
R Refused

MARKETABILITY AND EASE OF FINDING RENTERS

M1 In terms of your ability to market your property and lease your rental units, would you say that, because of the energy efficiency improvements, your property is EASIER to market and rent, HARDER to market and rent, or would you say there is no difference in your ability to market your property and lease your rental units?

1 Easier to market and rent [GO TO M2]
2 More difficult to market and rent [GO TO M3]
3 No difference [GO TO T1]
D Don’t know [GO TO M2]

M1A [IF I10=2 (Easier to rent) AND M1=2 (More difficult)] Earlier you said that it’s been easier to lease or market units. Can you please confirm for me whether the energy efficiency improvements have had an overall POSITIVE or NEGATIVE impact on marketing and renting units, or has there been no difference in ease of marketing your property?

1 Positive [SKIP TO M2]
2 Negative [SKIP TO M3]
3 No difference [SKIP TO T1]

M1B [IF I11=2 (Harder to market) AND M1=1 (Easier)] Earlier you said that it's been harder to lease or market units. Can you please confirm for me whether the energy efficiency improvements have had an overall POSITIVE or NEGATIVE impact on marketing and renting units, or has there been no difference in ease of marketing your property?

1 Positive [SKIP TO M2]
2 Negative [SKIP TO M3]

3 No difference [SKIP TO T1]M2 [IF M1=1 (EASIER TO MARKET AND RENT)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the value to you per year of having your property easier to market and rent, either in dollars or as a percentage of energy savings?

1 $____/year [SKIP TO T1]
2 _____% of annual energy savings [SKIP TO T1]
D Don't know [SKIP TO M2A]
[SAVINGS HAVE BEEN ESTIMATED FOR THE ENTIRE PROPERTY, NOT AT THE UNIT LEVEL]

M2A [IF M1=1 & M2=DON'T KNOW] In terms of energy bill savings, which of the following would you say is closest to the value of having your property easier to market and rent?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO M2AX]
7 Other
8 DO NOT READ: Have not noticed any change in being able to market and rent property
D Don't know

M2AX [IF M2A=6 OR 7] How much in total?

[IF M2A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

M3 [IF M1=2 (HARDER TO MARKET AND RENT)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the cost to you per year of the increased difficulty in marketing and renting your property, either in dollars or as a percentage of energy savings?

1 $____/year [SKIP TO T1]
2 _____% of annual energy savings [SKIP TO T1]
D Don't know [GO TO M3A]
[SAVINGS HAVE BEEN ESTIMATED FOR THE ENTIRE PROPERTY, NOT AT THE UNIT LEVEL]

M3A [IF M1=2 & M3=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the cost of the increased difficulty in marketing and renting your property?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings
7 Other
8 DO NOT READ: Have not noticed any change in being able to market and rent property
D Don't know

M3AX [IF M3A=6 OR 7] How much in total?

[IF M3A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

REDUCED TENANT TURNOVER

T1 In terms of the amount of tenant turnover in your property's rental units, would you say that, because of the energy efficiency improvements, your property has LESS tenant turnover than before the improvements were made, MORE tenant turnover, or would you say there is no difference in the amount of tenant turnover?

1 Less tenant turnover [GO TO T2]
2 More tenant turnover [GO TO T3]
3 No difference [GO TO PV1]
D Don't know [GO TO PV1]

T1A [IF I10=6 (Decreased turnover) AND T1=2 (More turnover)] Earlier you said that you've noticed a decrease in tenant turnover. Can you please confirm for me whether the energy efficiency improvements have caused MORE or LESS tenant turnover, or have they made no difference in the amount of tenant turnover?

1 Less [SKIP TO T2]
2 More [SKIP TO T3]
3 No difference [SKIP TO PV1]

T1B [IF I11=6 (Increased turnover) AND T1=1 (Less turnover)] Earlier you said that you've noticed an increase in tenant turnover. Can you please confirm for me whether the energy efficiency improvements have overall caused MORE or LESS tenant turnover, or have they made no difference in the amount of tenant turnover?

1 Positive [SKIP TO T2]
2 Negative [SKIP TO T3]
3 No difference [SKIP TO PV1]

T2 [IF T1=1 (LESS TENANT TURNOVER)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the value to you per year of having less tenant turnover, either in dollars or as a percentage of energy savings?

1 $____/year [SKIP TO PV1]
2 _____% of annual energy savings [SKIP TO PV1]
D Don't know [SKIP TO T2A]

T2A [IF T1=1 & T2=DON'T KNOW] In terms of energy bill savings, which of the following would you say is closest to the value of the decreased tenant turnover?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO T2AX]
7 Other [GO TO T2AX]
8 DO NOT READ: Have not noticed any decrease in tenant turnover
D Don't know

T2AX [IF T2A=6 OR 7] How much in total?

[IF T2A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

T3 [IF T1=2 (MORE TENANT TURNOVER)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the cost to you per year of the increased tenant turnover, either in dollars or as a percentage of energy savings?

1 $____/year [SKIP TO PV1]
2 _____% of annual energy savings [SKIP TO PV1]
D Don't know [GO TO T3A]

T3A [IF T1=1 & T3=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the cost to you of the increased tenant turnover?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO T3AX]
7 Other [GO TO T3AX]
8 DO NOT READ: Have not noticed any increased in tenant turnover
D Don't know

T3AX [IF T3A=6 OR 7] How much in total?

[IF T3A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

EXPECTED INCREASE IN PROPERTY VALUE

PV1 Not counting any investments you may have made in the energy efficiency improvements, would you say that, because of the energy efficiency improvements, your property has a HIGHER value than it would have without the improvements, a LOWER value than it would have without the improvements, or would you say about the same value?

1 Higher value [GO TO PV2]
2 Lower value [GO TO PV3]
3 No difference [GO TO EQ1]
D Don't know [GO TO EQ1]

PV2 [IF PV1=1 (HIGHER VALUE)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, how much do you think the improvements add to the value of your property, either in dollars or as a percentage of energy savings?

1 $____ [SKIP TO EQ1]
2 _____% of annual energy savings [SKIP TO EQ1]
D Don't know [SKIP TO PV2A]

PV2A [IF PV1=1 & PV2=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the increase in property value?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO PV2AX]
7 Other [GO TO PV2AX]
8 DO NOT READ: Have not noticed any increased property value
D Don't know

PV2AX [IF PV2A=6 OR 7] How much in total?

[IF PV2A=6, $/ must be higher than $XX, or % must be greater than 100]
1 $___
2 ____% of annual energy savings

PV3 [IF PV1=2 (LOWER VALUE)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, how much do the improvements take away from the value of your property, either in dollars or as a percentage of energy savings?

1 $____/ [SKIP TO EQ1]
2 _____% of annual energy savings [SKIP TO EQ1]
D Don't know [GO TO PV3A]

PV3A [IF PV1=2 & PV3=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the amount that the improvements take away from the value of your property?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO PV3AX]
7 Other [GO TO PV3AX]
8 DO NOT READ: Have not noticed any decreased property value
D Don't know

PV3AX [IF PV3A=6 OR 7] How much in total?

[IF PV3A=6, $ must be higher than $XX, or % must be greater than 100]
1 $___
2 ____% of annual energy savings

EQUIPMENT MAINTENANCE/RELIABILITY
[ONLY ASK IF INSTALLED HEATING AND COOLING EQUIPMENT]

EQ1 [ASK IF INSTALLED HEATING AND COOLING EQUIPMENT; OTHERWISE, SKIP TO LT1] In terms of the maintenance requirements or reliability of your heating and cooling equipment, would you say that, because of the energy efficiency improvements, your heating and cooling equipment 1) requires LESS maintenance and has IMPROVED reliability than before the improvements were made, 2) requires MORE maintenance and is LESS reliable, or would you say that 3) there is no difference in the maintenance requirements or reliability of your heating and cooling equipment?

1 Less maintenance/more reliable [GO TO EQ2]
2 More maintenance/less reliable [GO TO EQ3]
3 No difference [GO TO LT1]
D Don't know [GO TO LT1]

EQ1A [IF I10=3 or 4 (Improved HVAC) AND EQ1=2 (More maintenance)] Earlier you said that your heating and cooling equipment has been more reliable, or requires less maintenance. Can you please confirm for me whether the energy efficiency improvements have had an overall POSITIVE or NEGATIVE impact on maintenance of your heating and cooling equipment, or has there been no difference in maintenance requirements?

1 Positive [SKIP TO EQ2]

2 Negative [SKIP TO EQ3]
3 No difference [SKIP TO LT1]

EQ1B [IF I11=3 or 4 (Negative HVAC) AND EQ1=1 (Less maintenance)] Earlier you said that your heating and cooling equipment has been less reliable, or requires more maintenance. Can you please confirm for me whether the energy efficiency improvements have had an overall POSITIVE or NEGATIVE impact on maintenance of your heating and cooling equipment, or has there been no difference in maintenance requirements?

1 Positive [SKIP TO EQ2]
2 Negative [SKIP TO EQ3]
3 No difference [SKIP TO LT1]

EQ2 [IF EQ1=1 (LESS MAINTENANCE)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the value to you per year of the reduction in maintenance to heating and cooling equipment, either in dollars or as a percentage of energy savings?

1 $____/year [SKIP TO LT1]
2 _____% of annual energy savings [SKIP TO LT1]
D Don't know [SKIP TO EQ2A]

EQ2A [IF EQ1=1 & EQ2=DON'T KNOW] In terms of energy bill savings, which of the following would you say is closest to the value of the reduction in maintenance to heating and cooling equipment?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO EQ2AX]
7 Other [GO TO EQ2AX]
8 DO NOT READ: Have not noticed any reduction in maintenance to heating/cooling equipment
D Don't know

EQ2AX [IF EQ2A=6 OR 7] How much in total?

[IF EQ2A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

EQ3 [IF EQ1=2 (MORE MAINTENANCE)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the cost per year of the increase in maintenance to heating and cooling equipment, either in dollars or as a percentage of energy savings?

1 $____/year [SKIP TO LT1]
2 _____% of annual energy savings [SKIP TO LT1]
D Don't know [GO TO EQ3A]

EQ3A [IF EQ1=1 & EQ3=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the cost of the increase in maintenance to heating and cooling equipment?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO EQ3AX]
7 Other [GO TO EQ3AX]
8 DO NOT READ: Have not noticed any increase in maintenance to heating/cooling equipment
D Don't know

EQ2AX [IF EQ2A=6 OR 7] How much in total?

[IF EQ2A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

REDUCED MAINTENANCE FOR LIGHTING [ONLY ASK IF INSTALLED LIGHTING]

LT1 [ASK IF INSTALLED LIGHTING, OTHERWISE SKIP TO D1] The energy efficient lighting you installed, in addition to saving energy, generally has a longer lifetime and may require less maintenance than incandescent lighting. After installing the energy efficient lighting, would you say that your lighting requires LESS maintenance than before the improvements were made, requires MORE maintenance or would you say there is no difference in the maintenance requirements of your lighting?

1 Less maintenance [GO TO LT2]
2 More maintenance [GO TO LT3]
3 No difference [GO TO D1]
D Don't know [GO TO D1]

LT1A [IF I10=5 (Improved lighting) AND LT1=2 (More maintenance)] Earlier you said that your lighting requires less maintenance. Can you please confirm for me whether the energy efficiency improvements have had an overall POSITIVE or NEGATIVE impact on your lighting maintenance requirements, or has there been no difference in maintenance requirements?

1 Positive [SKIP TO LT2]
2 Negative [SKIP TO LT3]
3 No difference [SKIP TO D1]

LT1B [IF I11=5 (Negative lighting) AND LT1=1 (Less maintenance)] Earlier you said that your lighting requires more maintenance. Can you please confirm for me whether the energy efficiency improvements have had an overall POSITIVE or NEGATIVE impact on your lighting maintenance requirements, or has there been no difference in maintenance requirements?

1 Positive [SKIP TO LT2]
2 Negative [SKIP TO LT3]
3 No difference [SKIP TO D1]

LT2 [IF LT1=1 (LESS MAINTENANCE)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the value to you per year of the reduction in maintenance requirements of your lighting, either in dollars or as a percentage of energy savings?

1 $____/year [SKIP TO D1]
2 _____% of annual energy savings [SKIP TO D1]
D Don't know [SKIP TO LT2A]

LT2A [IF LT1=1 & LT2=DON'T KNOW] In terms of energy bill savings, which of the following would you say is closest to the reduction in maintenance requirements of your lighting?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO LT2AX]
7 Other [GO TO LT2AX]
8 DO NOT READ: Have not noticed reduction in maintenance requirements of lighting
D Don't know

LT2AX [IF LT2A=6 OR 7] How much in total?

[IF LT2A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

LT3 [IF LT1=2 (MORE MAINTENANCE)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the cost per year of the increase in maintenance requirements of your lighting, either in dollars or as a percentage of energy savings?

1 $____/year [SKIP TO Q#0] OR
2 _____% of annual energy savings [SKIP TO Q#0]
D Don't know [GO TO Q#0]

LT3A [IF LT1=2 & LT3=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the cost of the increase in maintenance requirements of your lighting?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO LT3AX]
7 Other [GO TO LT3AX]
8 DO NOT READ: Have not noticed an increase in the maintenance requirements of lighting
D Don't know

LT2AX [IF LT2A=6 OR 7] How much in total?

[IF LT2A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

DURABILITY

D1 In terms of the durability of your property, would you say that, because of the energy efficiency improvements, your property is 1) MORE durable and LESS prone to needing repairs than before the improvements were made, 2) LESS durable and MORE prone to needing repairs, or would you say that 3) there is no difference in the durability of your property?

1 More durable / fewer repairs [GO TO D2]
2 Less durable / more repairs [SKIP TO D3]
3 No difference [SKIP TO TC1]
4 Don't know [SKIP TO TC1]

D2 [IF D1=1 (MORE DURABLE)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the value to you per year of the increased durability of your property, either in dollars or as a percentage of energy savings?

1 $____/year [SKIP TO TC1]
2 _____% of annual energy savings [SKIP TO TC1]
D Don't Know [GO TO D2A]

D2A [IF D1=1 & D2=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the value of the increased durability of your property?…

[READ RESPONSES]

1	Nothing	
2	About one-fourth of typical annual energy bill savings	
3	About one-half of typical annual energy bill savings	
4	About three-fourths of typical annual energy bill savings	
5	About equal to the typical annual energy bill savings	
6	More than energy bill savings	[GO TO D2AX]
7	Other	[GO TO D2AX]
8	DO NOT READ: Have not noticed any increase in the durability of the property	
D	Don't know	

D2AX [IF D2A=6 OR 7] How much in total?

[IF D2A=6, $/year must be higher than $XX, or % must be greater than 100]

1 $___ / year
2 ____% of annual energy savings

D3 [IF D1=2 (LESS DURABLE)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the cost per year of the decreased durability of your property, either in dollars or as a percentage of energy savings?

1	$____/year	[SKIP TO TC1]
2	_____% of annual energy savings	[SKIP TO TC1]
D	Don't know	[GO TO D3A]

D3A [IF D1=1 & D3=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the cost of the decreased durability of your property?

[READ RESPONSES]

1	Nothing	
2	About one-fourth of typical annual energy bill savings	
3	About one-half of typical annual energy bill savings	
4	About three-fourths of typical annual energy bill savings	
5	About equal to the typical annual energy bill savings	
6	More than energy bill savings	[GO TO D3AX]
7	Other	[GO TO D3AX]
8	DO NOT READ: Have not noticed any decrease in the durability of the property	
D	Don't know	

D3AX [IF D3A=6 OR 7] How much in total?

[IF D3A=6, $/year must be higher than $XX, or % must be greater than 100]

1 $___ / year
2 ____% of annual energy savings

TENANT COMPLAINTS

TC1 In terms of the number of complaints made by your tenants, would you say that, because of the energy efficiency improvements, your tenants make FEWER complaints than before the improvements were made, make MORE complaints, or would you say there is no difference in the number of complaints made by your tenants?

1 Fewer complaints [GO TO TC2]
2 More complaints [SKIP TO TC3]
3 No difference [SKIP TO OTH1]
4 Don't know [SKIP TO OTH1]

TC2 [IF TC1=1 (FEWER COMPLAINTS)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the value to you per year of the decrease in tenant complaints, either in dollars or as a percentage of energy savings?

1 $____/year [SKIP TO OTH1]
2 _____% of annual energy savings [SKIP TO OTH1]
D Don't know [GO TO TC2A]

TC2A [IF TC1=1 & TC2=DON'T KNOW] In terms of energy bill savings, would you say the decrease in tenant complaints is worth…

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO TC2AX]
7 Other [GO TO TC2AX]
8 DO NOT READ: Have not noticed a decrease in tenant complaints
9 Don't know

TC2AX [IF TC2A=6 OR 7] How much in total?

[IF TC2A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

TC3 [IF TC1=2 (MORE COMPLAINTS)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the cost to you per year of the increase in tenant complaints, either in dollars or as a percentage of energy savings?

1 $____/year [SKIP TO OTH1]
2 _____% of annual energy savings [SKIP TO OTH1]
D Don't know [GO TO TC3A]

TC3A [IF TC1=1 & TC3=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the cost of the increase in tenant complaints?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO TC3AX]
7 Other [GO TO TC3AX]
8 DO NOT READ: Have not noticed an increase in tenant complaints
D Don't know

TC3AX [IF TC3A=6 OR 7] How much in total?

[IF TC3A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

OTHER NEI

OTH1 Is there another impact resulting from the energy efficiency improvements that we have not discussed?

1 Yes [GO TO OTH2]
2 No [SKIP TO T1]
D Don't know [SKIP TO T1]
R Refused [SKIP TO T1]

OTH2 What is the impact?

