Connecticut Non-Energy Impacts Literature Review: R1709

Final Report

Prepared for Connecticut Energy Efficiency Board (CTEEB)

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Executive Summary

APPRISE conducted a study for the Connecticut Energy Efficiency Board to assess how they may incorporate valuation of Non-Energy Impacts (NEIs) into their evaluations and their cost-effectiveness analyses. This report provides a review of the literature on NEIs.

Energy efficiency programs lead to substantial benefits beyond the energy and demand savings they achieve. These NEIs are important to understand and measure to effectively market the program to potential participants. NEIs are also important to accurately conduct the benefit-cost analysis for the energy efficiency investments.

This literature review addresses the challenge in this research area where studies point to previous studies (and those studies point to previous studies) that do not provide adequate documentation of the research methodology used to estimate the NEIs. This report provides a rigorous examination of the past studies to assess the specific models used and assumptions made.

This study includes NEI research that was completed in 2000 or later *with original research and calculation* of NEI values. While there are hundreds of reports that cover the NEI topic, many of those reports are dated and most do not calculate benefits that are specific to the program and jurisdiction studied. Many reports are literature reviews and even of those that do quantify the benefits, they usually utilize estimates that were previously calculated in prior studies.

Residential Impacts

The studies that were reviewed provided estimation of residential NEIs in the following categories.

- Medical/Health
- Safety
- Comfort
- Affordability
- Operation & Maintenance Costs
- Water Usage
- Economic
- Property Value
- Utility Rates and Arrearage Reduction
- Transmission & Distribution
- Environmental – Avoided Emissions
- Environmental – Participant Valuation

<u>Medical/Health Impacts</u>

Six of the reviewed studies estimated medical or health NEIs. In some cases the costs of treatments were estimated, and in some cases the participants were asked to value the impact of the program on the issue. The specific health and medical impacts that were examined were as follows.

- Cold-Related Thermal Stress
- Heat-Related Thermal Stress
- Health, general
- Asthma
- Colds and flu
- Allergies
- Bronchitis
- Headaches
- Doctor visits
- Medication
- Missed days at work or school

The studies estimated these impacts using the following approaches.

- Data from the National WAP Evaluation Occupant Survey.
- Study-specific participant surveys where the participant valued the benefit relative to the energy savings from the program.
- Pre/post participant and comparison group surveys with a differences-in-differences analysis of the results.

Table ES-1 summarizes the values for the estimates that were reviewed. The table shows that while estimates for various medical impacts generally range from a $4 annual benefit per unit to $19, the MA 2016 estimated much higher levels. Because these benefits are sensitive to the population of customers served and the types of interventions, it is difficult to generally apply these findings to other jurisdictions. However, the best estimate for health-related impacts from weatherization for low-income households would range from $30 to $45 based on the sum of the WI estimates or the total estimate for CO. We recommend that CT use this as an initial estimate of the benefits but prioritize this area for additional research to quantify findings that are specific to CT's programs.

Table ES-1
Health-Related Impacts from Weatherization

Weatherization Impact	Study	Annual Benefit Per Unit
Medication	WI Low-Income Weatherization NEB (2005)	$1
General, Asthma, Cold/Flu (non low-income)	MA Residential and Low-Income (2011)	$4
Doctor/Hospital Visits	WI Low-Income Weatherization NEB (2005)	$4-$5
Headaches	WI Low-Income Weatherization NEB (2005)	$5-$6
Other Illnesses (non-chronic)	WI Low-Income Weatherization NEB (2005)	$5-$6
Chronic Conditions	WI Low-Income Weatherization NEB (2005)	$9-$12
General, Asthma, Cold/Flu (low-income)	MA Residential and Low-Income (2011)	$19
Asthma	MA Low-Income Health & Safety (2016)	$332.00

Weatherization Impact	Study	Annual Benefit Per Unit
Heat-Related Thermal Stress	MA Low-Income Health & Safety (2016)	$172.93
Cold-Related Thermal Stress	MA Low-Income Health & Safety (2016)	$496.94
Missed Work/School	WI Low-Income Weatherization NEB (2005)	$4-$5
Missed Work	MA Low-Income Health & Safety (2016)	$186.81
Total Health Impact	CO Low-Income EE NEB Study (2010)	$44.02

Safety Impacts

Four of the reviewed studies estimated safety-related NEIs. The specific safety impacts that were examined were as follows.

- Carbon Monoxide Poisoning
- Home Fires
- Unspecified (General Safety)

The studies estimated these impacts using the following approaches.

- National data on incidents in combination with population estimates.
- Percent of participants who received a CO monitor.
- Value of NEI approximated by the cost of the installed measure.
- Study-specific participant surveys where the participant valued the benefit relative to the energy savings from the program.
- Pre/post participant and comparison group surveys with a differences-in-differences analysis of the results.

Table ES-2 summarizes the values for the estimates that were reviewed. While the CA 2001 study estimated benefits ranging from $2 to $3 for CO poisoning and the WI 2005 study estimate home safety values ranging from $20 to $26, the MA 2016 study had significantly higher estimates. Given the small number of studies and the large range of estimates, this is an area that requires further study before applying estimates to other jurisdictions.

Table ES-2
Safety-Related Impacts from Weatherization

Weatherization Impact	Study	Annual Benefit Per Unit
Carbon Monoxide Poisoning	CA LI Public Purpose Test (2001)	$2.27-$3.34
Carbon Monoxide Poisoning	MA Low-Income Health & Safety (2016)	$36.98
Home Fires	MA Low-Income Health & Safety (2016)	$57.48
Home Safety	WI Low-Income Weatherization NEB (2005)	$20-$26

Comfort Impacts

Six of the reviewed studies estimated NEIs related to comfort. The specific comfort impacts that were examined were as follows.

- Thermal Comfort/Home Productivity
- Indoor Noise Level
- General/Overall Comfort

The studies estimated these impacts using the following approaches.

- Data from the National WAP Evaluation Occupant Survey.
- Secondary data.
- Study-specific participant surveys where the participant valued the benefit relative to the energy savings from the program.
- Pre/post participant and comparison group surveys with a differences-in-differences analysis of the results.

Table ES-3 summarizes the values for the estimates that were reviewed. Benefits from noise reduction ranged from $13 to $31, from comfort ranged from $21 to $125, and benefits from productivity ranged from $0 to $38. We would recommend applying a value of $15 to noise reduction and $35 for comfort given these estimates. These are annual benefits per unit and apply to all weatherization programs that apply significant levels of air sealing and insulation.

Table ES-3
Comfort-Related Impacts from Weatherization

Weatherization Impact	Study	Annual Benefit Per Unit
Outside Noise	WI Low-Income Weatherization NEB (2005)	$13-$17
Indoor Noise	WI Low-Income Weatherization NEB (2005)	$19-$24
Indoor Noise (low-income)	MA Residential and Low-Income (2011)	$30
Indoor Noise (non low-income)	MA Residential and Low-Income (2011)	$31
Comfort	CO Low-Income EE NEB Study (2010)	$20.66
Comfort	WI Low-Income Weatherization NEB (2005)	$44-$56
Thermal Comfort (low-income)	MA Residential and Low-Income (2011)	$119.88
Thermal Comfort (non low-income)	MA Residential and Low-Income (2011)	$125
Productivity	CO Low-Income EE NEB Study (2010)	$0
Productivity Increase from Improved Sleep	MA Low-Income Health & Safety (2016)	$37.75

Affordability Impacts

Four of the reviewed studies estimated NEIs related to affordability. The specific affordability impacts that were examined were as follows.

- Short-Term High-Interest Loans
- Hardship Benefits
  - Knowledge/control over bills

  - Ability to pay bills
  - Number of shutoff notices
  - Likelihood of moving
- Transaction Costs
  - Costs for replacing bulbs
  - Reconnections
  - Calls to the utility's collections department

The studies estimated these impacts using the following approaches.