[RECORD VERBATIM]

OTH3 Would you say that [INSERT VERBATIM FROM OTH2] has had a positive impact or a negative impact on your property?

1 Positive impact [GO TO OTH4]
2 Negative impact [SKIP TO OTH5]
3 No impact [SKIP TO T1]
D Don't know [SKIP TO T1]

OTH4 [IF OTH3=1 (POSITIVE IMPACT)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the value to you per year of [INSERT VERBATIM FROM OTH2] either in dollars or as a percentage of energy savings?

1 $____/year [SKIP TO T1]
2 _____% of annual energy savings [SKIP TO T1]
D Don't know [GO TO OTH4A]

OTH4A [IF OTH3=1 & OTH4=DON'T KNOW] In terms of energy bill savings, would you say [INSERT VERBATIM FROM OTH2] is worth…

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO OTH4AX]
7 Other [GO TO OTH4AX]
D Don't know

OTH4AX [IF OTH4A=6 OR 7] How much in total?

[IF OTH4A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

OTH5 [IF OTH3=2 (NEGATIVE IMPACT)] A property with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the cost to you of [INSERT VERBATIM FROM OTH2] either in dollars or as a percentage of energy savings?

1 $____/year [SKIP TO T1]
2 _____% of annual energy savings [SKIP TO T1]
D Don't know [GO TO OTH5A]

OTH5A [IF OTH3=2 & OTH5=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the cost to you of [INSERT VERBATIM FROM OTH2]?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO OTH5AX]
7 Other [GO TO OTH5AX]D Don't know

OTH5AX [IF OTH5A=6 OR 7] How much in total?

[IF OTH5A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

TOTAL VALUE OF NEIS

TOT1 Next, please think about the total of all of the positive and negative effects caused by the energy efficient improvements made to your property EXCEPT for any changes in your property value. To summarize, you reported that [LIST POSITIVE EFFECTS] were positive effects and that [LIST NEGATIVE EFFECTS] were negative effects caused by the energy efficient improvements made to your property. Would you say that the combination of all of these effects is positive, negative or no effect?

1 Positive [GO TO TOT2]
2 Negative [GO TO TOT3]
3 No Effect [SKIP TO F1]
D Don’t know [SKIP TO F1]
R Refused [SKIP TO F1]

TOT2 [IF TOT1=1 (POSITIVE)] Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the value of all of the effects combined, either in dollars or as a percentage of energy savings?

1 $____/year [SKIP TO F1]
2 _____% of annual energy savings [SKIP TO F1]
D Don’t know [SKIP TO TOT2A]

TOT2A [IF TOT1=1 & TOT2=DON’T KNOW] In terms of energy bill savings, would you say the value of all of the effects combined is closest to…

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO TOT2AX]
7 Other
D Don’t know

TOT2AX [IF TOT2A=6 OR 7] How much in total?

[IF TOT2A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

TOT3 [IF TOT1=2 (NEGATIVE)] Assuming you [IF I7=1 or 3: and your tenants] are saving $XX per year on energy, what is the cost to you per year of all of the effects combined, either in dollars or as a percentage of energy savings?

1 $____/year [SKIP TO F1]
2 _____% of annual energy savings [SKIP TO F1]
D Don't know [GO TO TOT3A]

TOT3A [IF TOT1=2 & TOT3=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the value that all of the effects combined takes away from your property?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO TOT3AX]
7 Other [GO TO TOT3AX]
D Don't know

TOT3AX [IF TOT3A=6 OR 7] How much in total?

[IF TOT3A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

FIRMOGRAPHCS / DETAILS ABOUT APARTMENTS AND COMPANY

F_INT Now I have a few last questions for statistical purposes only.

F1 How many apartment units are located in the building at the address we have been talking about? [PROMPT: That is at (INSERT SAMPLE ADDRESS)?]

___ [RECORD # UNITS]
888 Don't know

F2 Do you or your firm own and manage this property, manage this property only, or own this property but not manage it?

1 Own and manage property
2 Manage property only
3 Own but not manage
4 Other
D Don't know
R Refused

F3A In total, how many multifamily residential properties do you or your firm own and manage?

___ [RECORD NUMBER]
888 Don't know

F3A_1 In total, how many apartment units are located in these properties?
[PROMPT: That is, the properties you own *and* manage.]

____ [RECORD NUMBER]
8888 Don't know

F3B In total, how many multifamily residential properties do you or your firm manage, but not own?

___ [RECORD NUMBER]
888 Don't know

F3B_1 In total, how many apartment units are located in these properties?
[PROMPT: That is, the properties you manage, but do not own.]

____ [RECORD NUMBER]
8888 Don't know

F3C In total, how many multifamily residential properties do you or your firm own, but not manage?

___ [RECORD NUMBER]
888 Don't know

F3C_1 In total, how many apartment units are located in these properties?
[PROMPT: That is, the properties you own, but do not manage.]

____ [RECORD NUMBER]
8888 Don't know

APPENDIX F: NEI SURVEY: LOW-INCOME AND NON-LOW-INCOME RETROFITS

Massachusetts Statewide: Low-income and Non-low-income Retrofits — NEI Survey

CaseID

Respondent Data

- Name
- Phone
- Address

Utility Name

- Ex
- Ex
- Ex

Utility Program Name

- Ex
- Ex
- Ex

Measures received

- Ex
- Ex
- Ex
- Ex

Estimated Annual Energy Savings

INTRODUCTION AND SCREENING

Hello, my name is ______, and I'm calling from Tetra Tech on behalf of Massachusetts utilities and energy efficiency organizations about some of the programs and services they offer to residential customers, including the home energy efficiency improvements you had done recently through [PA NAME's] energy efficiency programs. The survey should take around 20 minutes and the information you provide will help the sponsors improve their programs and services. Your responses will be kept strictly confidential.

I1 May I speak with [CONTACT NAME]?

1 Yes [GO TO I2]

2 No [SKIP TO I3]

I2 Are you the person in your household who is most familiar with the energy efficiency improvements made to your home recently at the following address: [ADDRESS]?

1 Yes [SKIP TO I4]
2 No, someone else in the household is more familiar [SKIP TO I3]
3 Landlord for participating address [GO TO I2A]
D DON'T KNOW [SKIP TO I3]
R REFUSED [THANK & TERMINATE]

I2A Do you live in one of the units at [INSERT ADDRESS] that had the energy efficiency improvements made?

1 Yes [SKIP TO I3A]
2 No, live at different address [THANK & TERMINATE]
R Refused [THANK & TERMINATE]

I3 Is there someone else in your home I could speak to now who has been involved with the energy efficiency improvements made to your home recently?

1 Yes [RE-READ INTRO AND START WITH I2]
2 No [ASK TO SCHEDULE A TIME TO CALL BACK]
D Don't know [THANK & TERMINATE]
R Refused [THANK & TERMINATE]

I3A First, I would like to confirm that the energy efficiency improvements were made to a home that was built before 2009.

1 Yes, this is a home built before 2009 [GO TO I4]
2 No, this is a home built since 2009 [THANK & TERMINATE]
D Don't know [THANK & TERMINATE]
R Refused [THANK & TERMINATE]

I4 Next, I would like to confirm that you installed the following energy efficiency improvements with the help of [PA NAME]'s [NAME OF PA'S PROGRAM] program in the past 2 years: [LIST EFFICIENCY MEASURES FROM PROGRAM DATA]. Is that correct?

1 Yes [GO TO I5]
2 Yes, but installed different efficiency measures
[RECORD EFFICIENCY MEASURES AND RE-SCHEDULE INTERVIEW]
3 No, did not participate in the program [THANK & TERMINATE]
D Don't know [THANK & TERMINATE]
R Refused [THANK & TERMINATE]

I5 Do you own or rent your home?

1 Own
2 Rent
R Refused

I6 What type of building is your home? [READ RESPONSES]

1 Detached single-family home
2 Townhouse or duplex, with a wall separating the units from basement to roof, and with separate utilities for each unit
3 Two, three, or four family building–one or more units stacked on top of another OR with one water and sewer bill for the whole building
4 Part of a building with five or more units
5 Other (SPECIFY)
D Don't know
R Refused

I7 Comparing your home now to before you had the energy efficiency improvements installed, would you say your home is more energy-efficient, less energy-efficient or about the same level of energy efficiency?

1 More energy-efficient
2 Less energy-efficient
3 Same level of efficiency
D Don't know
R Refused

I8_int Homes such as yours that have had energy efficiency improvements typically are more energy efficient than comparable homes that have not had similar efficiency improvements made. As a result, homes such as yours use less energy for heating, cooling, and water heating and have lower energy bills.

I8 In addition to your energy savings, have you noticed any other positive impacts resulting from the energy efficiency improvements made to your home?

[IF YES: What are they?]
[PROBE: Is there anything else? RECORD UP TO THREE RESPONSES]

1 No benefits
2 Fewer drafts; home feels more comfortable
3 Quieter, less noise from outside
4 Quieter, less noise from appliances or heating and cooling equipment
5 Increased property value
6 Improved health, general
7 Improved health, asthma or other chronic health conditions
8 Improved health, fewer colds and flu
9 Improved safety of the home
10 Improved reliability of heating and cooling equipment or appliances
11 More affordable energy bills
12 Other (SPECIFY)
13 Don't know/don't remember
14 Refused

I9 Have you noticed any negative impacts resulting from the energy efficiency improvements made to your home?

[IF YES: What are they?]
[PROBE: Is there anything else? RECORD UP TO THREE RESPONSES]

1 No negative impacts
2 More drafts; home feels LESS comfortable
3 Noisier, MORE noise from outside
4 Noisier, MORE noise from appliances or heating and cooling equipment
5 Declining health, general
6 Declining health, asthma or other chronic health conditions
7 Declining health, MORE colds and flu
8 Decreased safety of the home
9 Decreased reliability of heating and cooling equipment or appliances
10 Less affordable energy bills
11 Other (SPECIFY)
12 Don't know/don't remember
13 Refused

NEI_Int Next I would like to ask you about several impacts you may have experienced as a result of the energy efficiency improvements made to your home.

COMFORT

C1 In terms of the temperature and draftiness of your home, would you say that, because of the energy efficiency improvements, your home is MORE comfortable than it was before the improvements were made, LESS comfortable, or would you say there is no difference in the comfort level?

1 More comfortable [GO TO C2]
2 Less comfortable [SKIP TO C3]

3 No difference [SKIP TO N1]
D Don't know [SKIP TO N1]

C1A [IF I8=2 (Less drafts) AND C1=2 (Less comfortable) Earlier you said that you noticed fewer drafts or your home felt more comfortable. Can you please confirm for me whether the energy efficiency improvements have had an overall POSITIVE or NEGATIVE impact on your comfort level, or have they made no difference to your comfort level?

1 Positive [SKIP TO C2]
2 Negative [SKIP TO C3]
3 No difference [SKP TO N1]
D Don't know [SKIP TO N1]

C1B [IF I9=2 (More drafts) AND C1=1 (More comfortable)] Earlier you said that you noticed more drafts or your home felt less comfortable. Can you please confirm for me whether the energy efficiency improvements have had an overall POSITIVE or NEGATIVE impact on your comfort level, or have they made no difference to your comfort level?

1 Positive [SKIP TO C2]
2 Negative [SKIP TO C3]

C2 [IF C1=1 (MORE COMFORTABLE)] A home with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Compared to the typical energy savings of $XX per year, how much would you say this increased comfort adds to the value of living in your home each year, either in dollars or as a percentage of energy savings?

1 $____ / year [SKIP TO N1]
2 _____% of annual energy savings [SKIP TO N1]
D Don't know [GO TO C2A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the value of the increased comfort in terms of this estimate of bill savings.]

C2A [IF C1=1 & C2=DON'T KNOW] Compared to the typical energy bill savings of $x, would you say the increased comfort is worth…

[READ RESPONSES]

1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO C2AX]
7 Other [GO TO C2AX]
8 DO NOT READ: Have not noticed any increased comfort
D Don't know

C2AX [IF C2A=6 OR 7] How much in total?

[IF C2A=6, $/year must be higher than $XX, or % must be greater than 100]

1 $___ / year
2 ____% of annual energy savings

C3 [IF C1=2 (LESS COMFORTABLE)] A home with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you're saving $XX per year on energy, how much would you say the decreased comfort takes away from the value of living in your home each year, either in dollars or as a percentage of energy savings?

1 $____ / year [SKIP TO N1]
2 _____% of annual energy savings [SKIP TO N1]
D Don't know [GO TO C3A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the value of the decreased comfort in terms of this estimate of bill savings.]

C3A [IF C1=1 & C3=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the value that the decreased comfort takes away from living in your home?

[READ RESPONSES]

1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO C3AX]
7 Other [GO TO C3AX]
8 DO NOT READ: Have not noticed any decreased comfort
D Don't know

C3AX [IF C3A=6 OR 7] How much in total?

[IF C3A=6, $/year must be higher than $XX, or % must be greater than 100]

1 $___ / year
2 ____% of annual energy savings

OUTDOOR NOISE / QUIETER INTERIOR ENVIRONMENT

N1 In terms of the amount of noise you hear from outside your home, would you say that, because of the energy efficiency improvements, your home is QUIETER than it was before the improvements were made with less noise from outside, LESS QUIET with more noise from outside, or would you say there is no difference in the noise level?

1 Quieter, with less noise from the outside [GO TO N2]
2 Less quiet, with more noise from the outside [SKIP TO N3]
3 No difference [SKIP TO CF1]
D Don't know [SKIP TO CF1]

N1A [IF I8=3 (Less outside noise) AND N1=2 (More noise)] Earlier you said that you noticed less noise from outside your house. Can you please confirm for me whether the energy efficiency improvements have made your home more quiet, less quiet, or have they made no difference to the noise level of your home?

1 More quiet [SKIP TO C2]
2 Less quiet [SKIP TO C3]
3 No difference [SKIP TO CF1]
D Don't know [SKIP TO CF1]

N1B [IF I9=3 (More noise) AND N1=1 (Quieter)] Earlier you said that you noticed more noise from outside your house. Can you please confirm for me whether the energy efficiency improvements have made your home more quiet or less quiet, or have they made no difference to the noise level in your home?

1 More quiet [SKIP TO C2]
2 Less quiet [SKIP TO C3]
3 No difference [SKIP TO CF1]
D Don't know [SKIP TO CF1]

N2 [IF N1=1 (QUIETER)] A home with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you're saving $XX per year on energy, how much would you say this reduced noise level adds to the value of living in your home each year, either in dollars or as a percentage of energy savings?

1 $____ / year [SKIP TO CF1]
2 _____% of annual energy savings [SKIP TO CF1]
D Don't know [GO TO N2A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the value of the decreased noise level in terms of this estimate of bill savings.]

N2A [IF N1=1 & N2=DON'T KNOW] In terms of energy bill savings, would you say the decreased noise is worth…

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO N2AX]
7 Other [GO TO N2AX]
8 DO NOT READ: Have not noticed any decreased noise
D Don't know

N2AX [IF N2A=6 OR 7] How much in total?

[IF N2A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

N3 [IF N1=2 (NOISIER)] A home with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you're saving $XX per year on energy, how much would you say the increased noise level takes away from the value of living in your home each year, either in dollars or as a percentage of energy savings?

1 $____ / year [SKIP TO CF1]
2 _____% of annual energy savings [SKIP TO CF1]
D Don't know [GO TO N3A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the value of the increased noise level in terms of this estimate of bill savings.]

N3A [IF N1=2 & N3=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the value that the increased noise takes away from living in your home?

[READ RESPONSES]

1	Nothing	
2	About one-fourth of typical annual energy bill savings	
3	About one-half of typical annual energy bill savings	
4	About three-fourths of typical annual energy bill savings	
5	About equal to the typical annual energy bill savings	
6	More than energy bill savings	[GO TO N3AX]
7	Other	[GO TO N3AX]
8	DO NOT READ: Have not noticed any increased noise	
D	Don't know	

N3AX [IF N3A=6 OR 7] How much in total?

[IF N3A=6, $/year must be higher than $XX, or % must be greater than 100]

1 $___/year

2 ____% of annual energy savings

HEALTH, COLDS, FLUS, ASTHMA AND OTHER CHRONIC CONDITIONS

CF1 In terms of the frequency or intensity of colds, flus, and other illnesses, such as asthma or other chronic health conditions, would you say that you and your household, because of the energy efficiency improvements, have had FEWER cases or symptoms of the cold, flu or other illnesses such as asthma, MORE cases or symptoms of the cold, flu or other illnesses such as asthma, or would you say there is no difference in the frequency or intensity of colds, flus, and other illnesses such as asthma?
[IF RESPONDENT INDICATES THERE HAVE BEEN CHANGES IN HEALTH, BUT NOT DUE TO EFFICIENCY IMPROVEMENTS, CHOOSE "NO DIFFERENCE".]

1	Fewer colds, flus, and improved chronic conditions	[SKIP TO CF2]
2	More colds, flus, and worsened chronic conditions	[SKIP TO CF3]
3	No difference	[SKIP TO PV1]
4	Other (SPECIFY)	[GO TO CF1A]
D	Don't Know	[SKIP TO PV1]

CF1A [IF CF1=2 and any of I8_6, I8_7 or I8_8: Earlier you said that your household had noticed improved health.]
[IF CF1=1 and any of I9_5, I9_6 or I9_7: Earlier you said that your household had noticed declining health.]
Can you please confirm for me whether the energy efficiency improvements have had an overall positive or negative impact on your household's health, or have they made no difference to your household's health?

[INDICATE ALL THAT APPLY]

1	Positive	[SKIP TO CF2]
2	Negative	[SKIP TO CF3]
3	No difference	[SKIP TO PV1]
D	Don't Know	[SKIP TO PV1]

CF2 [IF CF1=1 OR (4 WITH ANY IMPROVEMENTS)] A home with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you're saving $XX per year on energy, how much would you say the decrease in the number of cases or severity of symptoms of colds, flus and other illnesses adds to the value of living in your home each year, either in dollars or as a percentage of energy savings?

1	$____ / year	[SKIP TO PV1]
2	_____% of annual energy savings	[SKIP TO PV1]
D	Don't know	[GO TO CF2A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the value of the decrease in the number of cases or severity of symptoms of colds, flus, and other illnesses in terms of this estimate of bill savings.]

CF2A [IF CF1=1 OR (4 WITH ANY IMPROVEMENTS)] & CF2=DON'T KNOW] In terms of energy bill savings, would you say the decrease in the number of cases or severity of symptoms of colds, flus and other illnesses, is worth…

[READ RESPONSES]

1	Nothing	
2	About one-fourth of typical annual energy bill savings	
3	About one-half of typical annual energy bill savings	
4	About three-fourths of typical annual energy bill savings	
5	About equal to the typical annual energy bill savings	
6	More than energy bill savings	[GO TO A2AX]
7	Other	[GO TO A2AX]
8	DO NOT READ: Have not noticed any decrease colds, flu, or other illnesses or in asthma or other chronic conditions.	
9	Don't know	

CF2AX [IF CF2A=6 OR 7] How much in total?

[IF CF2A=6, $/year must be higher than $XX, or % must be greater than 100]

1 $___/year

2 ____% of annual energy savings

CF3 [IF CF1=2 OR (4 WITH ANY WORSENING)] A home with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you're saving $XX per year on energy, how much would you say the increase in the number of cases or severity of symptoms colds, flus and other illnesses takes away from the value of living in your home each year, either in dollars or as a percentage of energy savings?

1	$____ / year	[SKIP TO PV1]
2	_____% of annual energy savings	[SKIP TO PV1]
D	Don't know	[GO TO CF3A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the value of the increase in the number of cases or severity of symptoms of colds, flus, and other illnesses in terms of this estimate of bill savings.]

CF3A [IF CF1=2 OR (4 WITH ANY WORSENING)] & CF3=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the value the increase in the number of cases or severity of symptoms colds, flus and other illnesses takes away from living in your home?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO CF3AX]
7 Other [GO TO CF3AX]
8 DO NOT READ: Have not noticed any increase in colds, flu or other illnesses or worsening of asthma or other chronic conditions
9 Don't know

CF3AX [IF CF3A=6 OR 7] How much in total?

[IF CF3A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

EXPECTED INCREASE IN PROPERTY VALUE [ONLY ASK IF OWN HOME]

PV1 [IF I5 NE 1 SKIP TO EQ1] Not counting any investments you made in the energy efficiency improvements, would you say that, because of the energy efficiency improvements, your home has a HIGHER value than it would have without the improvements, a LOWER value than it would have without the improvements, or would you say about the same value?

1 Higher value [GO TO PV2]
2 Lower value [SKIP TO PV3]
3 No difference [SKIP TO EQ1]
D Don't know [SKIP TO EQ1]

PV2 [IF PV1=1 (HIGHER VALUE)] A home with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you're saving $XX per year on energy, how much would you say the improvements add to the overall value of your property, either in dollars or as a percentage of energy savings?

1 $____ [SKIP TO EQ1]
2 _____% of annual energy savings [SKIP TO EQ1]
D Don't know [GO TO PV2A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the value of the higher property values in terms of this estimate of bill savings.]

PV2A [IF PV1=1 & PV2=DON'T KNOW] In terms of energy bill savings, would you say the improvements add to the value of your home:

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO PV2AX]
7 Other [GO TO PV2AX]
8 DO NOT READ: Have not noticed any increased property value
9 Don't know

PV2AX [IF PV2A=6 OR 7] How much in total?

[IF PV2A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

PV3 [IF PV1=2 (LOWER VALUE)] A home with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you're saving $XX per year on energy, how much would you say the improvements take away from the value of your home, either in dollars or as a percentage of energy savings?

1 $____ [SKIP TO EQ1]
2 _____% of annual energy savings [SKIP TO EQ1]
D Don't know [GO TO PV3A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the value of the decreased property values in terms of this estimate of bill savings.]

PV3A [IF PV1=2 & PV3=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the amount that the improvements take away from the value of your home?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO PV3AX]
7 Other [GO TO PV3AX]
8 DO NOT READ: Have not noticed any decreased property value
D Don't know

PV3AX [IF PV3A=6 OR 7] How much in total?

[IF PV3A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___
2 ____% of annual energy savings

EQUIPMENT MAINTENANCE / RELIABILITY [ONLY ASK IF INSTALLED HEATING AND COOLING EQUIPMENT]

EQ1 [ASK IF RESPONDENT INSTALLED HEATING AND COOLING EQUIPMENT; OTHERWISE, SKIP TO LT1] In terms of the maintenance requirements or reliability of your heating and cooling equipment, would you say that, because of the energy efficiency improvements, your heating and cooling equipment 1) requires LESS maintenance and is MORE reliable than before the improvements were made, 2) requires MORE maintenance and is LESS reliable, or would you say that 3) there is no difference in the maintenance requirements or reliability of your heating and cooling equipment?

1 Less maintenance/more reliable [GO TO EQ2]
2 More maintenance/less reliable [SKIP TO EQ3]
3 No difference [SKIP TO LT1]
D Don't know [SKIP TO LT1]

EQ1A [IF I8=10 (Increased reliability) AND EQ1=2 (More maintenance)] Earlier you said that your appliances or heating and cooling equipment seemed more reliable. Can you please confirm for me whether the energy efficiency improvements have had an overall POSITIVE or NEGATIVE impact on your appliance or equipment's reliability, or have the improvements made no difference to its reliability?

1 Positive [SKIP TO EQ2]
2 Negative [SKIP TO EQ3]
3 No difference [SKIP TO LT1]
D Don't know [SKIP TO LT1]

EQ1B [IF I8=9 (Decreased reliability) AND EQ1=2 (Less maintenance)] Earlier you said that your appliances or heating and cooling equipment seemed less reliable. Can you please confirm for me whether the energy efficiency improvements have had a POSITIVE or NEGATIVE impact on your appliance or equipment's reliability, or have the improvements made no difference to its reliability? 1 Positive [SKIP TO EQ2] 2 Negative [SKIP TO EQ3]

3 No difference [SKIP TO LT1]
D Don't know [SKIP TO LT1]

EQ2 [IF EQ1=1 (LESS MAINTENANCE)] A home with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you're saving $XX per year on energy, how much would you say the reduction in maintenance of heating and cooling equipment adds to the value of living in your home each year, either in dollars or as a percentage of energy savings?

1 $____ / year [SKIP TO LT1]
2 _____% of annual energy savings [SKIP TO LT1]
D Don't know [GO TO EQ2A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the value of the reduction in maintenance of heating and cooling equipment in terms of this estimate of bill savings.]

EQ2A [IF EQ1=1 & EQ2=DON'T KNOW] In terms of energy bill savings, would you say the reduction in maintenance of heating and cooling equipment is worth…

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO EQ2AX]
7 Other [GO TO EQ2AX]
8 DO NOT READ: Have not noticed any reduction in maintenance to heating and cooling equipment
D Don't know

EQ2AX [IF EQ2A=6 OR 7] How much in total?

[IF EQ2A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

EQ3 [IF EQ1=2 (MORE MAINTENANCE)] A home with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you're saving $XX per year on energy, how much would you say the increase in maintenance of heating and cooling equipment takes away from the value of living in your home each year, either in dollars or as a percentage of energy savings?

1 $____ / year [SKIP TO LT1]
2 _____% of annual energy savings [SKIP TO LT1]
D Don't know [GO TO EQ3A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the value of the increase in maintenance of heating and cooling equipment in terms of this estimate of bill savings.]

EQ3A [IF EQ1=2 & EQ3=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the value that the increase in maintenance to heating and cooling equipment takes away from living in your home?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO EQ3AX]
7 Other [GO TO EQ3AX]
8 DO NOT READ: Have not noticed any increase in maintenance to heating and cooling equipment
D Don't know

EQ3AX [IF EQ3A=6 OR 7] How much in total?

[IF EQ3A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___/year
2 ____% of annual energy savings

LIGHTING QUALITY AND LIFETIME [ONLY ASK IF INSTALLED LIGHTING]

LT1 [ASK IF RESPONDENT INSTALLED LIGHTING; OTHERWISE, SKIP TO D1] The energy efficient lighting you installed, in addition to saving energy, generally has a longer lifetime and may also have a different lighting quality than incandescent lighting. After installing the energy efficient lighting, would you say that the longer lifetime and lighting quality of the new lighting, taken together, is a POSITIVE feature of the lighting, a NEGATIVE feature of the lighting, or makes no difference to you?

1 Positive feature [GO TO LT2]
2 Negative feature [SKIP TO LT3]
3 No difference [SKIP TO D1]
D Don't know [SKIP TO D1]

LT2 [IF LT1=1 (POSITIVE FEATURE)] A home with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you're saving $XX per year on energy, how much would you say the longer life and lighting quality of your energy efficient lighting add to the value of living in your home each year, either in dollars or as a percentage of energy savings?

1 $____ / year [SKIP TO D1]
2 _____% of annual energy savings [SKIP TO D1]
D Don't know [GO TO LT2A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the value of the longer life and lighting quality of your energy efficient lighting in terms of this estimate of bill savings.]

LT2A [IF LT1=1 & LT2= DON'T KNOW] In terms of energy bill savings, would you say the longer life and lighting quality is worth…

[READ RESPONSES]

1	Nothing	
2	About one-fourth of typical annual energy bill savings	
3	About one-half of typical annual energy bill savings	
4	About three-fourths of typical annual energy bill savings	
5	About equal to the typical annual energy bill savings	
6	More than energy bill savings	[GO TO LT2AX]
7	Other	[GO TO LT2AX]
8	DO NOT READ: Have not noticed longer life and lighting quality	
D	Don't know	

LT2AX [IF LT2A=6 OR 7] How much in total?

[IF LT2A=6, $/year must be higher than $XX, or % must be greater than 100]

1 $___/year

2 ____% of annual energy savings

LT3 [IF LT1=2 (NEGATIVE FEATURE)] A home with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you're saving $XX per year on energy, how much would you say the longer life and lighting quality of your energy efficient lighting takes away from the value of living in your home each year, either in dollars or as a percentage of energy savings?

1	$____ / year	[SKIP TO D1]
2	_____% of annual energy savings	[SKIP TO D1]
D	Don't know	[GO TO LT3A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the value of the longer life and lighting quality of your energy efficient lighting in terms of this estimate of bill savings.]

LT3A [IF LT1=2 & LT3=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the value that the longer life and lighting quality takes away from living in your home?

[READ RESPONSES]

1	Nothing	
2	About one-fourth of typical annual energy bill savings	
3	About one-half of typical annual energy bill savings	
4	About three-fourths of typical annual energy bill savings	
5	About equal to the typical annual energy bill savings	
6	More than energy bill savings	[GO TO LT3AX]
7	Other	[GO TO LT3AX]
8	DO NOT READ: Have not noticed longer life and lighting quality	
D	Don't know	

LT3AX [IF LT3A=6 OR 7] How much in total?

[IF LT3A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

DURABILITY OF HOME

D1 In terms of the durability of your home, would you say that, because of the energy efficiency improvements, your home is 1) MORE durable and LESS prone to needing repairs than before the improvements were made, 2) LESS durable and MORE prone to needing repairs, or would you say that 3) there is no difference in the durability of your home?

1 More durable/fewer repairs [GO TO D2]
2 Less durable/ more repairs [SKIP TO D3]
3 No difference [SKIP TO T1]
D Don't know [SKIP TO T1]

D2 [IF D1=1 (MORE DURABLE)] A home with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you're saving $XX per year on energy, how much would you say the increased durability adds to the value of living in your home each year, either in dollars or as a percentage of energy savings?

1 $____ / year [SKIP TO T1]
2 _____% of annual energy savings [SKIP TO T1]
D Don't know [GO TO D2A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the value of the increased durability in terms of this estimate of bill savings.]

D2A [IF D1=1 & D2=DON'T KNOW] In terms of energy bill savings, would you say the increased durability of your home is worth…

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO D2AX]
7 Other [GO TO D2AX]
8 DO NOT READ: Have not noticed any increase in the durability of the home
D Don't know

D2AX [IF D2A=6 OR 7] How much in total?

[IF D2A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___/year
2 ____% of annual energy savings

D3 [IF D1=2 (LESS DURABLE)] A home with the type of energy efficiency improvements you installed typically saves $XX annually on energy bills. Assuming you're saving $XX per year on energy, how much would you say the decreased durability of your home takes away from the value of living in your home each year, either in dollars or as a percentage of energy savings?

1 $____ / year [SKIP TO T1]
2 _____% of annual energy savings [SKIP TO T1]
D Don't know [GO TO D3A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the value of the decreased durability in terms of this estimate of bill savings.]

D3A [IF D1=2 & D3=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the value that the decreased durability of your home takes away from living in your home?

[READ RESPONSES]
1 Nothing
2 About one-fourth of typical annual energy bill savings
3 About one-half of typical annual energy bill savings
4 About three-fourths of typical annual energy bill savings
5 About equal to the typical annual energy bill savings
6 More than energy bill savings [GO TO D3AX]
7 Other [GO TO D3AX]
8 DO NOT READ: Have not noticed any decrease in the durability of the home
D Don't know

D3AX [IF D3A=6 OR 7] How much in total?

[IF D3A=6, $/year must be higher than $XX, or % must be greater than 100]
1 $___ / year
2 ____% of annual energy savings

TOTAL VALUE OF NEIS

T1 [ASK IF I5=1 (OWN); OTHERWISE, SKIP TO T2] Next, please think about the total of all of the positive and negative effects caused by the energy efficient improvements made to your home EXCEPT for any changes in your property value. To summarize, you reported that [LIST POSITIVE EFFECTS] were positive effects and that [LIST NEGATIVE EFFECTS] were negative effects caused by the energy efficient improvements made to your home. Would you say that the combination of all of these effects is positive, negative or no effect?

1 Positive [SKIP TO T3]
2 Negative [SKIP TO T5]
3 No Effect [SKIP TO H1]
D Don't know [SKIP TO H1]
R Refused [SKIP TO H1]

T2 [ASK IF I5=2 (RENT)] Next, please think about the total of all of the positive and negative effects caused by the energy efficient improvements made to your home. To summarize, you reported that [LIST POSITIVE EFFECTS] were positive effects and that [LIST NEGATIVE EFFECTS] were negative effects caused by the energy efficient improvements made to your home. Would you say that the combination of all of these effects is positive, negative or no effect?

1 Positive [GO TO T3]
2 Negative [SKIP TO T5]
3 No Effect [SKIP TO H1]
D Don't know [SKIP TO H1]
R Refused [SKIP TO H1]

T3 [IF T1=1 OR T2=1 (POSITIVE)] Assuming you're saving $XX per year on energy, what is the value of all of the effects combined each year, either in dollars or as a percentage of energy savings?

1 $____ / year [SKIP TO H1]
2 _____% of annual energy savings [SKIP TO H1]
D Don't know [GO TO T3A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the combined value of all of the effects in terms of this estimate of bill savings.]

T3A [IF (T1=1 OR T2=1) & T3=DON'T KNOW] In terms of energy bill savings, would you say the value of all of the effects combined is worth…

[READ RESPONSES]

1	Nothing	
2	About one-fourth of typical annual energy bill savings	
3	About one-half of typical annual energy bill savings	
4	About three-fourths of typical annual energy bill savings	
5	About equal to the typical annual energy bill savings	
6	More than energy bill savings	[GO TO T3AX]
7	Other	[GO TO T3AX]
D	Don't know	

T3AX [IF T3A=6 OR 7] How much in total?

[IF T3A=6, $/year must be higher than $XX, or % must be greater than 100]

1 $___ / year
2 ____% of annual energy savings

T4 [IF T1=2 OR T2=2 (NEGATIVE)] Assuming you're saving $XX per year on energy, how much value would you say all of the effects combined takes away from the value of living in your home each year, either in dollars or as a percentage of energy savings?

1	$____ / year	[SKIP TO H1]
2	_____% of annual energy savings	[SKIP TO H1]
D	Don't know	[GO TO T4A]

[IF REPONDENT SAYS THEY HAVE NOT REALIZED ENERGY SAVINGS: The annual energy bill savings are an estimate based on the type of energy efficiency improvements made to your home. Please try to estimate the combined value of all of the effects in terms of this estimate of bill savings.]

T4A [IF T1=2 OR T2=2 & T4=DON'T KNOW] In terms of energy bill savings, which of the following is closest to the value that all of the effects combined take away from living in your home?

[READ RESPONSES]

1	Nothing	
2	About one-fourth of typical annual energy bill savings	
3	About one-half of typical annual energy bill savings	
4	About three-fourths of typical annual energy bill savings	
5	About equal to the typical annual energy bill savings	
6	More than energy bill savings	[GO TO T4AX]
7	Other	[GO TO T4AX]
D	Don't know	

T4AX [IF T4A=6 OR 7] How much in total?

[IF T4A=6, $/year must be higher than $XX, or % must be greater than 100]

1 $___ / year
2 ____% of annual energy savings

HOUSEHOLD HEALTH

H1 Next I have just a few more questions about your household's health since you installed the energy efficiency improvements. Since installing the energy efficiency improvements, have you or anyone else in your household missed work because of illness to you or a member of your household?

1 Yes [GO TO H2]
2 No [SKIP TO H3B]
D Don't know [SKIP TO H4]
R Refused [SKIP TO H4]

H2 How many days of work have you or anyone else in your household missed work because of illness to you or a member of your household?