- Data from the National WAP Evaluation Occupant Survey.
- Secondary data.
- Study-specific participant surveys where the participant was asked how much s/he would be willing to pay for the NEI.
- Study-specific participant surveys where the participant valued the benefit relative to the energy savings from the program.
- CFL program installation rates.
- Utility data on number of low-income reconnections.
- Utility data on number of customer calls.

Table ES-4 summarizes the values for the estimates that were reviewed. While the CO 2010 study estimated total affordability benefits of about $107, the WI study estimated total benefits of about $74. These impacts are related to the effectiveness of the weatherization services and should be estimated for the particular program that is evaluated.

Table ES-4
Affordability-Related Impacts from Weatherization

Weatherization Impact	Study	Annual Benefit Per Unit
Likelihood of Moving Due to Energy Costs	WI Low-Income Weatherization NEB (2005)	$1
Bill-Related Calls to Utility	WI Low-Income Weatherization NEB (2005)	$4-$6
Shutoff Notices	WI Low-Income Weatherization NEB (2005)	$9-$12
Ability to Pay Bills	WI Low-Income Weatherization NEB (2005)	$22-$29
Control of Energy Bills	WI Low-Income Weatherization NEB (2005)	$28-$36
Knowledge/Control Over Bills	CO Low-Income EE NEB Study (2010)	$43.06
Hardship	CO Low-Income EE NEB Study (2010)	$61.76
Transactions Costs	CA LI Public Purpose Test (2001)	$0
Transactions Costs	CO Low-Income EE NEB Study (2010)	$1.63
High-Interest Loans	MA Low-Income Health & Safety (2016)	$0
High-Interest Loans	CA LI Public Purpose Test (2001)	$2.57

Operation & Maintenance Cost Impacts

Five of the reviewed studies estimated NEIs related to operation and maintenance costs. These impacts were examined for residents and for owners of multi-family buildings.

- Home Durability
- Equipment Maintenance
- Lighting Maintenance
- Tenant Complaints

The studies estimated these impacts using the following approaches.

- Study-specific participant surveys where the participant valued the benefit relative to the energy savings from the program.
- Technical Reference Manual estimates for replacement costs and number of replacements avoided.

Table ES-5 summarizes the values for the estimates that were reviewed. These estimates are variable and will relate to the types and effectiveness of benefits delivered. They should be estimated directly for the program that is implemented.

Table ES-5
Operation & Maintenance-Related Impacts from Weatherization

Weatherization Impact	Study	Annual Benefit Per Unit
Lighting Maintenance	Mid-Atlantic TRM 6.0 (2016)	$2.01
Lighting Quality	WI Low-Income Weatherization NEB (2005)	$19-$25
Lighting Maintenance	MA Residential and Low-Income (2011)	$66.73
Home Durability (low-income)	MA Residential and Low-Income (2011)	$35
Home Durability (non low-income)	MA Residential and Low-Income (2011)	$49
Equipment Performance	WI Low-Income Weatherization NEB (2005)	$14-$18
Equipment Maintenance	WI Low-Income Weatherization NEB (2005)	$19-$24
Equipment Maintenance (low-income)	MA Residential and Low-Income (2011)	$54
Appliance Function	CO Low-Income EE NEB Study (2010)	$62.14
Equipment Maintenance (non low-income)	MA Residential and Low-Income (2011)	$124
Tenant Complaints	MA Residential and Low-Income (2011)	$19.61

Water Usage Impacts

Three of the reviewed studies estimated savings on water costs. The studies estimated these impacts using the following approaches.

- Engineering approach using the water and sewer rate, number of household members per home, length of showers or number of gallons of water used, and reduction in shower or fixture flow.

- Study-specific participant surveys where the participant valued the benefit relative to the energy savings from the program.

Table ES-6 summarizes the values for the estimates that were reviewed. The water and sewer savings were about $20, but will vary depending on the measures installed and the costs for water and sewer, that have been increasing. Therefore, these benefits should be estimated directly for the program.

Table ES-6
Water Usage Impacts from Weatherization

Weatherization Impact	Study	Annual Benefit Per Unit
Water Savings	WI Low-Income Weatherization NEB (2005)	$4.89, $8-$10
Water and Sewer Savings	WI Home Energy Plus (2017)	$17-$19
Water and Sewer Savings	CO Low-Income EE NEB Study (2010)	$22.81

Economic Impacts

Seven of the reviewed studies estimated NEIs related to economic impacts. The studies estimated impacts on output, labor income, and on jobs.

The studies estimated these impacts using the following approaches.

- IMPLAN input-output modeling.
- Program expenditures and RIMS economic multipliers for program spending categories compared to spending on energy, and economic multipliers for retail spending compared to spending on energy.
- Multipliers taken from the literature.
- Interviews and surveys where participants were asked to estimate the number of jobs created.
- Program tracking data and Department of Labor data and other organization data on jobs created.

Table ES-7 summarizes the values for the estimates that were reviewed. There is a large range of estimates and these will vary depending on the level of the program investment, the types of investments, the amount invested in-state, and the multipliers for the state. Therefore, these should be estimated directly for the program.

Table ES-7
Economic Impacts from Weatherization

Weatherization Impact	Study	Annual Benefit Per Unit
Economic Impact	CO Low-Income EE NEB Study (2010)	$18.69
Labor Income	WI Low-Income Weatherization NEB (2005)	$187
Economic Output	WI Low-Income Weatherization NEB (2005)	$341

Property Value Impacts

Five of the reviewed studies estimated NEIs related to property values. The specific impacts that were examined were as follows.

- Property Value
- Increased Marketability for owners of multi-family buildings

The studies estimated these impacts using the following approaches.

- Study-specific participant surveys where the participant valued the benefit relative to the energy savings from the program.
- The assessed valuation improvement, or as a proxy, the cost of repairs made to the home.

Table ES-8 summarizes the values for the estimates that were reviewed. While the CA, WI and CO studies estimated values that ranged from $17 to 22, the MA 2011 study estimated values that ranged from approximately $1,000 to $2,000. A value of approximately $20 should be assigned to this benefit or additional research should be conducted.

Table ES-8
Property Value Impacts from Weatherization

Weatherization Impact	Study	Annual Benefit Per Unit
Property Value	CA LI Public Purpose Test (2001)	$17.80
Property Value	WI Low-Income Weatherization NEB (2005)	$17-$22
Property Value	CO Low-Income EE NEB Study (2010)	$21.43
Property Value (low-income)	MA Residential and Low-Income (2011)	$949
Property Value (non low-income)	MA Residential and Low-Income (2011)	$1,998

Utility Rates and Arrearage Reduction

Four of the reviewed studies estimated NEIs related to utility rates and arrearage reduction impacts from the utility perspective. The specific impacts that were examined were as follows.

- Reduced Energy Sold at Discounted Rate
- Arrearages Carrying Costs
- Customer Shutoffs, Reconnections, Notices, and Calls

The studies estimated these impacts using the following approaches.

- Average usage reduction estimate times rate discount.
- Energy savings times the rate times the arrearage reduction value based on a literature review.
- Utility collections data on frequency and cost of actions with an estimate of the program impact on the collections action.

Table ES-9 summarizes the values for the estimates that were reviewed. The studies estimated the impacts of various benefits so they are difficult to compare, except for CO and MD which both estimated the impact on arrearage carrying costs at about $5 per unit. These impacts are related to the effectiveness of the weatherization services and should be estimated for the particular program that is evaluated.

Table ES-9
Utility Rates and Arrearage Reduction Impacts from Weatherization

Weatherization Impact	Study	Annual Benefit Per Unit
Reconnections	CO Low-Income EE NEB Study (2010)	-$0.66
Notices	CO Low-Income EE NEB Study (2010)	$0.07
Shutoffs	CO Low-Income EE NEB Study (2010)	$0.94
Customer Calls	CO Low-Income EE NEB Study (2010)	$1.36
Arrearage Carrying Cost	CO Low-Income EE NEB Study (2010)	$5.25
Arrearage Carrying Cost	MD Empower Energy Efficiency NEBs (2014)	$5.50
Reduced Rate Subsidy	CA LI Public Purpose Test (2001)	$7.27

Transmission & Distribution Impacts

One of the reviewed studies (CA LI Public Purpose Test 2011) estimated NEIs related to transmission and distribution impacts. The study estimated these impact by multiplying the kWh savings by the utility avoided cost per kWh. However, the study recommended excluding the NEI because the energy savings incorporate these avoided costs.