___ [RECORD NUMBER]

H3 How does this compare to the 12 months before the efficiency improvements were installed? Would you say it is more, less, or about the same?

1 More [Go to H3A]
2 Less [Go to H3A]
3 About the same [Skip to H4]
D Don't know [Skip to H4]
R Refused [Skip to H4]

H3A [IF H3=1 or 2] How many [more/less]?

___ [RECORD NUMBER] [Skip to H3D]

H3B In the 12 months before the efficiency improvements were installed, did you or anyone else in your household miss work because of illness to you or a member of your household?

1 Yes [GO TO H3C]
2 No [SKIP TO H4]
D Don't know [SKIP TO H4]
R Refused [SKIP TO H4]

H3C How many days of work did you or anyone else in your household miss because of illness to you or a member of your household in the 12 months before the efficiency improvements were installed?

___ [RECORD NUMBER]

H3D Please think of the reasons for the change in the number of sick days off work in your household, from the year before the energy efficiency improvements were installed to the period since they were installed. Do you think the change is related to the energy efficiency improvements or do you think the change is unrelated to the improvements?

1 Related
2 Unrelated
3 Don't know
R Refused

H4 Since installing the energy efficiency improvements, have you or anyone else in your household sought medical care at a hospital, emergency room, or urgent care facility for heat stress that occurred while inside your home?

1	Yes	[GO TO H5]
2	No	[SKIP TO H6B]
D	Don't know	[SKIP TO H8]
R	Refused	[SKIP TO H8]

H5 How many times have you or anyone else in your household sought medical care at a hospital, emergency room, or urgent care facility for heat stress?

___ [RECORD NUMBER]

How does this compare to the twelve months before you installed the efficiency improvements? Would you say it is more, less, or about the same?

1	More	[GO TO H6A]
2	Less	[GO TO H6A]
3	About the same	[SKIP TO H7]
D	Don't know	[SKIP TO H7]
R	Refused	[SKIP TO H7]

H6A [IF H6=1 or 2] How many [more/less]?

___ [RECORD NUMBER] [Skip to H7]

H6B In the twelve months before the efficiency improvements were installed, did you or anyone else in your household seek medical care because of heat stress that occurred while inside your home?

1	Yes	[GO TO H6C]
2	No	[SKIP TO H8]
D	Don't know	[SKIP TO H8]
R	Refused	[SKIP TO H8]

H6C How many times did you or anyone else in your household seek care because of heat stress in the twelve months before the efficiency improvements were installed?

___ [RECORD NUMBER] [SKIP TO H8]

H7 Since installing the energy efficiency improvements, how many days were you or anyone else in your household hospitalized due to heat stress?

___ [RECORD NUMBER]

H8 Since installing the energy efficiency improvements, have you or anyone else in your household sought medical care at a hospital, emergency room, or urgent care facility for overexposure to cold conditions inside your home?

1 Yes [GO TO H9]
2 No [SKIP TO H10B]
D Don't know [SKIP TO H12]
R Refused [SKIP TO H12]

H9 How many times have you or anyone else in your household sought medical care at a hospital, emergency room, or urgent care facility for overexposure to cold conditions inside your home?

___ [RECORD NUMBER]

H10 How does this compare to the 12 months before you installed the efficiency improvements? Would you say it is more, less, or about the same?

1 More [GO TO H10A]
2 Less [GO TO H10A]
3 About the same [SKIP TO H11]
D Don't know [SKIP TO H11]
R Refused [SKIP TO H11]

H10A [IF H10=1 OR 2] How many [more/less]?

___ [RECORD NUMBER] [SKIP TO H11]

H10B In the twelve months before the efficiency improvements were installed, did you or anyone else in your household seek medical care for overexposure to cold conditions inside your home?

1 Yes [GO TO H10C]
2 No [SKIP TO H12]
D Don't know [SKIP TO H12]
R Refused [SKIP TO H12]

H10C How many times did you or anyone else in your household seek care for overexposure to cold conditions inside your home in the 12 months before the efficiency improvements were installed?

___ [RECORD NUMBER] [SKIP TO H12]

H11 Since installing the energy efficiency improvements, how many days were you or anyone else in your household hospitalized due to overexposure to cold conditions?

___ [RECORD NUMBER]

H12 Has anyone in your household been diagnosed with asthma or a related chronic health condition?

1 Yes [GO TO H13]
2 No [SKIP TO DG1]
D Don't know [SKIP TO DG1]

H13 [ASK IF H12=1] Since installing the energy efficiency improvements, have you or anyone else in your household sought medical care at a hospital, emergency room, or urgent care facility due to their asthma or other chronic health condition?

1 Yes [GO TO H14]
2 No [SKIP TO H15B]
D Don't know [SKIP TO DG1]
R Refused [SKIP TO DG1]

H14 How many times have you or anyone else in your household sought medical care at a hospital, emergency room, or urgent care facility due to their asthma or other chronic health condition?

___ [RECORD NUMBER]

H15 How does this compare to the 12 months before you installed the efficiency improvements? Would you say it is more, less, or about the same?

1 More [GO TO H15A]
2 Less [GO TO H15A]
3 About the same [SKIP TO H16]
D Don't know [SKIP TO H16]
R Refused [SKIP TO H16]

H15A [IF H15=1 OR 2] How many [more/less]?

___ [RECORD NUMBER] [SKIP TO H16]

H15B In the twelve months before the efficiency improvements were installed, did you or anyone else in your household seek medical care for their asthma or related chronic health condition?

1	Yes	[GO TO H15C]
2	No	[SKIP TO DG1]
D	Don't know	[SKIP TO DG1]
R	Refused	[SKIP TO DG1]

H15C How many times did you or anyone else in your household seek care for their asthma or related chronic health condition in the twelve months before the efficiency improvements were installed?

___ [RECORD NUMBER] [SKIP TO DG1]

H16 Since installing the energy efficiency improvements, how many days were you or anyone else in your household hospitalized due to their asthma or other chronic health condition?

___ [RECORD NUMBER]

DEMOGRAPHICS

DG1 Now I have a few last questions for statistical purposes only. Including yourself, how many people live in your home in the following age ranges most of the year?

_A Less than 18 years old
_B 18 to 64
_C 65 or older

FOR DG1_A TO DG1_C

__ [RECORD NUMBER]
99 REFUSED

DG2 Approximately how many square feet is your home?

1 Less than 1,500
2 1,500 to less than 2,000
3 2,000 to less than 2,500
4 2,500 to less than 3,000
5 3,000 to less than 4,000
6 4,000 to less than 5,000
7 5,000 or more
D Don't know
R Refused

DG3 [IF DG2=D/R] How many rooms are in your home, not counting bathrooms or unfinished basements?

1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 9
10 10 or more
11 Refused

DG4 What is the highest level of education that you have completed?

[READ CATEGORIES]
1 Less than high school
2 High school graduate
3 Technical or trade school graduate
4 Some college
5 College graduate
6 Some graduate school
7 Graduate degree
R Refused

DG5 What is your age? Are you…

[READ CATEGORIES]
1 18 to 24
2 25 to 34
3 35 to 44
4 45 to 54
5 55 to 64
6 65 or over
R Refused

DG6 What category best describes your total household income in 2010, before taxes?

[READ CATEGORIES]
1 Less than $15,000
2 $15,000 to less than $25,000
3 $25,000 to less than $35,000
4 $35,000 to less than $50,000
5 $50,000 to less than $75,000
6 $75,000 to less than $100,000
7 $100,000 to less than $150,000
8 $150,000 or more
R Refused

DG7 [DO NOT READ] Gender

1 Female
2 Male

PUC 2-5

Request:

Referring to Schedule NG-6, page 4, did the Company use the same source material and CPI as is used in Energy Efficiency benefit-cost analyses? Are the values the same for all residential accounts? If not, what are those values for each type of residential account?

Response:

Yes, the Company used the same source material as the Energy Efficiency benefit-cost analysis. However, the Energy Efficiency benefit-cost analysis did not use a Consumer Price Index (CPI) to adjust the benefit values from the original 2010 dollars. The Company adjusted these values to 2020 dollars in this analysis to use a consistent dollar year across benefits and costs. The original 2010 values are shown in Schedule NG-6 at page 3. As discussed in the Company's response to PUC 2-11, these values are based on analysis of low-income energy efficiency programs and, therefore, are applicable only to Rate A-60 customers.

Prepared by or under the supervision of: Meghan McGuinness

PUC 2-6

Request:

Referring to the response to PUC 1-15 (referencing $10,000 of marketing cost) and Schedule NG-6, did the Company include any marketing costs in the BCA analysis? If yes, please indicate where it was included. If not, please explain why not.

Response:

The Company did not include marketing costs in the benefit-cost analysis (BCA). The Company does not plan to request to expand its marketing budget for the purpose of marketing the Low-Income Community Remote Distributed Generation Incentive, but rather intends to use funds that are already included in the annual program budget for this purpose, as well. Accordingly, the marketing costs are not an incremental cost to the program and were not included in the BCA of the adder.

Prepared by or under the supervision of: Meghan McGuinness and Ian Springsteel

PUC 2-7

Request:

Why did the Company include 2 cents more per kWh for bill credits applied to participating A-60 accounts instead of the same bill credit all other participants would receive?

Response:

The Company chose to include 2 cents more per kWh for bill credits applied to participating Rate A-60 accounts in order to present such customers with a more significant bill savings than would be provided by the Minimum Bill Credit alone, creating a more compelling case for enrolling in a Community Remote Distributed Generation (CRDG) facility. The Company also hopes that this enhanced savings opportunity will make more Rate A-60 customers aware of the CRDG opportunity, thereby increasing enrollment. In the Company's view, increasing participation of Rate A-60 customers within the Renewable Energy Growth Program will distribute its benefits more equitably among all customers that the Company serves. Finally, ensuring that Rate A-60 customers are provided with meaningful bill savings will enhance potential utility cost savings by reducing the likelihood that participating customer accounts fall into arrears.

Prepared by or under the supervision of: Ian Springsteel

PUC 2-8

Request:

Please provide the analysis referenced on page 11 of the testimony of Springsteel and McGuinness.

Response:

The values referenced in the pre-filed Direct Testimony of Ian Springsteel and Meghan McGuinness on page 11 are from the incremental cost analysis conducted by Sustainable Energy Advantage, LLC (SEA) and presented at the August 28, 2020 Stakeholder Meeting. Please see Attachment PUC 2-8 for SEA's presentation, which provides a detailed overview of its analysis. The values in the Company's testimony are based on the "LMI Ground" results on slide 21, and not the "LMI Rooftop" results because, as noted on slide 15, the "LMI Rooftop" results are inclusive of additional costs associated with rooftop projects that are not specific to acquiring and serving low- and moderate-income (LMI) customers.

Prepared by or under the supervision of: Meghan McGuinness

2021 REG Public Policy Adder Development Process

Second Stakeholder Meeting

Sustainable Energy Advantage, LLC
National Grid

August 28, 2020

Sustainable Energy Advantage, LLC

Outline of Presentation

- Overview of Public Policy Adder Goals, Categories and Survey Results
  - Recap of OER/DG Board/National Grid Public Policy Goals
  - Compensation Rate Adders in SMART Program
- Public Policy Adder Calculation Methodology/ Assumptions
  - How SEA Calculates RI REG Ceiling Prices
  - How SEA Calculates Proposed RI REG Public Policy Adders
  - Survey Methodology/Approach
  - Analysis of Survey Results
- Initial Incremental Cost (and NPV of Cost) Results
  - Comparison of SMART Adder values to Proposed RI Adder Values
- Appendix

Overview of Public Policy Adder Goals, Categories and Survey Results

Sustainable Energy Advantage, LLC

Near- and Medium-Term Public Policy Goals Shared by DG Board and National Grid (and Potential Adders/Subtractors)

- Near-Term Public Policy Goals (Representing Adders and/or Subtractors Under Active Consideration and Development for 2021 REG Pilot Development)
  - **Beneficial Siting (Adder(s)):** Renewable energy projects with environmentally-beneficial siting characteristics (including but not limited to projects sited on rooftops, carports/canopies, landfill and brownfields);
  - **Discouraging Detrimental Siting (Potentially a Subtractor):** Renewable energy projects that may be sited on parcels in which development would cause undue environmental damage and/or be inconsistent with the most optimal use of the land; and
  - **Low/Moderate Income (LMI, Adder):** Renewable energy projects that provide clear and tangible benefits to participants from low- or moderate-income households

Near- and Medium-Term Public Policy Goals Shared by DG Board and National Grid (and Potential Adders/Subtractors)

- Medium-Term Public Policy Goals (Representing Adders Under Consideration and Potential Development for 2022)
  - **Encouraging Energy Storage (Adder):** Renewable energy projects paired with on-site energy storage capable of shifting and/or reducing load (e.g. through demand response or other activities)
- Other Public Policy Goals (Representing Adders Not Currently Under Consideration)
  - **Net Locational/Grid Value:** Renewable energy projects that may be sited in certain locations that provide quantifiable system benefit (or incur substantial net system cost)

Case Study: Compensation Rate Adders in SMART Program

- The Solar Massachusetts Renewable Target (SMART) program includes multiple adders to compensate projects for their location, offtaker, or other attributes
- The SMART adders are meant to both compensate project types that are associated with a higher cost of development in addition to incenting project types that are favorable from a policy perspective
- All offtaker-based and other adders are subject to decreases in their value as each adder tranche is filled (except for location-based adders)

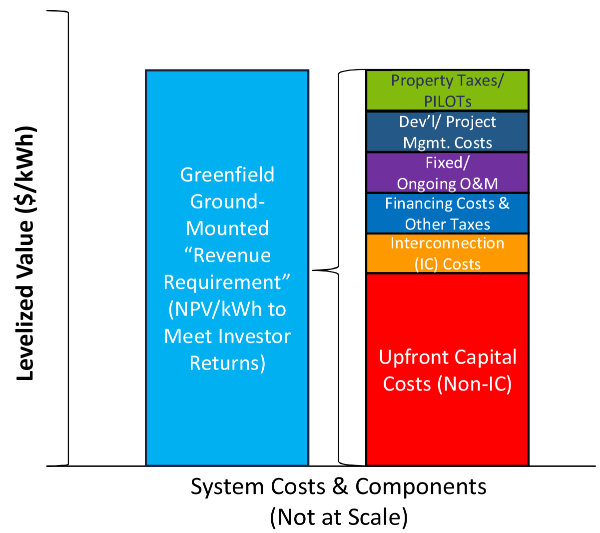
Adder Category	Adder	Tranche 1 Value ($/kWh)
Location Based	Building Mounted	$0.02
	Floating	$0.03
	Brownfield	$0.03
	Landfill	$0.04
	Canopy	$0.06
	Agricultural Solar	$0.06
Offtaker Based	Community Shared Solar	$0.05
	Low Income Property	$0.03
	Low Income Community Shared Solar	$0.06
	Public Entity	$0.04
Other	Energy Storage	Variable
	Solar Tracking	$0.01
	Pollinator	$0.003

Public Policy Adder Calculation Methodology/ Assumptions

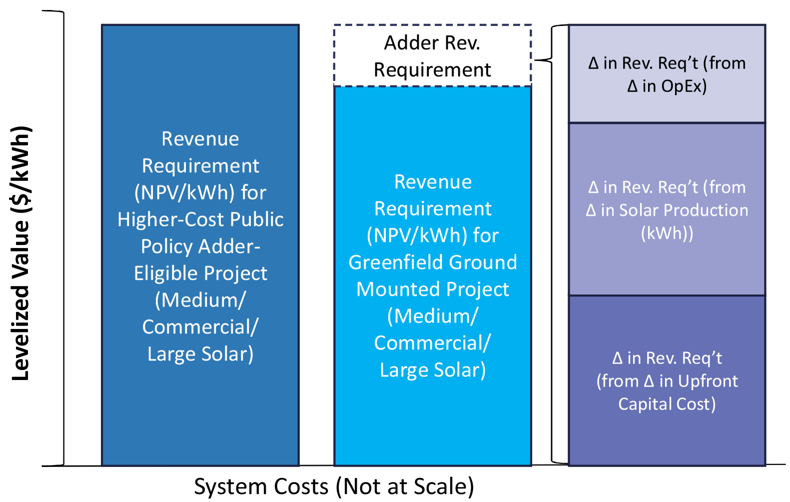
Sustainable Energy Advantage, LLC

How SEA Calculates RI REG Ceiling Prices

- SEA utilizes Cost of Renewable Energy Spreadsheet Tool (CREST), which it developed for NREL
- The model takes as inputs all of the capital and operating costs of a greenfield ground-mounted project of a given size category
- It then outputs the net present value (NPV) of the revenue requirement per kWh needed to meet investor returns
- When calculating the RI REG ceiling prices, the model calculates the following over the full term of the tariff payment:
  - The total revenue the project needs; ***LESS***
  - Federal tax benefits and post-contract revenue in the ISO-NE energy markets



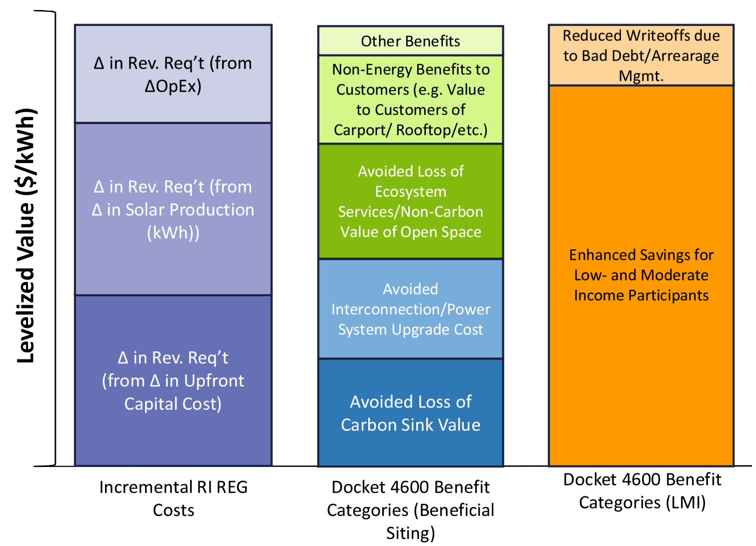
How SEA Calculates Proposed RI REG Public Policy Adders



- To set appropriate adder values, we compare the greenfield ground-mounted project to a project expected to create a certain degree of public policy value (e.g. rooftop, carport, LMI, etc.) of the same size
- Projects suspected to offer enhanced public policy value **tend to have incremental capital and operating costs relative to greenfield ground-mounted projects of the same size** (as well as reduced energy production)
- The adder revenue requirement is intended to represent **the net difference in capital costs, operating costs and production needed** to help preferred projects reach investor returns
- To establish these values, SEA undertook a survey of Rhode Island and regional market participants

Objective: Balancing Benefits with Costs in Line with Docket 4600 Benefit Categories

- However, RIPUC has required adder costs to be weighed against the Societal, Power System and Customer benefits in its Benefit-Cost Framework (developed in Docket 4600)
- Provision of "identifiable benefits to customers" (per the REG law) is *sine qua non* for adder proposal/adoption
- Thus, degree of benefits must scale relatively closely (or preferably exceed) incremental costs of certain potentially preferred projects



NOTE: Benefits/Costs in Graphic Not Necessarily to Scale

Survey Methodology/Approach

- To determine the incremental capital, OpEx and production impacts associated with systems that could notionally be eligible for Public Policy Adders, SEA conducted a survey of 27 different solar project developers
- All developers had experience (and often significant experience) in each of the market sectors in which they provided information
- Survey utilized prior SEA data regarding the costs of Greenfield Ground Mount, Carport, Rooftop, LMI, Landfill and Brownfield
- SEA then requested survey respondents to verify the accuracy of the data, or otherwise provide more accurate data regarding the overall cost and production profile of each project type
- We summarize (in the next several slides) the categories surveyed, as well as our findings regarding the drivers of incremental project costs

Categories of Potential Preferred Projects Included in Survey

- Categories
  - Rooftop Solar
  - Carport Solar
  - LMI (Rooftop and Ground Mount)
  - Landfill Solar
  - Brownfield Solar
- Project Sizes
  - 25-250 kW (RI REG Medium Solar range)
  - 251-999 kW
  - 1-5 MW
  - <=25 kW assumed not eligible (most already are roof-mounted)

Survey Results in Comparison to SEA Expected Values

- Mean estimates of installed cost premiums for each project type provided by survey respondents were generally in line with SEA's initial estimates
- Notable departures from SEA initial estimates include:
  - Higher estimates for Commercial Ground-mounted LMI (+$0.22/W)
  - Lower estimates for Rooftop LMI (all sizes)
  - High variance in Carport estimates (+$0.30/W for Medium, -$0.19/W for Commercial, -$0.30/W for Large)
  - Higher estimates for Medium and Commercial Landfill (+$0.25/W-$0.31/W)
- Estimates regarding operating cost premiums reported the largest cost premiums were for project management of LMI projects and O&M for Carport projects
- For a complete account of inputs derived from the survey and utilized in analysis, please see Appendix

Major Drivers of Incremental Costs for Potential Preferred Projects (Informed in Part by Incremental Cost Survey) (1)

- Rooftop Solar
  - **Capital:** Can include some amount of residual roof/site maintenance costs (which can also be offset by lower permitting costs relative to greenfield ground-mounted development)
  - **Operating Expenses (OpEx):** On-site nature of project can incur additional O&M and insurance expense (esp. since maintenance requires access to premises and to rooftops, as well as specialized labor and equipment)
  - **Production:** Rooftops cannot be as easily selected for maximizing system production relative to greenfield ground mounts (as they often cannot be oriented as close to due south, or cannot be tilted to maximize system production based on latitude when placed on a flat roof)
- Carport Solar
  - **Capital:** Substantially increased mounting costs (associated with steel structure for shading vehicles), as well as initial structural engineering costs (to ensure proper snow/wind loading)
  - **OpEx:** Increased costs of maintenance (required for accessing larger mounting system)
  - **Production:** Similar to rooftops, tilt of Carport structure makes optimum tilting and orientation nearly impossible (given dual use as shading for vehicles)

Drivers of Incremental Costs for Potential Preferred Projects (Informed in Part by Incremental Cost Survey) (2)

- LMI Ground Mounted Solar
  - **Capital:** Incremental upfront cost of initial customer acquisition (which can often be somewhat higher for LMI participants)
  - **OpEx:** Incremental ongoing cost of customer billing/customer care
  - **Production:** N/A (the nature of the offtaker has no material bearing on the quality of the site, which determines the quantity of production).
- LMI Rooftop Solar
  - **Capital:** Similar to Rooftop, but inclusive of initial customer acquisition costs associated with LMI/CRDG ground-mounted projects
  - **OpEx:** Similar to the combination of both LMI/CRDG ground-mounts, but also inclusive of additional expense associated with Rooftop projects
  - **Production:** Similar issue with non-optimal tilt and orientation as for other Rooftop projects

Drivers of Incremental Costs for Potential Preferred Projects (Informed in Part by Incremental Cost Survey) (3)

- Landfill Solar
  - **Capital:** Increased labor/capital costs associated with complexity/safety requirements of installations and specialized foundations needed, as well as cost of capping landfill (if not done already) and the capitalization of a decommissioning reserve
  - **OpEx:** Maintenance and insurance can be higher given more stringent monitoring requirements (to ensure ongoing safety/minimization of methane leakage)
  - **Production:** Depending on slope and orientation of cap upon landfill, production can be relatively similar to a greenfield ground mount, but evidence suggests it is a tiny bit lower
- Brownfield Solar
  - **Capital:** Increased permitting and (in many cases) initial remediation costs, and the capitalization of a decommissioning reserve
  - **OpEx:** Insurance can be expensive-to-impossible to get, monitoring costs also high (similar to Landfill)
  - **Production:** Unlikely to be highly different, but evidence also suggests (like Landfill) that it is a tiny bit lower

Range of Inputs Derived from Survey (for Potential Adders)

	Lowest/Highest Cost Input Range						Lowest/Highest Production Input Range
Project Type	*Capital Cost ($/kW$_{DC}$, Incl. IC)*	*Capital Cost Premia ($/kW$_{DC}$, Incl. IC)*	*O&M Premia %*	*Insurance Premia (%)*	*Land/Site Lease Premia (%)*	*Project Mgmt. Premia (%)*	*Capacity Factors (%)*
Greenfield Ground Mounted	$1,384-$2,288	N/A (Serves as Basis for Comparison, Except as Indicated)					13.4%-14.6%
Rooftop	$1,474-$2,288	($110)-$250	15%	10%	23%	10%	13.3%-14.6%
LMI Rooftop	$1,754-$2,888	$310-$620	23%*	5%*	9%	58%	13.3%-14.6%
LMI Ground Mounted	$1,664-$2,888	$280-$660	23%	5%	9%	58%	14.7%-15.2%
Carport	$2,105-$3,388	$700-$1,100	36%	16%	20%	9%	13.1%-14.6%
Landfill	$1,624-$2,838	$240-$510	9%	13%	0%	10%	14.0%-15.2%
Brownfield	$1,584-$2,738	$80-$450	16%	13%	2%	7%	14.0%-15.2%

*Premium is relative to a non-LMI rooftop project.

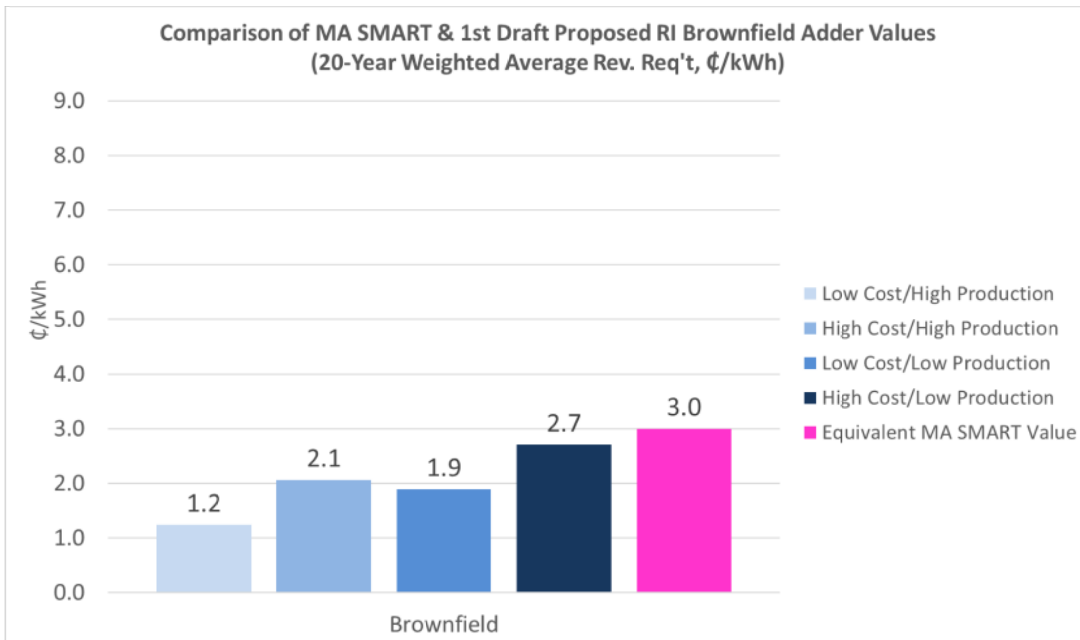
Public Policy Adders Case Matrix

Project Type	Size Category	Modeled Size (kW_{DC})	Case #1: Low Cost/ High Production	Case #2: Low Cost/ Low Production	Case #3: High Cost/ High Production	Case #4: High Cost/ Low Production
Rooftop	25-250 kW	250	• 1st **Quartile** Upfront Cost • Production @ **Highest End** of Rooftop Range **(14.6%)** • **Mean** OpEx % Increase	• 1st **Quartile** Upfront Cost • Production @ **Lowest End** of Rooftop Range **(13.3%)** • **Mean** OpEx % Increase	• 3rd **Quartile** Upfront Cost • Production @ **Highest End** of Rooftop Range **(14.6%)** • **Mean** OpEx % Increase	• 3rd **Quartile** Upfront Cost • Production @ **Highest End** of Rooftop Range **(13.3%)** • **Mean** OpEx % Increase
Rooftop	251-999 kW	500				
Rooftop	1-5 MW	4,500				
Carport	25-250 kW	250	• 1st **Quartile** Upfront Cost • Production @ **Highest End** of Carport Range **(14.6%)** • **Mean** OpEx % Increase	• 1st **Quartile** Upfront Cost • Production @ **Lowest End** of Carport Range **(13.1%)** • **Mean** OpEx % Increase	• 3rd **Quartile** Upfront Cost • Production @ **Highest End** of Carport Range **(14.6%)** • **Mean** OpEx % Increase	• 3rd **Quartile** Upfront Cost • Production @ **Highest End** of Rooftop Range **(13.1%)** • **Mean** OpEx % Increase
Carport	251-999 kW	500				
Carport	1-5 MW	4,500				
LMI Rooftop	25-250 kW	250	• 1st **Quartile** Upfront Cost • Production @ **Highest End** of Rooftop Range **(14.6%)** • **Mean** OpEx % Increase	• 1st **Quartile** Upfront Cost • Production @ **Lowest End** of Rooftop Range **(13.3%)** • **Mean** OpEx % Increase	• 3rd **Quartile** Upfront Cost • Production @ **Highest End** of Rooftop Range **(14.6%)** • **Mean** OpEx % Increase	• 3rd **Quartile** Upfront Cost • Production @ **Highest End** of Rooftop Range **(13.3%)** • **Mean** OpEx % Increase
LMI Rooftop	251-999 kW	500				
LMI Rooftop	1-5 MW	4,500				
LMI Ground	25-250 kW	250	• 1st **Quartile** Upfront Cost • Production @ **Highest End** of Ground Mount Range **(15.2%)** • **Mean** OpEx % Increase	• 1st **Quartile** Upfront Cost • Production @ **Lowest End** of Ground Mount Range **(14.7%)** • **Mean** OpEx % Increase	• 3rd **Quartile** Upfront Cost • Production @ **Highest End** of Ground Mount Range **(15.2%)** • **Mean** OpEx % Increase	• 3rd **Quartile** Upfront Cost • Production @ **Highest End** of Ground Mount Range **(14.7%)** • **Mean** OpEx % Increase
LMI Ground	251-999 kW	500				
LMI Ground	1-5 MW	4,500				
Landfill	25-250 kW	250	• 1st **Quartile** Upfront Cost • Production @ **Highest End** of Landfill Range **(15.2%)** • **Mean** OpEx % Increase	• 1st **Quartile** Upfront Cost • Production @ **Lowest End** of Landfill Range **(14.5%)** • **Mean** OpEx % Increase	• 3rd **Quartile** Upfront Cost • Production @ **Highest End** of Landfill Range **(15.2%)** • **Mean** OpEx % Increase	• 3rd **Quartile** Upfront Cost • Production @ **Highest End** of Landfill Range **(14.5%)** • **Mean** OpEx % Increase
Landfill	251-999 kW	500				
Landfill	1-5 MW	4,500				
Brownfield	25-250 kW	250	• 1st **Quartile** Upfront Cost • Production @ **Highest End** of Landfill Range **(15.2%)** • **Mean** OpEx % Increase	• 1st **Quartile** Upfront Cost • Production @ **Lowest End** of Landfill Range **(14.5%)** • **Mean** OpEx % Increase	• 3rd **Quartile** Upfront Cost • Production @ **Highest End** of Landfill Range **(15.2%)** • **Mean** OpEx % Increase	• 3rd **Quartile** Upfront Cost • Production @ **Highest End** of Landfill Range **(14.5%)** • **Mean** OpEx % Increase
Brownfield	251-999 kW	500				
Brownfield	1-5 MW	4,500				

Initial Incremental Cost (and NPV of Cost) Results

Sustainable Energy Advantage, LLC

Comparison of SMART Adder values to Proposed RI Adder Values



Comparison of SMART Adder NPV to Proposed RI Adder NPV

Adder Category	Low Cost/High Production (¢/kWh)		Low Cost/Low Production (¢/kWh)		High Cost/High Production (¢/kWh)		High Cost/Low Production (¢/kWh)		MA SMART (¢/kWh)	
	Nominal	NPV[1]	Nominal	NPV[1]	Nominal	NPV[1]	Nominal	NPV[1]	Nominal	NPV[1]
Rooftop	1.5	***0.8***	2.8	***1.5***	2.3	***1.3***	3.7	***2.0***	1.9	***1.0***
LMI Rooftop	3.3	***1.6***	4.6	***2.5***	3.8	***2.0***	5.3	***2.8***	3.0	***1.6***
LMI Ground	2.4	***1.3***	2.4	***1.3***	2.5	***1.3***	2.5	***1.3***	6.0	***3.2***
Carport	5.5	***2.8***	7.5	***4.0***	5.6	***3.0***	7.6	***4.1***	6.0	***3.2***
Landfill	1.4	***0.7***	2.1	***1.1***	1.9	***1.0***	2.6	***1.4***	4.0	***2.1***
Brownfield	1.2	***0.6***	1.9	***1.0***	2.1	***1.1***	2.7	***1.4***	3.0	***1.6***

[1]Assumes 7% discount rate, but final adder values will likely reflect National Grid return on equity (ROE)

Q&A

Sustainable Energy Advantage, LLC

Sustainable Energy Advantage, LLC

Appendix

Upfront Capital Cost Premia by Type from Incremental Cost Survey

Estimates of Premia Over Greenfield Ground-Mounted Solar Installed Costs ($/W$_{DC}$ from Incremental Cost Survey)

Type	*Size*	*N*	*SEA Initial Estimate*	*Mean Response from Survey*	*Mean Δ from SEA Estimate*	*25th-75th Range (from Survey)*
Ground-Mounted LMI	25-250 kW	4	$0.40	**$0.42**	**$0.02**	$0.38-$0.40
	251-999 kW	6	$0.40	**$0.62**	**$0.22**	$0.47-$0.66
	1-5 MW	8	$0.40	**$0.37**	**-$0.03**	$0.28-$0.45
Rooftop LMI	25-250 kW	4	$0.60	**$0.50**	**-$0.10**	$0.31-$0.60
	251-999 kW	7	$0.62	**$0.55**	**-$0.07**	$0.54-$0.62
	1-5 MW	6	$0.62	**$0.49**	**-$0.13**	$0.37-$0.47
Rooftop	25-250 kW	14	$0.00	**-$0.04**	**-$0.04**	($0.11)-0.00
	251-999 kW	17	$0.22	**$0.24**	**$0.02**	$0.20-$0.22
	1-5 MW	14	$0.22	**$0.21**	**-$0.01**	$0.09-$0.25
Solar Canopy	25-250 kW	9	$0.45	**$0.75**	**$0.30**	$0.70-$1.10
	251-999 kW	15	$1.37	**$1.18**	**-$0.19**	$1.18-$1.37
	1-5 MW	12	$1.54	**$1.24**	**-$0.30**	$1.19-$1.48
Landfill	25-250 kW	3	$0.17	**$0.42**	**$0.25**	$0.25-$0.55
	251-999 kW	6	$0.16	**$0.47**	**$0.31**	$0.29-$0.51
	1-5 MW	8	$0.38	**$0.27**	**-$0.11**	$0.24-$0.30
Brownfield	25-250 kW	3	$0.13	**$0.18**	**$0.05**	$0.08-$0.45
	251-999 kW	3	$0.13	**$0.29**	**$0.16**	$0.17-$0.23
	1-5 MW	4	$0.27	**$0.28**	**$0.01**	$0.20-$0.34