Environmental – Avoided Emissions Impacts

Six of the reviewed studies estimated NEIs related to reduced emissions. The studies estimated impacts on NOx, SO2, CO2, PM2.5, and VOCs.

The studies estimated these impacts using the following approaches.

- Use of environmental adders per kwh saved.
- Estimates of emissions intensity and damage multiplied by program savings.
- Use of emissions rates from the EPA and marginal damage values from the Air Pollution Emission Experiments and Policy (APEEP) Model along with energy usage impact estimates.

- Use of the state-specific generation mix from fuel sources, the program-estimated energy savings, and emissions factors from eGRID, EPA, EIA, and the IPCC.
- Subtraction of RGGI price or other benefits already claimed

Environmental – Participant Valuation Impacts

Two of the reviewed studies estimated participant valuation of environmental benefits. The studies estimated these impacts using study-specific participant surveys where the participant valued the benefit relative to the energy savings from the program.

Table ES-10 summarizes the values for the estimates that were reviewed. The estimates for avoided air emissions ranged from $0 to $128 and the participant value of $4 to $22. These impacts are related to the effectiveness of the energy services and should be estimated for the particular program that is evaluated.

Table ES-10
Environmental Impacts from Weatherization

Weatherization Impact	Study	Annual Benefit Per Unit
Avoided Air Emissions	CA LI Public Purpose Test (2001)	$0.00
Avoided Air Emissions	CO Low-Income EE NEB Study (2010)	$3.49
Avoided Air Emissions	WI Low-Income Weatherization NEB (2005)	$128.35
Avoided Air Emissions per kWh	MD Empower Energy Efficiency NEBs (2014)	$0.011/kWh saved
Participant Value of Environmental Impact	WI Low-Income Weatherization NEB (2005)	$4-$6
Participant Value of Environmental Impact	CO Low-Income EE NEB Study (2010)	$21.67

Commercial & Industrial Impacts

The studies that were reviewed provided estimation of residential NEIs in the following categories.

- Economic
- Operations & Maintenance

Economic Impacts

Two of the reviewed C&I studies estimated NEIs related to economic impacts. The studies estimated impacts on jobs.

The studies estimated these impacts using the following approaches.

- Interviews and surveys where participants were asked to estimate the number of jobs created.
- Program tracking data and Department of Labor data and other organization data on jobs created.

- IMPLAN input-output modeling.

The economic impacts are presented in the residential section.

Operation & Maintenance Impacts
Five of the reviewed C&I studies estimated NEIs related to operation and maintenance costs. These following impacts were examined.
- Water Usage
- Operating Costs

The studies estimated these impacts using the following approaches.
- Engineering approach using water savings for the measure by the percent of participants who installed the measure.
- Engineering/life-cycle cost analysis was used to estimate the difference in the average annual life-cycle cost between the baseline and energy efficient technologies.
- Study-specific participant surveys where the participant valued the benefit relative to the energy savings from the program.
- Study-specific participant surveys where the participant provided data on the hours of maintenance required by the replaced measure and the energy-efficient measure.
- Using a Technical Reference Manual to estimate costs reduced from delamping, both lamps and labor.

Table ES-11 summarizes the values for the estimates that were reviewed. These impacts are related to the type of measures installed and should be estimated for the particular program that is evaluated.

Table ES-11
C&I Operation and Maintenance Impacts from Energy Efficiency

Impact	Study	Benefit
Custom Electric (Annual $/kWh or Therm)	MA C&I New Construction NEI (2016)	$0.0060/energy unit
Prescriptive Electric (Annual $/kWh or Therm)	MA C&I New Construction NEI (2016)	$0.0160/energy unit
Custom Gas (Annual $/kWh or Therm)	MA C&I New Construction NEI (2016)	$0.0050/energy unit
Prescriptive Gas (Annual $/kWh or Therm)	MA C&I New Construction NEI (2016)	$0.2350/energy unit
Operation & Maintenance	WA Operations Resource Assessment (2000)	$170,000 per participant
Avoided Replacement Lamp	Mid-Atlantic TRM 6.0 (2016)	$1.25 per lamp
Avoided Baseline Replacement Lamp	MD Empower Energy Efficiency NEBs (2014)	$6.39 per lamp

Findings and Recommendations

This study included Non-Energy Impact (NEI) research that was completed in 2000 or later with original research and calculation of NEI values. This review is important because it

provides information on the approaches used to measure NEIs, challenges and limitations of the various approaches, and the value ranges that have been estimated. The NEIs achieved are specific to the program design, measures, effectiveness, energy savings, characteristics of the jurisdiction, and characteristics of the population served. In most cases, original research needs to be conducted to provide a justifiable estimate of the NEIs for Connecticut's programs.

The findings from this review suggest the following areas that can most readily be applied to CT given the lower variability in the estimates. These are annual benefits per weatherized unit and apply to all weatherization programs with significant levels of air sealing and insulation.

- Noise Reduction Impacts: We recommend applying a value of $15 to noise.
- Comfort Impacts: We recommend applying a value of $35 for comfort.

The findings from this review suggest the following key areas for additional research and estimation.

- Medical and Health Impacts: There are many potential medical and health benefits that may arise from energy efficiency services in vulnerable low-income households. Because these benefits are sensitive to the population of customers served and the types of interventions, it is difficult to generally apply these findings to other jurisdictions. If CT's program is serving a population that has a high percentage of households with members who are vulnerable to health issues, CT should undertake pre and post-treatment survey research to estimate these benefits.

- Affordability Impacts: Low-income weatherization programs that provide significant reductions in energy usage may impact affordability for households who have difficulty with their energy bills. These impacts are related to the effectiveness of the weatherization services and should be estimated for the particular program that is evaluated. They can be estimated through analysis of collections data.

- Arrearage Carrying Cost Impacts: These should also be estimated through an analysis of customer balances and specific utility costs.

- Operations and Maintenance Impacts: These estimates are variable and will relate to the types and effectiveness of benefits delivered. They should be estimated directly for the program that is implemented.

- Water Usage Impacts: Water and sewer savings will vary depending on the measures installed and the costs for water and sewer. These costs have increased dramatically over the past few years in some jurisdictions. Therefore, these benefits should be estimated directly for the program based on estimated reduction in this usage and the local costs.

- Economic Impacts: There is a large range of estimates and these will vary depending on the level of the program investment, the types of investments, the amount invested in-state, and the multipliers for the state. Therefore, these should be estimated directly for the program based on local investments and economic multipliers.

- Environmental Impacts: These impacts are related to the effectiveness of the energy services and should be estimated for the particular program that is evaluated. They can be estimated based on the energy usage reductions for each fuel type and models that provide local valuation of these benefits based on population density.

The following benefits are difficult to estimate, do not appear to have large impacts, and should not be prioritized for analysis.

- Safety-Related Impacts
- Property Value Impacts

Additionally, more NEI research is needed to assess the findings summarized in this report and to further estimate the impact of energy efficiency on NEIs. Because the findings may be used in cost-effectiveness tests and impact the level of energy efficiency investments, it is critical to conduct additional studies that provide verification or refutation of these results. Such studies need to be clear about the methodology used, assumptions made, data sources employed, and limitations of the analyses.

NEIs are real and they can be significant. While it can be challenging to estimate and monetize these benefits, it is important to do so. Connecticut should use the information in this report as a starting point to assess the potential range of benefits that can be achieved, how to prioritize NEI research, and where adjustments should be made to cost-effectiveness testing. Additional steps in this research project include development of a database to provide easier comparison of methods and results, and assessment and implementation of adjustments to those estimates that allow for better application to Connecticut's energy efficiency programs.

I. Introduction

APPRISE is conducting a study for the Connecticut Energy Efficiency Board to assess how they may incorporate valuation of Non-Energy Impacts (NEIs) into their evaluations and cost-effectiveness analyses. This report is the first deliverable of the project and provides a review of the literature on NEIs.