O&M Cost Premia by Type (from Incremental Cost Survey)

Percentage Difference in Annual Operating Costs ($/kW-yr, Based on Incremental Cost Survey)

Project Type	*Project Size*	*Cost Category*	*N*	*25th-75th Range*	*Mean*
LMI Greenfield/Rooftop (Relative to Greenfield/Rooftop)	*All Sizes*	*O&M*	8	8%-29%	**23%**
		Insurance	7	0%-7.5%	**5%**
		Land/Site Lease	7	0%-18%	**9%**
		Project Management	7	18%-64%	**58%**
Rooftop (Relative to Greenfield)	*All Sizes*	*O&M*	10	5%-25%	**15%**
		Insurance	11	0%-14%	**10%**
		Land/Site Lease	12	0%-25%	**23%**
		Project Management	6	0%-13%	**10%**
Solar Canopy (Relative to Greenfield)	*All Sizes*	*O&M*	9	20%-50%	**36%**
		Insurance	9	5%-20%	**16%**
		Land/Site Lease	9	0%-20%	**20%**
		Project Management	6	0%-15%	**9%**
Brownfield Solar (Relative to Greenfield)	*All Sizes*	*O&M*	8	8%-20%	**16%**
		Insurance	7	0%-15%	**13%**
		Land/Site Lease	6	(3%)-0%	**2%**
		Project Management	5	0%-10%	**7%**
Landfill Solar (Relative to Greenfield)	*All Sizes*	*O&M*	5	0%-15%	**9%**
		Insurance	5	10%-20%	**13%**
		Land/Site Lease	5	0%-0%	**0%**
		Project Management	5	5%-10%	**10%**

Summary of Incremental Cost Survey Results

Proposed Capacity Factors (%)			
Project Type	*Project Sizes*	*Low End of Range (for "Low Production" Cases)*	*High End of Range (for "High Production" Cases)*
Greenfield Ground Mounted	All Sizes (25-250 kW, 251-999 kW, 1-5 MW)	14.7%	15.2%
LMI Ground Mounted		14.7%	15.2%
Rooftop LMI		13.3%	14.6%[1]
Rooftop		13.3%	14.6%[1]
Solar Canopy		13.1%	14.6%[1]
Landfill		14.5%	15.2%
Brownfield		14.5%	15.2%

[1]See National Renewable Energy Laboratory (NREL). 2020 Annual Technology Baseline (ATB). Available at: https://atb.nrel.gov/electricity/2020/data.php. Utilized production data associated with Chicago, IL, which has a very similar latitude to Providence, RI.

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PUC 2-9

Request:

Please provide a quantitative analysis that supports the need to pay a CRDG project an additional one cent per kWh for output linked to its participating A-60 customers. How was the 1 cent derived?

Response:

The Company has proposed an adder of 3 cents per kWh for Community Remote Distributed Generation (CRDG) projects serving Rate A-60 customers, with the requirement that project developers return two-thirds of that value to the Rate A-60 customers enrolled in these projects, such that project owners retain 1 cent per kWh. The 1 cent incremental value was informed by the incremental cost analysis conducted by Sustainable Energy Advantage, LLC (SEA), included in the Company's response to Data Request PUC 2-8, which found that projects serving low- and moderate- income customers face incremental costs associated with customer recruitment and ongoing customer management of 2.4 cents to 2.5 cents per kWh (These values have been revised upward by SEA, to 2.5 to 2.7 cents per kWh in Supplemental Schedule JK-4). The Company believes that providing incremental compensation of 1 cent per kWh to these projects is appropriate because it expects that the premium provided to the projects by the CRDG ceiling price may reduce the necessary level of incremental payments to project owners to cover incremental low-income customer-related costs.

Prepared by or under the supervision of: Meghan McGuinness

PUC 2-10

Request:

Referencing PUC 1-27, are the utility cost savings and price hedging savings dependent on the adder or are these savings realized for each A-60 participant in a CRDG project, regardless of the adder?

Response:

The Company's analysis assumes that, in the absence of the adder, a Rate A-60 customer would not be recruited as a participant in a Community Remote Distributed Generation (CRDG) project. As such, these savings are assumed to occur as a result of the adder. As noted in the Company's response to Data Request PUC 1-30, there are currently no Rate A-60 customers receiving credits from CRDG projects.

Prepared by or under the supervision of: Meghan McGuinness

PUC 2-11

Request:

Referencing PUC 1-27, are the utility cost savings and price hedging savings realized for each A-16 participant in a CRDG project?

Response:

The Company based its assumptions for utility cost savings on studies of low-income energy efficiency program impacts, and applied them in the benefit-cost analysis (BCA) to Rate A-60 customers. As noted in the Company's response to Data Request PUC 2-4, at Attachment PUC 2-4, page 4-1: "Theoretically, these benefits could apply to some extent to all [program administrators] programs and customers, but the [non-energy impacts] literature has rarely quantified this benefit for non-low-income customers and programs. Therefore, NMR recommends limiting the utility-perspective [non-energy impacts] to low-income programs." In the context of energy efficiency, the Company applies these values only to its income-eligible energy programs.

While there may be potential utility cost savings from participation of Rate A-16 customers in a Community Remote Distributed Generation (CRDG) project, there are two reasons why the Company would expect such savings from Rate A-16 customers to be limited in this context. First, in general, the Company would expect that Rate A-16 customers with the highest probability of having electric accounts in arrears would be low- and moderate-income customers who are not currently on Rate A-60. Such customers are unlikely to be targeted by developers for enrollment in a CRDG project. Second, Rate A-16 electric customers have historically been less likely than Rate A-60 electric customers to default on bill payment. See, for example, the Company's response to Data Request PUC 2-13.

With respect to price hedging, the Company's energy efficiency BCA applies this benefit only to income-eligible programs. Inclusion of this benefit is based on a July 2012 memorandum to the Massachusetts Program Administrators entitled "Additional Non-Energy Impacts for Low Income Programs," which is included as Attachment PUC 2-11. However, this benefit may also apply to Rate A-16 customers.

Prepared by or under the supervision of: Meghan McGuinness

Memo

To: Massachusetts Program Administrators

From: Evaluation Management Committee

CC: Jerry Oppenheim and Ralph Prahl

Date: July 25, 2012

Re: Additional Non-Energy Impacts for Low Income Programs

Overview

Members of the Program Administrator (PA) evaluator group have been meeting with Jerry Oppenheim of LEAN and Ralph Prahl of the EEAC over the past several months to discuss Low-Income Non-Energy Impacts (NEIs) that were not included in the NMR study[1] submitted with the PAs' 2012 Mid-Term Modification filing. Lynn Westerlind (National Grid), Monica Kachru, Riley Hastings, Lisa Shea (all from NSTAR) and Monica Cohen (Columbia Gas of MA) have been on point for the PAs.

During these discussions it was determined that there were some NEIs that were not included in the study that could reasonably have been included. The group reached consensus that it is reasonable to add or revise the value used for the following four NEIs in the Low-Income Programs:

1. Refrigerator recycling
2. Lighting quality
3. Price hedging
4. Economic development

Below please find more detailed information about each of the four NEIs.

The group has also agreed to perform a study of health NEI study which will be incorporated into the programs once the research is complete.

Refrigerator recycling

The NMR study[2] quantified the benefits of turning in a refrigerator and/or freezer as part of the MA turn-in program. Hazardous materials such as chlorofluorocarbon (CFC) or hydro chlorofluorocarbon (HCFC) gases, polychlorinated biphenyls (PCBs), mercury, and oils contaminated with CFCs and HCFCs are removed from the collected units and disposed of in accordance with US EPA Responsible Appliance Disposal (RAD) program guidelines. The study analyzed the environmental benefits derived from properly collecting, destroying, or recycling the materials contained within refrigerators. After

[1] NMR Group (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation, filed with 2012 Mid-Term Modifications, D.P.U. 11-106 through D.P.U. 11-116.
[2] NMR Group (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation.

confirming with those knowledgeable, it was determined that old appliances are indeed removed and properly disposed of through the Low-Income Programs, and this benefit should be included in the Low-Income Programs for consistency. The total benefit is comprised of 3 parts: $1.06 for avoided landfill space, $1.25 for recycling of plastics and glass, and $170.22 for incineration of insulating foam.

Lighting quality

The NMR study recommended using the one-time operation and maintenance (O&M) benefit of $3.00 per CFL bulb and $3.50 per fixture. The study also did a survey of LI program participants and found that respondents assigned a positive value of $56 to the lighting quality and lifetime of program sponsored energy efficient lighting. The group has agreed that $56 per LI participant is a reliable estimate of lighting quality NEIs and will use that in lieu of the $3.00 and $3.50 per bulb and fixture, respectively.

Price hedging

The group determined that there is a value in minimizing program participants' exposure to price increases. With residential home heating fuels prices fluctuating, energy efficiency programs mitigate the impact of energy price fluctuations that affect customers' energy bills, by reducing the amount of energy that customers consume. A relevant paper came out of the Lawrence Berkeley National Lab that quantified the value that wind power provides as a hedge against volatile natural gas prices.[3] The paper found a hedge value of $0.76/MMBTU of gas and $0.005/kWh.

Economic development

The group determined that there is an economic development benefit with respect to low-income programs that should be factored into cost effectiveness screening, so long as it complies with applicable regulatory and legal precedent. As discussed below, the group has determined that the focused low-income economic development benefit proposed does comply with such precedent.

The GCA does not give express guidance, but does mention economic development as a factor in prioritizing projects. GL c. 25, section 21(b)(2) has general language with respect to economic development noting that it can be included in determining which projects to prioritize: "With the approval of the Council, the plan may also include a mechanism to prioritize projects that have substantial benefits in reducing peak load, reducing the energy consumption or costs of municipalities or other governmental bodies, or that have economic development, job creation or job retention benefits." This language is not determinative, but does indicate the legislature's concern with economic development.

The Department's Energy Efficiency Guidelines are importantly instructive. Economic development benefits are not explicitly listed in the non-electric benefits/non-gas benefits that are expressly articulated in sections 3.4.4.1.a or 3.4.4.1.b, but both of these sections of the Guidelines provide a basket for inclusion of "all benefits associated with providing energy efficiency services to Low-Income Customers." Accordingly the Department EE Guidelines uniquely single out low-income customers as a class (unlike residential or commercial/industrial) when non-resource benefits are being articulated. This reference to low-income benefits is an important data point. The group has added a unique low-income benefit based on economic development benefits and such an approach is consistent with the Department's guidelines.

The next level of detail was consideration of the Supreme Judicial Court (SJC) guidance with respect to externalities from the case Massachusetts Electric Company v DPU, 419 Mass 239 (1994). In that case the SJC articulated the need for connection between costs/benefits to be included in utility cost effectiveness screening and "reasonably anticipated future circumstances [which] will impose costs on the utility that will be detrimental to the interest of ratepayers." The Department cannot take into

[3] Lawrence Berkeley National Lab (2002). Quantifying the Value that Wind Power Provides as a Hedge Against Volatile Natural Gas Prices.

account broad external societal costs and benefits that do not and cannot reasonably be anticipated to have an effect on the utilities'/PAs' costs and thereby on rates paid by customers. Factoring in reasonable economic development benefits in cost effectiveness screening can be related back to costs on the utility/PA that are born by ratepayers, in particular the subsidization of low income rates by all customers.

By linking the economic development benefit at the highest level to the GCA, at the next level to the Department's Energy Efficiency Guidelines, and then on a third level with the SJC precedent on externalities. The group thinks it is reasonable to include economic development as a benefit unique to low-income.

The tables below show the calculated economic development values of $0.486 per therm and $0.04 per kWh. These values were calculated utilizing the increase in GSP if programs were operating in isolation rather than simultaneously.

Table 1: Massachusetts – Gas Estimate

Increase in GSP (Billion $) (1)	Savings (Tbtu) (2)	Savings (therms) (3)	Economic output per therm (4)	11% for low income (5)	Inflated from 2008 to 2011$ (6)
28	664	6,640,000,000	$4.22	$0.46	$0.486

(1) Energy Efficiency: Engine of Economic Growth; ENE; October 2009; page 49.
(2) Energy Efficiency in Massachusetts: Engine of Economic Growth; ENE; October 2009; page 2.
(3) Tbtu times 10,000,000
(4) Calculated as Increase in GSP/Savings (therms)
(5) Multiply economic output per therm by 11%; assumes 11% inures to the benefit of low-income (the low-income fraction of population).
(6) Uses an inflation rate of 1.85% from BCR models.

Table 2: Massachusetts – Electric Estimate

Increase in GSP (Billion $) (1)	Savings (GWh) (2)	Savings (kWh) (3)	Economic output per therm (4)	11% for low income (5) (6)
70	217,300	217,300,000,000	$0.32	$0.04

(1) Energy Efficiency: Engine of Economic Growth; ENE; October 2009; page 47.
(2) Energy Efficiency in Massachusetts: Engine of Economic Growth; ENE; October 2009; page 2.
(3) GWh times 1,000,000
(4) Calculated as Increase in GSP/Savings (kWh)
(5) Multiply economic output per therm by 11%; assumes 11% inures to the benefit of low-income (the low-income fraction of population).
(6) Using an inflation rate of 1.85% from BCR models does not change the estimate of $0.04/kWh from 2008 to 2011$.

PUC 2-12

Request:

Please provide the following information, starting with the first year in which the CRDG program began providing credits to customers: (1) total number of CRDG projects in operation; (b) total MWhs produced from the CRDG projects; (c) total number of customer accounts by rate class receiving bill credits under the CRDG program; (d) total annual dollar value of bill credits provided to the customer accounts by rate class; and (e) total payments made to the CRDG projects. In addition to the aggregate totals, please provide this information by year.

Response:

(1) The Company currently has two projects operating under the Community Remote Distributed Generation (CRDG) program. Both Host customers signed up with the program in 2020.

(b) There has been a total of 2,135,340 kWh, or 2,135.34 MWh, generated by the Hosts.

(c) & (d) Please refer to the table below for satellites receiving credits:

Rate Class	Tariff Description	# of customers	$ of credits
C06	Elec C-06 Small C&I-Std Ofr Fixed	35	$7,933.80
G02	Elec G-02 Large C&I	18	$7,898.57
G32	Elec G-32 T&D 200 kW Dem	4	$3,339.89

(e) A total of $355,888.72 in incentive payments have been made to the two Host customers, all within the last year.

Prepared by or under the supervision of: Rocco Lattanzio

PUC 2-13

Request:

For each of the years 2016, 2017, 2018, and 2019, how many A-60 accounts were written off as uncollectible and what percentage of total A-60 accounts did this number represent in each respective year? If any accounts were written off in 2020, please also provide this information.

Response:

Please see the table below for the requested information:

	A-60 Write Offs	**A-60 Total Customers**	**Write Off %**		**A-16 Write Offs**	**A-16 Total Customers**	**Write Off %**
2016	2,912	32,224	9.04%	2016	18,895	368,115	5.13%
2017	3,070	25,582	12.00%	2017	17,246	390,779	4.41%
2018	2,747	30,613	8.97%	2018	17,268	398,647	4.33%
2019	2,511	31,110	8.07%	2019	17,507	388,682	4.50%
2020	1,807	29,500	6.13%	2020	17,011	395,060	4.31%

Prepared by or under the supervision of: Ian Springsteel

PUC 2-14

Request:

For each of the years 2016, 2017, 2018, and 2019, how many A-16 accounts were written off as uncollectible and what percentage of total A-16 accounts did this number represent in each respective year? If any accounts were written off in 2020, please also provide this information.

Response:

Please see the Company's response to Data Request PUC 2-13 for the requested information.

Prepared by or under the supervision of: Ian Springsteel

PUC 2-15

Request:

Assuming the proposed Community Remote Commercial Solar allocation of 5 MW and the proposed Community Remote Large allocation of 5.897 are fully subscribed and all units become operational, for the first full year of commercial operation please provide (with accompanying schedules showing the calculations and assumptions):

a. an estimate of the total incremental cost to ratepayers for the difference between the pricing for those classifications (using 18.11 for Community Remote Commercial and 13.63 for Community Remote Large Solar) and the pricing for the classifications of Commercial Solar and Large Solar (using 15.75 and 11.85 respectively);

b. an estimate of the incremental cost above that in (a) to ratepayers if 20% of the CRDG project customers were A-60 and the low-income adder was paid,

c. an estimate of the number A-60 customers that would be served if 20% of the CRDG project customers were A-60,

d. the total aggregate amount of billing credits that the Company would provide to those participating A-60 customers,

e. the total aggregate amount credited to the A-60 participants from the 2 cent component of the low-income adder, and

f. the total aggregated amount paid to the CRDG project owners from the 1 cent component of the low-income adder.

Response:

Please see Attachment PUC 2-15 for the requested information to each subpart, including the underlying calculations and assumptions.

Prepared by or under the supervision of: Meghan McGuinness

	Input Assumptions		**Value**	**Notes and line references**
1	CRDG Commercial Scale Solar Capacity (MW)		5	
2	CRDG Large Scale Solar Capacity (MW)		5.897	
3	Capacity factor		15%	Applied to all capacity
4	Hours in year		8760	
5	Assumed subscription size (kW)		4	As assumed in BCA
6	Assumed % allocated to A-60 customers		20%	
7	Ceiling Price for Commercial Scale Solar 751-999kw (cents/kWh)		15.75	Analysis assumes all available capacity is allocated to projects sized between 751 and 999 kW
8	Ceiling Price for CRDG Commercial Scale Solar 751-999 kW (cents/kWh)		18.11	Analysis assumes all available capacity is allocated to projects sized between 751 and 999 kW
9	*Incremental cost of CRDG (cents/kWh)*		*2.36*	(line 8- line 7)
10	Ceiling Price for CRDG Large Scale Solar (cents/kWh)		11.85	
11	Ceiling Price for CRDG Largel Scale Solar (cents/kWh)		13.63	
12	*Incremental cost of CRDG (cents/kWh)*		*1.78*	(line 11 - line 10)
13	Adder payment (cents/kWh)		3	
14	Portion of adder returned to A-60 customer (cents/kWh)		2	
15	Portion of adder to project owner (cents/kWh)		1	
16	Minimum Bill Credit CRDG Commercial Scale Solar 751-999 kW (cents/kWh)		1.18	
17	Minimum Bill Credit CRDG Large Scale Solar (cents/kWh)		0.89	
18	Total Output Commercial Scale Solar (kWh)		6,570,000	(line 1 * line 3 * line 4 *1000)
19	Total Output Large Scale Solar (kWh)		7,748,658	(line 2 * line 3 * line 4 *1000)
	Responses			
Part a.	**Incremental cost of CRDG**			
20	Incremental Cost (Commercial)	$	155,052	(line 9 * line 18) / 100
21	Incremental Cost (Large)	$	137,926	(line 12 * line 19) / 100
22	**Total Incremental Cost of CRDG**	**$**	**292,978**	**(line 20 + line 21)**
Part b.	**Incremental cost of adder w/ 20% of capacity to A-60 customers**			
23	Commercial Scale CRDG	$	39,420	(line 6 * line 18 * line 13) / 100
24	Large Scale	$	46,492	(line 6 * line 19 * line 13) / 100
25	**Total incremental cost of adder**	**$**	**85,912**	**(line 23 + line 24)**
Part c.	**Total A-60 customers served**			
26	Commercial		250	(line 1 * line 6) / (line 5 / 1000)
27	Large		295	(line 2 * line 6) / (line 5 / 1000)
28	**Total A-60 customers served**		**545**	**(line 26 + line 27)**
Part d.	**Total billing credit value to A-60 participants**			
29	Minimum Bill Credit -- CRDG Commercial Scale Solar	$	15,505	(line 6 * line 16 * line 18) / 100
30	Adder-related credit -- CRDG Commerial Scale Solar	$	26,280	(line 6 * line 14* line 18) / 100
31	**Total billing credits -- CRDG Commercial Scale Solar**	**$**	**41,785**	**(line 29 + line 30)**
32	Minimum Bill Credit -- CRDG Large Scale Solar	$	13,793	(line 6 * line 17 * line 19) / 100
33	Adder-related credit -- CRDG Large Scale Solar	$	30,995	(line 6 * line 14* line 19) / 100
34	**Total billing credits -- CRDG Large Scale Solar**	**$**	**44,787**	**(line 32 + line 33)**
35	**Total billing credits from all CRDG to A-60 participants**	**$**	**86,572**	**(line 31 + line 34)**
Part e.	**Adder-related payment to A-60 participants**			
36	Adder related credit from part d. (Commercial Scale)	$	26,280	(line 30)
37	Adder related credit from part d. (Large Scale)	$	30,995	(line 33)
38	**Total adder-related credit to A-60 participants**	**$**	**57,275**	**(line 36 + line 37)**
Part f.	**Total adder-related payment to elgibile CRDG project owners**			
39	Adder-related payment-- CRDG Commerial Scale Solar	$	13,140	(line 6 * line 15 * line 18) / 100
40	Adder-related payment -- CRDG Large Scale Solar	$	15,497	(line 6 * line 15* line 19) / 100
41	**Total adder- related payment to CRDG project owners**	**$**	**28,637**	**(line 39 + line 40)**

PUC 2-16

Request:

Referring to the testimony of Springsteel and McGuinness at page 30 of 33, please explain why the Company would expect a reduction in interconnection costs and associated O&M for a carport project, compared to ground mounted solar projects. Please provide data supporting the conclusion and describe the features and/or locational characteristics that are assumed for carport projects that result in a reduction in these costs.

Response:

The table below summarizes interconnection costs for all awarded Renewable Energy (RE) Growth ground mounted solar projects over the 2019 and 2020 Program Years (excluding cancelled projects), in comparison to the awarded solar carport projects.

Interconnection Costs by Project Class, 2019 and 2020 RE Growth Program Years ($/kW)

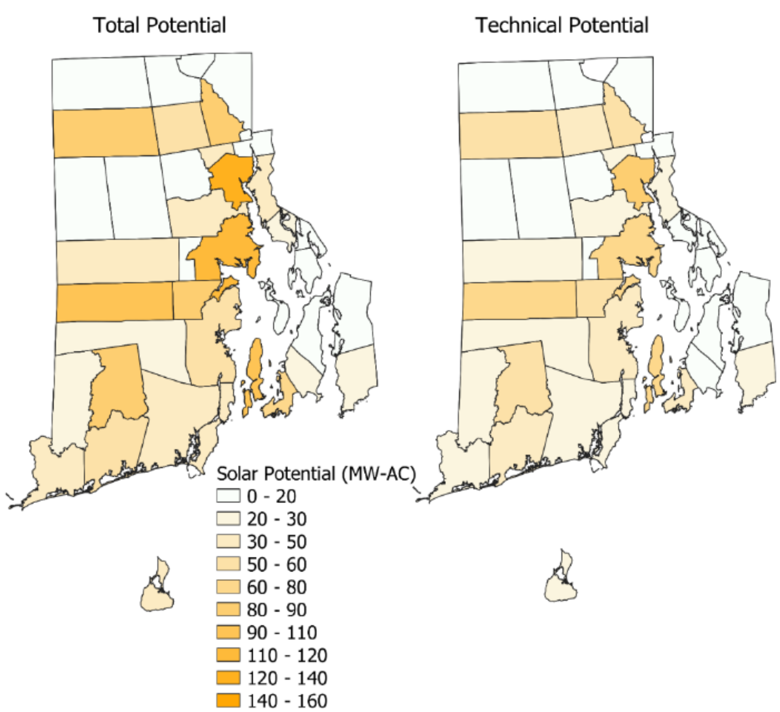
Project Class	N	Median	Average	Capacity-Weighted Average
Large-Scale Solar (including CRDG)	6	$127.25	$151.36	$138.07
Commercial-Scale Solar (including CRDG)	6	$88.95	$216.83	$745.61
Medium-Scale Solar	8	$237.09	$199.10	$199.09
All Ground Mount	20	$163.99	$190.10	$264.53
All Carports	3	$58.82	$69.25	$60.74
Difference (All GM minus Carports)		***$105.16***	***$120.85***	***$203.79***

Interconnection costs depend on many factors, including availability of and proximity to three-phase distribution feeder lines, available hosting capacity, any necessary substation upgrades, and the ability to share or use an existing service connection. The Company posits that carport projects are more likely than ground mounted solar projects to be located near three-phase feeder lines, in locations on the system with available hosting capacity, and are more likely to be able to share or use an existing service connection. All other factors being held equal, these characteristics seem likely to lead to lower interconnection costs, through a reduced need for reconductoring and substation upgrades, particularly in comparison to ground mounted solar projects that are often located on undeveloped land in more remote areas. While the Company recognizes that the limited number of carports prevents it from making a statistically meaningful comparison, the initial data above aligns with the Company's expectation that interconnection costs associated with solar carports should generally be lower than for many ground mounted solar projects.

Prepared by or under the supervision of: Meghan McGuinness

The figures below, from a recent study by Synapse Energy Economics on solar siting opportunities in Rhode Island that was conducted for the Office of Energy Resources, show the solar technical potential by municipality, followed by a map of three-phase feeder lines in Rhode Island. In general, there is meaningful overlap between the areas of technical potential for carport solar and a high prevalence of three-phase lines.

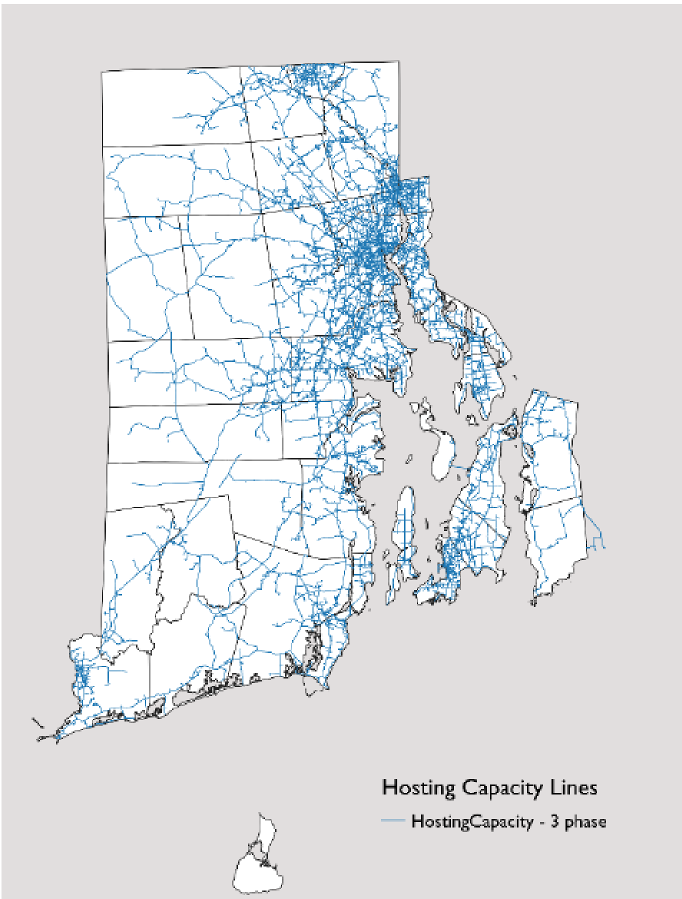
Figure 28. Maps of total and technical parking lot solar potential (MW)



Source: Knight, P., C. Odom, E.Camp, D. Bhandari, and J. Frost, Solar Siting Opportunities for Rhode Island, prepared for Rhode Island Office of Energy Resources (August 31, 2020), page 49.

Prepared by or under the supervision of: Meghan McGuinness

Figure 30. 3-phase feeder lines in Rhode Island



Source: *Id.,* page 56.

PUC 2-17

Request:

Referring to the testimony of Springsteel and McGuinness, page 28 of 33, lines 4 through 8, does the value of benefits associated with avoiding projects that will be located on greenspace depend upon the assumption that a carport project displaces a solar project that would have been built on greenspace?

a. If so, please elaborate on why that assumption is reasonable, including data (if any) that supports the assumption that when a carport project is built it necessarily means that a project will not be built on greenspace.

b. If it is uncertain whether the building of a carport necessarily means that a solar project will not be built on greenspace, was this uncertainty accounted for when evaluating the benefits and costs of carports? If so, please explain.

Response:

a. No. As explained below in part b., the Company's analysis does not assume that a solar carport project will necessarily displace a solar project built on greenspace.

b. As noted in the pre-filed Direct Testimony of Ian Springsteel and Meghan McGuinness at page 28, the Company's analysis assumes that the solar carport project displaces a "typical" Renewable Energy (RE) Growth Program solar project, which is a composite of average site and interconnection cost attributes of recently awarded RE Growth solar projects. The Company provides more details of this assumption for key benefit inputs below.

  - Interconnection costs and associated operation and maintenance (O&M) expenses: the interconnection cost savings from solar carports included in the Company's analysis was based on a comparison between the interconnection costs of the solar carport projects selected through the RE Growth Program open enrollments as of the second open enrollment of the 2020 Program Year with the interconnection costs of all other non-carport solar projects selected in the same open enrollments. The projects in the comparison data set included both rooftop and ground mounted projects.

  - Avoided lost forest carbon storage and forest carbon uptake: The Company requested data from applicants in the Commercial Scale Solar and Large-Scale Solar categories from

Program Year 2018 through the first open enrollment for Program Year 2020 on the amount of forest clearing associated with individual RE Growth projects. The resulting data included both ground mounted and rooftop solar projects, and ground mounted projects included agricultural, commercial and industrial, and residential sites. The table below summarizes this data.

Acres of project-related forest clearing reported by RE Growth applicants (2018-1st Open Enrollment 2020):

	N	Min	Max	Mean
Commercial-Scale Solar	14	0	3	0.21
Large-Scale Solar	5	0	12	5.3

- Avoided loss of ecosystem services: To appropriately account for the probability that a solar carport project would displace a solar project on greenspace and thus preserve the ecosystem attributes associated with undeveloped open space, the Company adjusted the ecosystem services value in each size category to account for the following: (1) the proportion of awarded solar carport projects between Program Year 2018 and the first open enrollment of Program Year 2020 that were rooftop projects; and (2) the proportion of awarded ground mounted projects over this same time period that were on sites that were previously developed commercial or industrial sites or showed other clear signs of disturbance. This review of site characteristics was supplemented using project addresses and satellite imagery from Google Maps.

- Avoided lost property value: Please see the Company's response to Data Request PUC 2-18.

Prepared by or under the supervision of: Meghan McGuinness

PUC 2-18

Request:

Referring to the testimony of Springsteel and McGuinness, page 28 of 33, lines 4 through 8, does the value of benefits associated with avoiding reductions in property value depend upon the assumption that a carport project displaces a solar project that would have been built in a residential area that impacts property values?

a. If so, please elaborate on why that assumption is reasonable, including data (if any) that supports the assumption that when a carport project is built it necessarily means that a project will not be built in an area that lowers property values.

b. If it is uncertain whether the building of a carport necessarily means that a solar project will not be built in an area that lowers property values, was this uncertainty accounted for when evaluating the benefits and costs of carports? If so, please explain.

Response:

a. No. As discussed below in part b., the Company's benefit-cost analysis (BCA) does not assume that the development of a carport project necessarily means that an alternative solar project will not be built in an area that lowers property values.

b. The Company's assumptions regarding the likelihood that a project will have a negative impact on property values varies by scenario. The Company adjusted the calculated benefits from avoided property loss by factors calculated as described below.

In both the low- and mid-benefits scenarios, the Company's factor excludes the share of awarded projects, based on project data from Program Year 2018 through the first open enrollment of Program Year 2020, located in rural areas or on developed commercial and industrial or otherwise disturbed sites. The Company excluded projects located in rural areas based on a recent study finding that significant property value impacts were not observed from projects in rural areas.[1] In addition, the Company excluded projects on developed commercial and industrial or otherwise disturbed sites based on the same

[1] Gaur, Vasundhara, and Corey Lang, "Property Value Impacts of Commercial-Scale Solar Energy in Massachusetts and Rhode Island, University of Rhode Island," at page 17 (September 29, 2020), available at: https://works.bepress.com/corey_lang/33/.

study.[2] As discussed in the Company's response to Data Request PUC 2-17, the Company used information from project applications as well as satellite imagery from Google Maps to identify such projects.

In the high benefits scenario, the Company calculated the factor to exclude only projects on developed commercial and industrial or otherwise disturbed areas, but not projects in rural areas. This scenario assumes that property value impacts are likely to apply in rural communities. The Company believes this is a reasonable assumption for the high benefits scenario, given the extensive solar project development in certain rural communities in Rhode Island in recent years and the increasing local opposition to such development.

In reviewing its BCA for this response, the Company observed an error in the calculation of the property value benefits adjustment factors for the high scenarios for Medium and Commercial-Scale Solar projects in Schedule NG-7 attached to the pre-filed Direct Testimony of Ian Springsteel and Meghan McGuinness. Please see Attachment PUC 2-18 for a corrected version of Schedule NG-7. Because the factors applied to property value impacts in the high scenarios are the same factors that are applied to the value of avoided loss of ecosystem services across all scenarios, estimates of those values have also changed for Medium and Commercial-Scale Solar projects. As corrected, the factors the Company used to adjust the value of avoided property value loss for the high benefits scenarios (and the value of avoided loss of ecosystem services for all scenarios) are 0.24 for Medium-Scale Solar, 0.39 for Commercial-Scale Solar, and 0.85 for Large-Scale Solar (see Attachment PUC 2-18 at page 3).

The table below provides a summary of the BCA ratios by scenario, as filed and as corrected in Attachment PUC 2-18. These updates do not change the Company's conclusions regarding cost-effectiveness that are discussed in its testimony.

2 The same study, "Property Value Impacts of Commercial-Scale Solar Energy," at pages 17-18, observed that the overall negative effects on nearby property values are driven by farm and forest sites in non-rural areas, given that a separate specification of their model did not show a significant property value impact from projects sited at industrial sites or landfills.