Energy efficiency programs lead to substantial benefits beyond the energy and demand savings they achieve. These NEIs are important to understand and measure to effectively market the program to potential participants and to accurately conduct the benefit-cost analysis for the energy efficiency investments.

A. Study Design

The literature review addresses the challenge in this research area where studies point to previous studies (and those studies point to previous studies) that do not provide adequate documentation of the research methodology used to estimate the NEIs. This report provides a rigorous examination of the past studies to assess the specific models used and assumptions made.

This study included NEI research that was completed in 2000 or later and that included original research and calculation of NEI values. While there are hundreds of reports that cover the NEI topic, many of those reports are dated and most do not calculate benefits that are specific to the program and jurisdiction studied. Many reports are literature reviews and even of those that do quantify the benefits, they usually utilize estimates that were previously calculated in prior studies.

B. Purpose and Scope of this Report

This report provides a review of studies with original NEI calculation. Our review found 15 residential studies that provided original estimation of NEIs and seven commercial & industrial studies that provided such estimation. Many other papers were reviewed but were not included in this report because they did not include the estimation component with program-specific analyses.

Four sections follow this introduction.

- Section II: Studies Reviewed – This section of the report provides an overview of the residential and commercial and industrial NEI studies reviewed. A brief description of each study and its limitations is furnished.

- Section III: Residential Non-Energy Impacts – This section of the report provides a detailed description of the estimation methodology and results from residential NEI studies within each NEI category. The NEI categories are medical/health, safety, comfort, affordability, operation and maintenance, water usage, economic, property value, utility rates and arrearage reduction, transmission and distribution, environmental emissions, and participant valuation of environmental benefits.

- Section IV: Commercial and Industrial Non-Energy Impacts – This section of the report provides a detailed description of the estimation methodology and results from commercial and industrial NEI studies within each NEI category. The NEI categories are economic impacts and operations and maintenance.

- Section V: Findings and Recommendations – This section provides a summary of findings and recommendations.

APPRISE prepared this report under contract to Eversource and United Illuminating. Any errors or omissions in this report are the responsibility of APPRISE. Further, the statements, findings, conclusions, and recommendations are solely those of analysts from APPRISE and do not necessarily reflect the views of the Connecticut utilities.

II. Studies Reviewed

This section provides an overview of the residential non-energy impact (NEI) and commercial and industrial NEI studies reviewed. A brief description of the study and its limitations are included. The following section of this report discusses the approach and results for each NEI estimated in the reports.

A. Residential Studies Reviewed

The following residential non-energy impact (NEI) studies were reviewed.

1. Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study (Massachusetts)[1]
   This study estimated eight NEIs resulting from comprehensive low-income residential weatherization programs using the basic methodology and data from the National WAP Evaluation Occupant Survey, with updated methodology and input data specific to Massachusetts. Benefits associated with reduced asthma symptoms, reduced cold-related thermal stress, reduced heat-related thermal stress, fewer missed days at work, increased home productivity, reduced carbon monoxide poisoning, reduced home fires, and reduced use of short-term, high interest rate loans were estimated.

   Limitations of this study are described below.
   - An unmatched Pre- and Post-Weatherization Treatment Group from the National WAP Occupant Survey was used.
   - The differences-in-differences analysis method was not used despite the fact that there were Pre- and Post-Treatment results for the Treatment and Comparison Groups.
   - Most of the changes in outcomes that were valued were not statistically significant.
   - Not all calculations were shown. There was little detail on how benefits of reduced carbon monoxide poisoning and reduced home fires were calculated.

2. Residential and Low-Income Non-Energy Impacts Study (Massachusetts)[2]
   This study estimated NEIs resulting from low-income retrofit programs and residential retrofit and new construction programs. The study examined NEIs from multiple perspectives: utility, participant (both occupant and owner), and society. The study included an extensive literature review complemented by in-depth interviews with program managers, health and safety experts, and social service providers familiar with low-income weatherization programs. For some participant-perspective NEIs, occupant and owner surveys were conducted to elicit NEI values using a relative valuation methodology. Only the NEIs estimated directly by the authors, either via participant

[1] Beth Hawkins, Dr. Bruce Tonn, Erin Rose, Greg Clendenning, and Lauren Abraham (2016). Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by Three-Cubed and NMR Group, Inc. August 5, 2016.
[2] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

surveys or algorithms and data directly from the Program Administrators or specific to the program population, are included in this review.

Occupant surveys were conducted with 213 low-income households and 209 non-low-income households that participated in various programs offered by the PAs.

- The sample was developed from participants in MA low-income retrofit programs (single and multi-family programs), residential cooling and heating programs, residential heating and hot water programs, and non-low-income retrofit programs.
- The sample was divided into three strata representing homes retrofitted with shell measures (air sealing, insulation, and weatherization), or with heating/cooling system measures, or with shell measures plus heating/cooling system measures.
- Bill savings were estimated for each respondent in the sample, and respondents were asked to value NEIs relative to their estimated bill savings.
    - Bill savings were estimated using data from the Program Administrators on the estimated energy savings associated with each efficiency measure installed, and a population-weighted average of gas and electric rates reported by the Executive Office of Energy and Environmental Affairs of Massachusetts. Respondents were told what the typical annual energy bill savings were for households who installed the types of measures installed in their homes.
    - Respondents were asked if their home had a particular NEI, whether it was positive or negative, and how much value (positive or negative) they derived from the NEI, either in dollar terms or percent of bill savings.
    - NEI values for those who believed their home was no different than before were set to zero. NEIs for respondents who could not provide an estimate (even after prompting) were treated as missing.
- After responding to questions valuing individual NEIs, respondents were asked to assign an annual value to the total impact of all NEIs (with the exception of changes in property value). Each respondent's individual NEI values were then scaled in proportion to the total impact to account for overlap in NEIs and/or overestimation of individual NEIs.
- Outliers (cases that were at least three times the standard deviation of percent bill savings of the total scaled NEI value) were excluded.
- Results were weighted to strata and income group because program participants who received both shell measures and heating/cooling system measures were oversampled.
- Table II-1 displays the population size, the sample size, and the estimated average annual bill savings for each group.

Table II-1
MA Study Methodology

Income Group	Strata Measure Group	Population Size	Sample Size	Annual Savings for Relative Valuation
Low-Income	Heating & Cooling	1,087	72	$392
	Shell	869	72	$583

Income Group	Strata Measure Group	Population Size	Sample Size	Annual Savings for Relative Valuation
	Shell, Heating & Cooling	672	69	$445
	Total	2,628	213	$473
Non-Low-Income	Heating & Cooling	13,313	68	$347
	Shell	12,574	70	$380
	Shell, Heating & Cooling	944	71	$1,275
	Total	26,831	209	$673

Owner surveys were conducted with 21 owners and managers representing 27 low-income rental housing buildings from the population of 196 low-income rental housing buildings. The same basic methodology of revealed valuation from the occupant surveys was utilized in the owner surveys.

Limitations of this study are described below.

- Energy savings were used to estimate bill savings but it was not clear how the energy savings were estimated.
- Estimated bill savings used in the relative valuation of NEIs by survey respondents were not based on a pre/post utility billing analysis with a comparison group. In some cases, the estimated annual bill savings were quite high – the estimates ranged from a low of $3.15 to a high of $2,150.81 for low-income households, and $13.93 to $4,910.74 for non-low-income households. In no cases were the bill savings negative, which may not hold true had a billing analysis been conducted to estimate the bill savings.
- Some of the survey estimates were based on very small sample sizes. In particular, the NEIs for owners/managers of low-income multi-family rental housing were based on surveys conducted with 21 owners/managers of 27 buildings.

3. Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure (Massachusetts)[3]

   This study updated measure-level NEI values from the 2011 NMR[4] study for heating, cooling, and water heating system measures, to account for measures that were early replacement compared to replace on failure. Results were specific to non-low-income residential heating, cooling, and/or water heating equipment. The report does not adjust values for low-income residential measures because these were assumed to be early replacement.