Benefit Scenario	Project Class	NPV Costs ($/kW)	NPV Benefits as Filed ($/kW)	Corrected NPV Benefits ($/kW)	BCA Ratio as Filed	Corrected BCA Ratio
	Medium-Scale	$ 616	$ 568	$ 558	0.92	0.91
	Commercial-Scale	$ 616	$ 513	$ 508	0.83	0.83
Low	Large-Scale	$ 616	$ 392	$ 392	0.64	0.64
	Medium-Scale	$ 616	$ 868	$ 858	1.41	1.39
	Commercial-Scale	$ 616	$ 745	$ 741	1.21	1.20
Mid	Large-Scale	$ 616	$ 465	$ 465	0.76	0.76
	Medium-Scale	$ 616	$ 2,495	$ 1,494	4.05	2.43
	Commercial-Scale	$ 616	$ 1,640	$ 1,420	2.66	2.31
High	Large-Scale	$ 616	$ 701	$ 701	1.14	1.14

Prepared by or under the supervision of: Meghan McGuinness

No.	Mixed Benefit-Cost, Cost, or Benefit Category	Treatment in Benefit-Cost Analysis (Quantified, Qualified, Not Treated)	Notes	Benefit, cost, other
Power System Level				
1	Energy Supply & Transmission Operating Value of Energy Provided or Saved (Power System Level)	Quantified	Market value of incremental energy purchased by Company due to lower expected production from carport project.	Cost
2	Renewable Energy Credit Cost/Value	Quantified	Value of foregone RECs value due to lower production from carport project.	Benefit
3	Retail Supplier Risk Premium (Power System Level)	Quantified	Wholesale Risk Premium is built into the retail costs of electric energy from the AESC 2018 study and is icluded in the cost of incremental wholesale energy market purchases due to lower production from a carport project relative to a groundmount solar project	Cost
4	Forward Commitment Capacity Value (Power System Level)	Assumed to be zero	Projects are assumed to have the same peak coincidence factor and no meaningful difference in capacity value.	0
5	Forward commitment avoided ancillary services value (Power System Level)	Assumed to be zero	Would not expect a meaningful difference between the two types of projects.	0
6	Utility / Third Party Developer Renewable Energy, Efficiency, or DER costs	Quantified	Cost of carport adder	Cost
	Utility / Third Party Developer Renewable Energy, Efficiency, or DER costs	Quantified	Reduction in REG energy payments (excluding adder) due to lower carport production	Offset to cost
	Utility / Third Party Developer Renewable Energy, Efficiency, or DER costs	Quantified	Reduction in interconnection costs to developers	Benefit
7	Electric Transmission Capacity Value (Power System Level)	Assumed to be zero	No transmission capacity benfits would be expected from either project	0
8	Electric transmission infrastructure costs for Site Specific Resources	Assumed to be zero	No imcremental transmission infrastructure cost expected for REG projects.	0
9	Net Risk Benefits to Utility System Operations from DER Flexibility & Diversity (Power System Level)	Assumed to be zero	No reason to expect this outcome to differ between projects.	0
10	Option value of individual resources (Power System Level)	Assumed to be zero	No reason to expect tthis outcome to differ between projects.	0
11	Investment under uncertainty: real options value (Power System Level)	Expected to be zero	No reason to expect this outcome to differ between projects.	0
12	Energy Demand Reduction Induced Price Effect (DRIPE) (Power System Level)	Quantfied	Included in estimation of incremental emergy costs to customers due to lower production from carport.	Cost
13	GHG Compliance Costs (Power System Level)	Quantified	Included in estimation of incremental emergy costs to customers due to lower production from carport.	Cost
14	Criteria Air Pollutant and Other Environmental Externality Costs (Power System Level)	Quantified	Included in estimation of incremental emergy costs to customers due to lower production from carport.	Cost
15	Innovation and learning by doing (Power System Level)	Assumed to be zero	No reason to expect this outcome to differ between projects.	0
16	Distribution Capacity Costs (Power System Level)	Assumed to be zero	No reason to expect this outcome to differ between projects.	0
17	Distribution Delivery Costs (Power System Level)	Quantified	Reduction in O&M and tax costs associated with interconnection upgrades	Benefit
18	Distribution system safety loss/gain (Power System Level)	Assumed to be zero	Distribution system properties assumed to be the same for typical project and carport project.	0
19	Distribution System Performance (Power System Level)	Assumed to be zero	Distribution system properties assumed to be the same for typical project and carport project.	0
20	Utility low income (Power System Level)	Assumed to be zero	No reason to expect this outcome to differ between projects.	0
21	Distribution System and Customer Reliability/Resilience Impacts (Power System Level)	Assumed to be zero	No reason to expect this outcome to differ between projects.	0
Customer Level				
22	Program participant / prosumer benefits / costs (Customer Level)	Not quantified	Additional private economic costs and benefits to carport owners are not included.	Expected benefit
23	Participant non-energy benefits: oil, gas, water, waste water (Customer Level)	Not quantified	Additional private economic costs and benefits to carport owners are not included.	Undetermined
24	Low income participant benefits (Customer Level)	N/A	Commercial customers expected to be primary participants.	N/A
25	Customer empowerment and choice (Customer Level)	N/A		N/A
26	Non-participant rate and bill impacts (Customer Level)	Not quantified	Adder impacts on bills expected to be small.	
Societal Level				
27	GHG Externality Cost (Societal Level)	Quantified	Analysis of impacts of lower energy output from carport incudes impact of incremental GHG from wholesale market purchases.	Cost
	GHG Externality Cost (Societal Level)	Quantified	Captures GHG impact of forest clearing for project development.	Benefit
28	Criteria Air Pollutant and Other Environmental Externality Costs (Societal Level)	Quantified	Analysis of impacts of lower energy output from carport incudes impact of incremental NOx from wholesale market purchases.	Cost
29	Conservation and community benefits (Societal Level)	Quantified	Value of avoided loss of ecosystem services	Benefit
	Conservation and community benefits (Societal Level)	Quantified	Value of avoided loss of open space, based on property value impacts from greenfield projects.	Benefit
Customer Level	Non-energy benefits: Economic Development (Societal Level)	Not Quantified	Not quantified. Canopy construction would be the primary driver of economic development benefits.	Benefit
30	Innovation and knowledge spillover - related to demo projects and other RD&D (Societal Level)	Assumed to be zero	No reason to expect tthis outcome to differ between projects.	0
31	Societal low-income impacts (Societal Level)	Assumed to be zero	No reason to expect tthis outcome to differ between projects.	0
32	Public Health (Societal Level)	Assumed to be zero	No reason to expect tthis outcome to differ between projects.	0
33	National security and US international influence (Societal Level)	Assumed to be zero	No reason to expect tthis outcome to differ between projects.	0

PUC 2-19

Request:

For each year of the REGrowth Program please indicate the number of MWs in each class that could not be enrolled because of the target limit (not based on pricing). If there were no denied projects, please indicate the percentage of the target that was met.

Response:

Please see the tables below for the requested information.

Renewable Energy Growth Program - 2015 Program Year

Renewable Energy Class (Nameplate MW)	Annual Enrollment Target (Nameplate MW)	Total Eligible Projects (MW)	Total Projects Withdrawing/ Declining Offer (MW)	Total Awarded (MW)	Could not enroll due to Target limits (MW)	% Target Met	Amount above Target, using allowable re-allocated MW
Small-Scale Solar (.001-.025 MW DC)	3.00	----------	----------	3.41	----------	113.61%	0.41
Medium-Scale Solar (.026-.250 MW DC)	4.00	2.68	0.00	2.68	0.00	67.08%	0.00
Commercial-Scale Solar (.251-.999 MW DC)	5.50	4.15	0.00	4.15	0.00	75.40%	0.00
Large-Scale Solar (1-5 MW DC)	6.00	6.64	0.00	6.64	0.00	110.73%	0.64
Wind (1.5-2.99 MW)	5.00	6.00	0.00	6.00	0.00	120.00%	1.00
Wind (3-5 MW)			0.00				
Anaerobic Digestion (.150-1 MW)	1.50	0.00	0.00	0.00	0.00	0.00%	0.00
Small-Scale Hydropower (.010-.250 MW)		0.00	0.00	0.00	0.00	0.00%	0.00
Small-Scale Hydropower (.251-1 MW)		0.00	0.00	0.00	0.00	0.00%	0.00
Total(MW):	**25.00**			**22.88**			

Prepared by or under the supervision of: Thomas Kender and Shelanda Gonsalves

Renewable Energy Growth Program - 2016 Program Year

Renewable Energy Class (Nameplate MW)	Annual Enrollment Target (Nameplate MW)	Total Eligible Projects (MW)	Total Projects Withdrawing/ Declining Offer (MW)	Total Awarded (MW)	Could not enroll due to Target limits (MW)	% Target Met	Amount above Target, using allowable re-allocated MW
Small-Scale Solar (.001-.025 MW DC)	5.50	----------	----------	7.18	----------	130.5%	1.68
Medium-Scale Solar (.026-.250 MW DC)	5.00	4.50	0.00	4.50	0.00	89.9%	0.00
Commercial-Scale Solar (.251-.999 MW DC)	8.00	7.56	0.00	7.56	0.00	94.5%	0.00
Large-Scale Solar (1-5 MW DC)	11.00	7.85	0.00	7.85	0.00	71.4%	0.00
Wind (1.5-2.99 MW)	9.00	3.00	0.00	3.00	0.00	33.3%	0.00
Wind (3 -5 MW; 2-turbine)		0.00	0.00	0.00	0.00	0.0%	0.00
Wind (3 -5 MW; 3-turbine)		0.00	0.00	0.00	0.00	0.0%	0.00
Anaerobic Digestion (.15-.5 MW)	1.50	0.00	0.00	0.00	0.00	0.0%	0.00
Anaerobic Digestion (.501-1 MW)		0.00	0.00	0.00	0.00	0.0%	0.00
Small-Scale Hydropower (.010-.250 MW)		0.00	0.00	0.00	0.00	0.0%	0.00
Small-Scale Hydropower (.251-1 MW)		0.00	0.00	0.00	0.00	0.0%	0.00
Total(MW):	**40.00**			**30.08**			

Prepared by or under the supervision of: Thomas Kender and Shelanda Gonsalves

Renewable Energy Growth Program - 2017 Program Year

Renewable Energy Class (Nameplate MW)	Annual Enrollment Target (Nameplate MW)	Total Eligible Projects (MW)	Total Projects Withdrawing/ Declining Offer (MW)	Total Awarded (MW)	Could not enroll due to Target limits (MW)	% Target Met	Amount above Target, using allowable re-allocated MW
Small-Scale Solar (.001-.025 MW DC)	6.55	----------	----------	7.07	----------	107.9%	0.52
Medium-Scale Solar (.026-.250 MW DC)	3.00	4.62	1.00	3.62	0.00	120.6%	0.62
Commercial-Scale Solar (.251-.999 MW DC)	5.00	10.27	0.00	5.33	4.94	106.7%	0.33
Large-Scale Solar (1 -5 MW DC)	12.05	43.54	7.50	11.85	24.19	98.3%	0.00
Small Wind (.010-.999 MW)	0.40	0.00	0.00	0.00	0.00	0.0%	0.00
Wind I (1 -2.99 MW)	6.00	0.00	0.00	0.00	0.00	0.0%	0.00
Wind II (3 -5 MW; 2-turbine)		15.00	0.00	6.00	9.00	100.0%	0.00
Wind III (3 -5 MW; 3-turbine)		0.00	0.00	0.00	0.00	0.0%	0.00
CRDG Wind I (1 -2.99 MW DC)		0.00	0.00	0.00	0.00	0.0%	0.00
CRDG Wind II (3 -5 MW DC; 2-turbine)		0.00	0.00	0.00	0.00	0.0%	0.00
CRDG Wind III (3 -5 MW DC; 3-turbine)		0.00	0.00	0.00	0.00	0.0%	0.00
CRDG Commercial Solar (.251-.999 MW DC)	3.00	2.99	0.00	2.99	0.00	99.7%	0.00
CRDG Large Solar (1 -5 MW DC)	3.00	3.00	0.00	3.00	0.00	100.0%	0.00
Anaerobic Digestion I (.150-.5 MW)	1.00	0.00	0.00	0.00	0.00	0.0%	0.00
Anaerobic Digestion II (.501-1 MW)		0.00	0.00	0.00	0.00	0.0%	0.00
Small Scale Hydropower I (.010-.250 MW)		0.00	0.00	0.00	0.00	0.0%	0.00
Small Scale Hydropower II (.251-1 MW)		0.45	0.00	0.45	0.00	0.0%	0.00
Total:	**40.00**			**40.31**			

Renewable Energy Growth Program - 2018 Program Year

Renewable Energy Class (Nameplate MW)	Annual Enrollment Target (Nameplate MW)	Total Eligible Projects (MW)	Total Projects Withdrawing/ Declining Offer (MW)	Total Awarded (MW)	Could not enroll due to Target limits (MW)	% Target Met	Amount above Target, using allowable re-allocated MW
Small-Scale Solar (.001-.025 MW DC)	6.55	----------	----------	7.32	----------	111.7%	0.77
Medium-Scale Solar (.026-.250 MW DC)	3.00	7.13	0.05	3.10	3.97	103.4%	0.10
Commercial-Scale Solar (.251-.999 MW DC)	5.00	8.18	0.95	5.11	2.12	102.2%	0.11
Large-Scale Solar (1 - 5 MW DC)	12.05	36.87	0.00	14.48	22.39	120.2%	2.43
Small Wind (.010-.999 kW)	0.40	0.00	0.00	0.00	0.00	0.0%	0.00
Wind I (1 -2.99 MW)	6.00	0.00	0.00	0.00	0.00	0.0%	0.00
Wind II (3 -5 MW; 2-turbine)		6.00	0.00	6.00	0.00	100.0%	0.00
Wind III (3 -5 MW; 3-turbine)		0.00	0.00	0.00	0.00	0.0%	0.00
CRDG Wind I (1 -2.99 MW DC)		0.00	0.00	0.00	0.00	0.0%	0.00
CRDG Wind II (3 -5 MW DC; 2-turbine)		0.00	0.00	0.00	0.00	0.0%	0.00
CRDG Wind III (3 -5 MW DC; 3-turbine)		0.00	0.00	0.00	0.00	0.0%	0.00
CRDG Commercial Solar (.251-.999 MW DC)	3.00	2.00	1.00	1.00	0.00	33.2%	0.00
CRDG Large Solar (1 -5 MW DC)	3.00	3.00	0.00	3.00	0.00	100.0%	0.00
Anaerobic Digestion I (.150-.500 MW)	1.00	0.00	0.00	0.00	0.00	0.0%	0.00
Anaerobic Digestion II (.501-1 MW)		0.00	0.00	0.00	0.00	0.0%	0.00
Small Scale Hydropower I (.010-.250 MW)		0.00	0.00	0.00	0.00	0.0%	0.00
Small Scale Hydropower II (.251-1 MW)		1.22	0.00	0.74	0.48	74.0%	0.00
Total:	**40.00**			**40.74**			

Prepared by or under the supervision of: Thomas Kender and Shelanda Gonsalves

Renewable Energy Growth Program - 2019 Program Year

Renewable Energy Class (Nameplate MW)	Annual Enrollment Target (Nameplate MW)	Total Eligible Projects (MW)	Total Projects Withdrawing/ Declining Offer (MW)	Total Awarded (MW)	Could not enroll due to Target limits (MW)	% Target Met	Amount above Target, using allowable re-allocated MW
Small-Scale Solar (.001-.025 MW DC)	12.23	----------	----------	5.77	----------	47.2%	0.00
Medium-Scale Solar (.026-.250 MW DC)	6.80	8.77	0.00	7.26	1.51	106.8%	0.46
Commercial-Scale Solar (.251-.999 MW DC)	7.30	14.97	0.00	8.40	6.57	115.1%	1.10
Large-Scale Solar (1 -5 MW DC)	11.30	60.46	8.56	15.24	36.66	134.9%	3.94
Small Wind (.010-.999 MW)	0.40	0.00	0.00	0.00	0.00	0.0%	0.00
Wind I (1 -2.99 MW)	6.00	4.50	0.00	4.50	0.00	75.0%	0.00
Wind II (3 -5 MW; 2-turbine)			0.00				
Wind III (3 -5 MW; 3-turbine)			0.00				
CRDG Wind I (1 -2.99 MW DC)			0.00				
CRDG Wind II (3 - 5 MW DC; 2-turbine)			0.00				
CRDG Wind III (3 -5 MW DC; 3-turbine)			0.00				
CRDG Commercial Solar (.251-.999 MW DC)	5.00	6.69	2.66	4.03	0.00	80.6%	0.00
CRDG Large Solar (1 -5 MW DC)	5.30	3.39	0.00	3.39	0.00	64.0%	0.00
Anaerobic Digestion (.001 -5 MW)	1.00	0.00	0.00	0.00	0.00	0.0%	0.00
Hydropower (.001-5 MW)		0.48	0.00	0.48	0.00	48.0%	0.00
Total:	**55.33**			**49.08**			

Renewable Energy Growth Program - 2020 Program Year

Renewable Energy Class (Nameplate MW)	Annual Enrollment Target (Nameplate MW)	Total Eligible Projects (MW)	Total Projects Withdrawing/ Declining Offer (MW)	Total Awarded (MW)	Could not enroll due to Target limits (MW)	% Target Met	Amount above Target, using allowable re-allocated MW
Small-Scale Solar (.001-.025 MW DC)	6.95	----------	----------	3.83	----------	55.1%	0.00
Medium-Scale Solar (.026-.250 MW DC)	3.00	6.52	0.00	5.67	0.85	188.9%	2.67
Commercial-Scale Solar (.251-.999 MW DC)	8.24	8.88	1.86	7.02	0.00	85.2%	0.00
Large-Scale Solar (1 - 5 MW DC)	18.29	40.09	8.85	20.84	10.41	113.9%	2.54
Small Wind (.050 -1.5 MW)	3.00	1.00	0.00	1.00	0.00	33.3%	0.00
Wind (1.5 - 5 MW)		0.00	0.00	0.00	0.00	0.0%	0.00
CRDG Wind (1 - 5 MW)		0.00	0.00	0.00	0.00	0.0%	0.00
CRDG Commercial Solar (.251-.999 MW DC)	3.00	1.63	0.93	0.70	0.00	23.3%	0.00
CRDG Large Solar (1 - 5 MW DC)	3.00	5.69	2.69	3.00	0.00	99.8%	0.00
Anaerobic Digestion (.001 - 5 MW)	1.00	0.00	0.00	0.00	0.00	0.0%	0.00
Hydropower (.001-5 MW)		0.00	0.00	0.00	0.00	0.0%	0.00
Total:	**46.49**			**42.05**			

Note: Includes all awarded COE's from the 2020 Third Open Enrollment, of which six projects still pending PUC approval.

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