[3] Greg Clendenning and Lauren Abraham (2013). Massachusetts Residential Non-Energy Impacts (NEIs): Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure. Memo by NMR Group, Inc. to Tetra Tech and National Grid. July 15, 2013.

[4] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

In combination with program data on the percent of program participants that replaced failed systems (by type of system), NEIs were adjusted by developing attribution factors to attribute the portion of each NEI that was due to the measure being energy-efficient (rather than the "newness" of the measure). The adjusted NEIs were thermal comfort, health benefits, quieter indoor environment, home durability, and property value increase. Further adjustments were made to thermal comfort and health benefits to account for potential "snapback" in usage, which was not accounted for in the initial revealed valuation study.

Limitations of this study are described below.

- There was a high degree of uncertainty in the initial estimates upon which these adjustments were based.
- The methodology for developing the energy efficiency attribution factors for each NEI value was not transparent. Attribution factors were developed by the authors using "professional judgment and the NEI literature."

4. The Low-Income Public Purpose Test (LIPPT) – Final Report – Updated for Version 2.0 (California)[5]

This early study created NEB estimation rationales, methodologies and estimates for an extensive array of NEBs from a combination of utility, third party and article sources as well as primary research. The calculation methods and values (updated) for many of the NEBs remain in use by later studies. This study examined NEIs from low-income energy efficiency programs in California. NEIs were valued using various methodologies. Some NEIs from the study were estimated based on a literature review and some were based upon new estimation of some model parameters. The NEIs that included new estimates and which are included in this literature review are transmission and distribution (T&D) losses, reduced utility rate subsidies, environmental/emissions reductions, health and safety improvements and reduction in carbon monoxide poisoning, transaction costs, property values, and hardship benefits.

Limitations of this study are described below.

- Program impacts for many parameters including energy savings, energy bill savings, percent of CO problems eliminated, and CFL transactions costs were not based on program impact data or it was not clear how they were derived.
- Input sources were not clearly documented (an accompanying "Program Assumptions" table and "Select Research Values" table were referenced but not included in the report).
- The report is old (2001), and input values based on cost data may not be representative of current conditions (e.g., measure costs, medical cost data, etc.).

[5] TecMarket Works, Skumatz Economic Research, and Megdal and Associates (2001). The Low-Income Public Purpose Test – Final Report – Updated for Version 2.0. Prepared for RRM Working Group, Cost Effectiveness Committee. May 25, 2001.

5. Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs[6]
   This study estimated the NEIs of utility arrearage reduction in low-income programs and avoided air emissions from all programs. The present value of arrearage reduction was estimated using energy saving results from an impact evaluation and an arrearage reduction value from a literature review. The present value of avoided air emissions was estimated by type of pollutant (CO2, SO2, NOx) using damage values published by government agencies (social cost of carbon and criteria pollutant damage values) and emissions intensity data from PJM.

   Limitations of this study are described below.
   - A literature review was used to estimate the arrearage reduction percentage.
   - Damage values for environmental impact may be outdated.

6. Mid-Atlantic Technical Reference Manual Version 6.0[7]
   This TRM estimated the operation and maintenance (O&M) cost savings from residential lighting measures using an engineering approach.

   Limitations of this study are described below.
   - Engineering estimates were used.
   - Installation rates were from a 2009 impact evaluations.

7. New Jersey Natural Gas 2015 SAVEGREEN Evaluation – Final Report[8]
   This study estimated environmental and economic NEIs from a Home Performance and a Heating and Water Heating Replacement Program through New Jersey Natural Gas's (NJNG) SAVEGREEN Project. The study also examined health and safety-related issues found during audits in the homes of program participants, but the study did not examine the program-induced change in H&S-related issues or monetize these impacts.

   Environmental impacts were estimated for the value of avoided air emissions (carbon dioxide (CO2), sulfur dioxide (SO2), nitrogen oxides (NOx), fine particulate matter (PM2.5), and volatile organic compounds (VOCs)). The value of avoided air emissions was estimated using program savings from an energy usage impact analysis (weather-normalized, comparison group adjusted) and air pollutant emissions rates and marginal damage values from published sources, discounted over the lifetime of the measures.

   Macroeconomic impacts (changes in output and employment) were estimated using the RIMS-II regional input-output model. These programs result in economic benefits by

[6] Itron, Inc. (2014). Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs. August 5, 2014.
[7] Shelter Analytics (2016). Mid-Atlantic Technical Reference Manual Version 6.0. Prepared for Northeast Energy Efficiency Partnerships, Inc. (NEEP) by Shelter Analytics. May 2016.
[8] APPRISE Incorporated (2015). New Jersey Natural Gas 2015 SAVEGREEN Evaluation Final Report. December 2015.

shifting expenditures from industries that have lower economic multipliers to industries that have higher economic multipliers.

- Program expenditures replaced general retail expenditures. The evaluation assumed that program expenditures replace retail purchases that otherwise would have been made in the absence of the program charges to ratepayers. These expenditures on energy upgrades created more economic activity than expenditures on retail goods.
- Retail expenditures replaced natural gas expenditures. The evaluation assumed that when natural gas costs declined as a result of the program, participants increased spending on retail goods. These expenditures on retail goods created more economic activity than expenditures on natural gas.

Limitations of this study are described below.

- Health and safety issues were identified in the homes of participants during audits, but the study does not examine any program-induced change in these safety issues.
- Marginal damage values used for environmental impacts may be outdated.
- RIMS II economic multipliers from the Bureau of Economic Analysis (BEA) were based on the 2002 Benchmark Input-Output Table for the nation and 2010 regional data, which may be outdated.

8. South Jersey Gas 2016 Energy Efficiency Program Evaluation Final Report (New Jersey)[9]
This study estimated environmental and economic NEIs from South Jersey Gas's (SJG) Residential HVAC Loan Program and Residential Home Performance with Energy Star Loan Program.

Environmental impacts were estimated for the value of avoided air emissions (carbon dioxide (CO2), sulfur dioxide (SO2), nitrogen oxides (NOx), fine particulate matter (PM2.5), and volatile organic compounds (VOCs)). The value of avoided air emissions was estimated using program savings from an energy usage impact analysis (weather-normalized, comparison group adjusted) and air pollutant emissions rates and marginal damage values from published sources, discounted over the lifetime of the measures.

Macroeconomic impacts (changes in output and employment) were estimated using the RIMS-II regional input-output model. These programs result in economic benefits by shifting expenditures from industries that have lower economic multipliers to industries that have higher economic multipliers.

- Program expenditures replaced general retail expenditures. The evaluation assumed that program expenditures replaced retail purchases that otherwise would have been made in the absence of the program charges to ratepayers. These expenditures on energy upgrades created more economic activity than expenditures on retail goods.
- Retail expenditures replaced natural gas expenditures. The evaluation assumed that when natural gas costs declined as a result of the program, participants increased

[9] APPRISE Incorporated (2016). South Jersey Gas 2016 Energy Efficiency Program Evaluation Final Report. August 2016.

spending on retail goods. These expenditures on retail goods created more economic activity than expenditures on natural gas.

Limitations of this study are described below.

- Marginal damage values used for environmental impacts may be outdated.
- RIMS II economic multipliers from the Bureau of Economic Analysis (BEA) were based on the 2007 Benchmark Input-Output Table for the nation and 2013 regional data, and may also be outdated.

9. Ohio REACH Final Evaluation Report[10]

This study estimated the impact of a comprehensive low-income weatherization program that provided additional health and safety-related measures to at-risk households on health and safety issues. The additional health and safety measures included structural improvements, gutter/downspout repair and grading, environmental cleaning and extermination, and mold and moisture remediation.

A pre/post survey was conducted with participants and non-participants (i.e., those who did not receive program services) to identify basic healthy home issues.

- The study achieved an 86 percent response rate.
- There were 93 treatment surveys and 59 comparison group surveys completed.

A differences-in-differences analysis was conducted, taking the net difference between the participant group and non-participant group, to assess the change induced by the program.

The study authors attempted to conduct pre-treatment surveys with all clients prior to the delivery of any program services. Managers at the service-delivery agencies sent the researchers the clients who were prescreened for services, the pre-treatment survey was conducted, and then the study authors informed the agencies that the clients had been surveyed so that program service delivery could begin. Post-surveys were conducted with clients one year later, whether or not they had been treated by the program. Those who had not been treated by the program represent the non-participant comparison group for the difference-in-difference analysis. Because home conditions are related to the weather and the time of the year, these surveys were conducted at approximately the same time of the year.

Limitations of this study are described below.

- The comparison group was comprised of clients who did not receive services, so they may differ in important ways from the treatment group.
- While this study estimates the program-induced changes in H&S issues in the home, it does not monetize the impacts.

[10] APPRISE Incorporated (2010). Ohio Residential Energy Assistance Challenge Option Program (REACH) Final Evaluation Report. June 2010.

10. Ohio EPP Process Evaluation Final Report[11]
This study estimated the net economic impact of the Electric Partnership Program (EPP) for low-income customers in Ohio. The goal of the Ohio EPP is to reduce electricity energy consumption of households enrolled in the Ohio Percentage of Income Payment Program (PIPP). To accomplish these goals, the EPP provides cost-effective energy saving measures and energy education that vary with the customer's usage and payment. Three levels of service were provided for energy saving measures based on the customer's electric usage.

Economic impacts resulting from program spending and program net benefits were estimated using multipliers based on a review of the literature. Because not all program spending occurred within Ohio, the amount of program spending inside and outside of the state was estimated for each category of spending to determine the net impact on output and employment. Estimates of lifetime savings and program net benefits were used to estimate the net impact on output resulting from program benefits.

Limitations of this study are described below.
- An input-output model was not used. Multipliers were based on a literature review of other input-output economic studies in Ohio.
- Multipliers from the literature review may be outdated.

11. Assessment of Energy and Cost Savings for Homes Treated Under Wisconsin's Home Energy Plus Weatherization Program[12]
This study described a cost savings methodology for water conservation measures (low-flow showerheads and faucet aerators) by applying a representative water and sewer rate to typical water savings based on an engineering approach. The representative water and sewer rate was derived from a public data source on water and sewer rates in Wisconsin, and it represents the median value for about 400 municipalities in Wisconsin. Other inputs were based on assumptions about the typical household participating in the program, however, sources were not specified. Equations were not provided, making it unclear exactly what was represented by the estimated value for water conservation measures.

Limitations of this study are described below.
- An engineering approach was used and assumptions were made regarding the inputs.
- There were missing inputs and equations.

[11] APPRISE Incorporated (2003). Ohio EPP Process Evaluation Final Report. October 2003.
[12] Keene, Pigg, and Parkhurst (2017). Assessment of Energy and Cost Savings for Homes Treated under Wisconsin's Home Energy Plus Weatherization Program. Prepared for Wisconsin Department of Administration, Division of Energy, Housing and Community Resources. Research by Seventhwave. Submitted by Wisconsin Energy Conservation Corporation. March 24, 2017.

12. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report[13]

This study estimated NEIs in several categories using various methods.

- Economic impacts were calculated using an input-output model and multipliers for output, labor income, and employment impacts.
- Environmental benefits were calculated using emissions rate data from Wisconsin, avoided emissions resulting from the program, and values of avoided emissions from literature.
- Water bill savings using research from the water conservation literature and "Water Plan" model, and a survey of ten indicator communities in the State of Wisconsin.
- Additional participant savings using a participant survey and revealed valuation methodology.

The participant survey was conducted with a random sample of participants from Wisconsin's 2015 low-income weatherization program. The sample was stratified by region and housing unit type. A total of 362 program participants completed the survey with an overall response rate of 44 percent.

Respondents were asked to value NEIs relative to their perception of energy savings resulting from the program (it was unclear if respondents were provided with an estimate of their energy savings, either based on a billing analysis or other methods, or if respondents had to conceptualize the potential energy savings on their own). The NEIs included health and safety-related impacts, affordability, property value, operation and maintenance expenditures, environmental, and water use. Respondents were asked if there was an impact (positive or negative) from each category. As a follow-up, respondents were asked how valuable (positive or negative) the impact was. Respondents were also asked to value the total NEI from the program.

- For each category of NEI, the average share of the participant NEIs was estimated by translating responses into numeric multipliers and averaging across respondents.
- Dollar values were estimated by translating responses on how much more or less valuable participants stated the total of all NEIs were in comparison to estimated energy savings. Average multipliers were computed, and these energy savings multipliers were then applied to the average energy savings for the program ($220) to compute the total value of the participant NEIs.
- The average energy savings from the program were based on a billing analysis. It was not stated whether a comparison group was used in the billing analysis.
- The study estimated that the total participant NEI value was between $268 and $344 per year per participant, based on relative verbal scaling and self-reported percentages, respectively.

[13] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.

- Dollar values were estimated for individual categories of NEIs by applying the average share of the participant NEIs to the dollar estimate for the total participant NEI.

Limitations of this study are described below.

- Potential for double-counting benefits. In the participant survey, the study authors estimated the water bill cost savings to participants and included this in the "Total Participant" NEI value. However, the study authors also estimated water bill cost savings using a separate methodology.
- Economic benefits were annualized over the estimated 15-year measure lifetime of the program but no discounting was done.
- The damage values for estimating benefits of avoided emissions were an average of values found in the literature multiplied by a factor.

13. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[14]

This study estimated NEIs resulting from Xcel Energy's low-income energy efficiency programs in Colorado. NEIs were estimated for each program (Energy Savings Kits, Multifamily Weatherization, Non-Profit Energy Efficiency, and Single-Family Weatherization) and by fuel type (electric and natural gas). Various methods were used to estimate NEIs from the utility, societal, and participant perspectives. An overview of the methods used to estimate NEIs is provided below.

- Program data were used to estimate the program-induced change and monetize impacts related to arrearage values, customer contacts, power shutoffs, power reconnections, and write-offs.
  - Data for program participants were collected from the utility, which provided up to a year of "pre" data and several months of "post" data.
  - The "pre" and "post" data were averaged to simulate a year pre/post program participation.
- Input-output modeling was used to estimate the economic impacts of the programs.
- In-house modeling was used to estimate the emissions/environmental impacts of the programs.
- A participant survey was used to estimate participant effects related to health and safety, comfort, appliance function, hardship, neighborhood values, water bills, knowledge and comfort, environment, productivity, and other impacts. Samples of participants were selected from each program and sent postcards to participate in an internet survey. The following table provides the population, sample sizes, and number of respondents to the participant survey by program.

[14] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.

Table II-2
CO Study Methodology

Program	Total Participants	Survey Sample Size	Number of Respondents	Estimated Energy Savings
Energy Savings Kits	36,094	4,000	266	$40.60
Multifamily Wx	1,294	1,294	65	$260.40
Non-Profit Energy Efficiency	11	11	11	$2,655.40
Single-Family Wx	1,950	1,950	149	$238.30

The study authors recommended that Xcel Energy replace existing NEI multipliers with the new values from the study. The study authors recommended adopting all of the utility NEIs, and half of the societal and participant NEIs for cost-effectiveness testing. They stated that they some categories of the NEIs have shorter histories or regulators or other have less confidence in (newer modeling, more survey-based, etc.)

Limitations of this study are described below.

- The participant survey had a very low response rate given the large number invited to participate and the small number of responses. It was not clear that the respondents were representative of the population.
- The arrearage analysis used the gross impact. The study authors attempted to conduct a difference-in-difference analysis using a comparison group of customers who received an energy assistance grant but not energy efficiency services, but the "pre" values and "post" values for the comparison group were "significantly different from the values for the participants [and] the net impacts…were therefore, regarded as meaningless."
- The "pre" and "post" data for the arrearage analysis were averaged to simulate a year of pre-program participation and a year of post-program participation. However, the "pre" and "post" data that were averaged may not represent the same time period since the utility provided "up to a year" of "pre" data and "several months" of "post" data.
- Values from the literature were used to replace certain impacts unavailable from the program data provided by the utility. For example, it was too soon after the program's implementation to assess program data on write-offs, so values from the literature regarding utility write-offs were used in place of program data.

14. Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report[15]
This study estimated the job impacts from NYSERDA's Green Jobs Green New York (GJGNY) Program, a multifaceted program that includes Workforce Development and Training, Outreach and Marketing activities, and Residential (Home Performance with Energy Star and Multifamily Performance Program) and Commercial (Small Commercial

[15] Rohit Vaidya and Beth Poulin (2013). Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by NMR Group, Inc. November 2013.

Energy Efficiency) programs. In-depth interviews and surveys were conducted with program partners, trade ally groups, and other organizations involved in GJGNY to assess job impacts overall and by program initiative. Secondary data were obtained from NYSERDA, NYS Department of Labor, and Constituency-Based Organizations (CBOs) program records. Results from this study (Phase 1) were used to inform ICF's economic impact analysis (Phase 2) of the GJGNY Program.[16]

Job impacts of the GJGNY Program were estimated in full-time equivalents (FTEs) jobs. Estimates are provided for the state, sub-state region, NAICS code, and by GJGNY Program/Activity.

Limitations of this study are described below.

- The estimated 2015 Direct FTEs includes projections by survey respondents. The study noted that projections were much higher than job impacts reported to-date by respondents.
- The study noted that there may be some overlap in the trainee FTEs reported by Community-Based Organizations (CBOs) or Workforce Development (WFD) partners and other GJGNY program partners such as HPwES contractors.
- The study noted that wage data was difficult to obtain from respondents during interviews and surveys, and recommended improved tracking of pre- and post-training wage data to produce more reliable analysis of the wage impact of GJGNY program training efforts.

15. Economic Impacts of Green Jobs Green New York (GJGNY) Program Report[17]
This study estimates the total economic impact of the GJGNY Program in New York.[18] GJGNY is a multifaceted program that includes Workforce Development and Training, Outreach and Marketing activities, and Residential (Home Performance with Energy Star and Multifamily Performance Program) and Commercial (Small Commercial Energy Efficiency) programs. This study estimated the economic impact of the GJGNY Program overall, without distinguishing between program activities. Results from this study are provided in the Residential Impacts section of this report but could be included under Commercial & Industrial since the GJGNY Program includes a commercial program and other activities that are cross-cutting and not specific to residential programs.
The study used the IMPLAN Version 3.0 input-output model, created and maintained by the Minnesota IMPLAN Group (MIG), to conduct the economic impact analysis. Using estimates of the direct GJGNY-related jobs and labor income by industry and job category

[16] Elizabeth Johnston, Federico Garcia, and Daniel Vickery (2013). Economic Impacts of Green Jobs Green New York (GJGNY) Program Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by ICF International, Inc. November 2013.
[17] Elizabeth Johnston, Federico Garcia, and Daniel Vickery (2013). Economic Impacts of Green Jobs Green New York (GJGNY) Program Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by ICF International, Inc. November 2013.
[18] Rohit Vaidya and Beth Poulin (2013). Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by NMR Group, Inc. November 2013.

from Phase I of the research, this study estimated program-generated job opportunities in industries that sell and buy to the sectors directly impacted by the program (i.e., indirect effects) as well as in consumer goods and services industries (i.e., induced effects).

In addition to the limitations noted for Phase I of the research for the GJGNY Program, limitations of this study are described below.

- The study only examines gross impact. The study does not subtract the potential impact of alternative spending of the GJGNY funds.
- Impacts are not broken down by program component (e.g., HPwES Program, Multifamily Performance Program, Small Commercial Energy Efficiency Program, training, or marketing).

B. Commercial & Industrial Studies Reviewed

The following commercial & industrial NEI studies were reviewed.

1. Stage 2 Results – Commercial and Industrial New Construction Non-Energy Impacts Study – Final Report (Massachusetts)[19]
   This study estimated operating cost NEIs resulting from prescriptive and custom electric and gas commercial and industrial (C&I) new construction (NC) projects in Massachusetts. Stage 1 of this study found that self-reported NEIs for NC projects were unreliable; therefore, Stage 2 of this study estimated operational cost changes using an engineering/life-cycle cost analysis methodology for sampled measures from NC projects.

   Limitations of this study are described below.
   - Because project documentation was unavailable for some measures, the actual baseline could not be established and was assumed based on available resources instead (e.g., TRM).
   - Estimates for several measures categories were not statistically significant, but the study recommended including these NEIs in benefit-cost models.

2. Final Report – Commercial and Industrial Non-Energy Impacts Study (Massachusetts)[20]
   This study estimated NEIs resulting from prescriptive and custom electric and gas commercial and industrial (C&I) retrofit projects in Massachusetts. Structured in-depth interviews were conducted by telephone with participants from program year 2010 C&I custom and prescriptive energy efficiency programs. Results were presented as a total NEI value for each measure category as opposed to NEI values for each type of NEI.

   Limitations of this study are described below.
   - Self-reported data on NEI values by survey respondents.

[19] DNV GL (2016). Stage 2 Results – Commercial and Industrial New Construction Non-Energy Impacts Study – Final Report. Prepared by DNV GL for the Massachusetts Electric and Gas Program Administrators. March 24, 2016.

[20] Tetra Tech & DNV GL (2012). Final Report – Commercial and Industrial Non-Energy Impacts Study. Prepared by Tetra Tech and DNV GL for Massachusetts Program Administrators. June 29, 2012.

- While the survey took several measures to reduce missing values among survey respondents (e.g., by using a structured in-depth interview format with probes), data imputations were still performed for several respondents; there were non-trivial differences between the results with imputed data and results without imputed data, but the study suggested adopting the values with imputed data.
- There was potential for self-selection bias in the sample. The sample was constructed mostly of program participants who completed a previous survey on free-ridership and spillover.
- Computation of total NEIs using ratio estimates to extrapolate measure-level NEIs to the population of measures.

3. Operations Resource Assessment Service: Process and Impact Evaluation (Washington)[21]
   This study assessed NEIs using a participant survey and engineering estimates approach. To characterize the value of certain NEIs, the study used a modified "willingness to pay" approach to value NEIs relative to the energy savings expected from the program. Participants were asked to enumerate the NEIs they recognized from the measures they implemented, then asked whether they valued these benefits more than or less than the bill savings from that measure, and by how much. These multipliers were then used to estimate the value of the NEIs. An engineering estimates approach was used to estimate the water savings attributable to the program.

   Limitations of this study are described below.
   - Engineering estimates were used for water savings.

4. Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs[22]
   This study estimated the operation and maintenance (O&M) benefits from the EmPOWER C&I Prescriptive and Small Business Direct Install (SBDI) programs. Values were estimated from the bottom-up using an engineering approach for the O&M benefits associated with lighting measures. Data limitations precluded estimation of some other O&M benefits and the study chose not to use other O&M benefits from HVAC and Variable Frequency Drive (VFD) measures commonly cited in the literature for the following reasons.
   - It is difficult to distinguish between a retrofit HVAC unit and unit that is replaced on failure, and it is unclear how a new energy efficient HVAC unit would incur significantly lower O&M costs than a standard efficiency unit. However, the authors noted that O&M cost savings of HVAC measures were worthy of further consideration in the future.

[21] Ben Coates, Dennis Pearson, and Lisa Skumatz (2000). Operations Resource Assessment Service: Process and Impact Evaluation. Prepared by Seattle City Light Evaluation Unit, Energy Management Services Division, and Skumatz Economic Research Associates. May 2000.
[22] Itron, Inc. (2014). Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs. August 5, 2014.

- There were no quantitative estimates of the O&M impacts associated with VFDs available, and the authors could conceptualize both O&M cost savings and new O&M costs incurred through installation of VFDs. Because the advantages of energy savings and improved process control were expected to far outweigh O&M benefits or costs from VFDs, these were excluded, but the authors noted that O&M cost savings of VFDs were worthy of further consideration in the future.

Limitations of this study are described below.

- Engineering estimates, including assumptions regarding labor hours, baseline and measure costs.

5. Mid-Atlantic Technical Reference Manual Version 6.0[23]
This TRM estimated the operation and maintenance (O&M) cost savings from C&I lighting measures, including permanently de-lamping fixtures (removing the lamp and associated electrical sockets from a fixture). An engineering approach was used to estimate the cost savings.

Limitations of this study are described below.

- Engineering estimates, including assumptions regarding labor hours, baseline and measure cost.

6. Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report[24]
This study estimated the job impacts from NYSERDA's Green Jobs Green New York (GJGNY) Program, a multifaceted program that includes Workforce Development and Training, Outreach and Marketing activities, and Residential (Home Performance with Energy Star and Multifamily Performance Program) and Commercial (Small Commercial Energy Efficiency) programs. In-depth interviews and surveys were conducted with program partners, trade ally groups, and other organizations involved in GJGNY to assess job impacts overall and by program initiative. Secondary data were obtained from NYSERDA, NYS Department of Labor, and Constituency-Based Organizations (CBOs) program records. Results from this study (Phase 1) were used to inform ICF's economic impact analysis (Phase 2) of the GJGNY Program.[25]

Job impacts of the GJGNY Program were estimated in full-time equivalents (FTEs) jobs. Estimates are provided for the state, sub-state region, NAICS code, and by GJGNY Program/Activity.

[23] Shelter Analytics (2016). Mid-Atlantic Technical Reference Manual Version 6.0. Prepared for Northeast Energy Efficiency Partnerships, Inc. (NEEP) by Shelter Analytics. May 2016.
[24] Rohit Vaidya and Beth Poulin (2013). Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by NMR Group, Inc. November 2013.
[25] Elizabeth Johnston, Federico Garcia, and Daniel Vickery (2013). Economic Impacts of Green Jobs Green New York (GJGNY) Program Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by ICF International, Inc. November 2013.

Limitations of this study are described below.

- The estimated 2015 Direct FTEs includes projections by survey respondents. The study noted that projections were much higher than job impacts reported to-date by respondents.
- The study noted that there may be some overlap in the trainee FTEs reported by Community-Based Organizations (CBOs) or Workforce Development (WFD) partners and other GJGNY program partners such as HPwES contractors.
- The study noted that wage data was difficult to obtain from respondents during interviews and surveys, and recommended improved tracking of pre- and post-training wage data to produce more reliable analysis of the wage impact of GJGNY program training efforts.

7. Economic Impacts of Green Jobs Green New York (GJGNY) Program Report[26]
This study estimates the total economic impact of the GJGNY Program in New York.[27] GJGNY is a multifaceted program that includes Workforce Development and Training, Outreach and Marketing activities, and Residential (Home Performance with Energy Star and Multifamily Performance Program) and Commercial (Small Commercial Energy Efficiency) programs. This study estimated the economic impact of the GJGNY Program overall, without distinguishing between program activities; results from this study are provided in the Residential Impacts section of this report but could be included under Commercial & Industrial since the GJGNY Program includes a commercial program and other activities that are cross-cutting and not specific to residential programs.

The study used the IMPLAN Version 3.0 input-output model, created and maintained by the Minnesota IMPLAN Group (MIG), to conduct the economic impact analysis. Using estimates of the direct GJGNY-related jobs and labor income by industry and job category from Phase I of the research, this study estimated program-generated job opportunities in industries that sell and buy to the sectors directly impacted by the program (i.e., indirect effects) as well as in consumer goods and services industries (i.e., induced effects).

In addition to the limitations noted for Phase I of the research for the GJGNY Program, limitations of this study are described below.

- The study only examines gross impact. The study does not subtract the potential impact of alternative spending of the GJGNY funds.
- Impacts are not broken down by program component (e.g., HPwES Program, Multifamily Performance Program, Small Commercial Energy Efficiency Program, training, or marketing).

[26] Elizabeth Johnston, Federico Garcia, and Daniel Vickery (2013). Economic Impacts of Green Jobs Green New York (GJGNY) Program Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by ICF International, Inc. November 2013.

[27] Rohit Vaidya and Beth Poulin (2013). Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by NMR Group, Inc. November 2013.

III. Residential Non-Energy Impacts

The studies that were reviewed provided estimation of residential NEIs in the following categories.

- Medical/Health
- Safety
- Comfort
- Affordability
- Operation & Maintenance Costs
- Water Usage
- Economic
- Property Value
- Utility Rates and Arrearage Reduction
- Transmission & Distribution
- Environmental – Avoided Emissions
- Environmental – Participant Valuation

Within each section we list the studies that estimate that type of benefit and then provide a detailed description of the estimation methodology and results.

A. Medical Impacts

The following studies estimated health-related impacts.

1. Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study (Massachusetts)[28]
2. Residential and Low-Income Non-Energy Impacts Study (Massachusetts)[29]
3. Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure (Massachusetts)[30]
4. Ohio REACH Final Evaluation Report[31]
5. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report[32]

[28] Hawkins, Tonn, Rose, Clendenning, and Abraham (2016). Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by Three-Cubed and NMR Group, Inc. August 5, 2016.

[29] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

[30] Clendenning and Abraham (2013). Massachusetts Residential Non-Energy Impacts (NEIs): Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure. Memo by NMR Group, Inc. to Tetra Tech and National Grid. July 15, 2013.

[31] APPRISE Incorporated (2010). Ohio Residential Energy Assistance Challenge Option Program (REACH) Final Evaluation Report. June 2010.

[32] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.

6. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[33]

Below we describe the methodology and results for these NEI estimates.

1. Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study (Massachusetts)[34]
   Changes in these health-related outcomes were assessed using data from the National WAP Evaluation Occupant Survey (data from the national sample for asthma; data from the cold climate region for thermal stress and missed work days), supplemented with other data sources and general methodology used in the National WAP Evaluation to monetize the benefits of these health-related impacts.

   The table below provides the estimated health-related benefits of the program, overall and broken down by asthma, cold-related thermal stress, heat-related thermal stress, and missed days of work. The study recommended adopting the household annual benefits for each health-related impact. The general methodologies used to estimate these benefits are described following the table.

Table III-1
MA Low-Income Study NEI Estimates

Health-Related Impact	Annual Benefit ($/Unit Weatherized)		
	Household	Societal	Total
Asthma	$9.99	$322.01	$332.00
Cold-Related Thermal Stress	$463.21	$33.73	$496.94
Heat-Related Thermal Stress	$145.93	$27.00	$172.93
Missed Days of Work	$149.45	$37.36	$186.81
Total Health-Related Impacts	**$768.58**	**$420.10**	**$1,188.68**

   Asthma Treatment and Costs
   The following methodology was used to estimate the program impact on asthma and monetize the impact.
   - Benefits per Year per Unit Weatherized = reduction in asthma-related emergency department (ED) visits + reduction in asthma-related adult and child hospitalizations + reduction in high-cost asthma patients

[33] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.
[34] Hawkins, Tonn, Rose, Clendenning, and Abraham (2016). Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by Three-Cubed and NMR Group, Inc. August 5, 2016.

- Benefit of reduced asthma-related ED visits = (Number of reduced asthma-related ED visits per 1,000 units=54.6[35] * frequency of re-admittance=1[36] * average hospital cost for asthma-related ED visits for all individuals=$1,503[37]) / 1,000 units
  = $82 per year per unit weatherized
  - Reduction in asthma-related ED visits = 11.5% (statistically significant at 95% confidence level)[38]
  - Adult prevalence of asthma = 16.8%[39]
  - Child prevalence of asthma = 10.1% (poor white children); 16.0% (poor non-Hispanic black children)[40]
  - Demographics of WAP population receiving services = 19% non-Hispanic black and 81% other[41]

- Benefit of reduced asthma-related adult hospitalizations = (# of reduced asthma-related adult hospitalizations per 1,000 units=9.9[42] * frequency of re-admittance=1 * average hospital cost for adult asthma-related hospitalization=$8,381[43]) / 1,000 units
  = $82 per year per unit weatherized

- Benefit of reduced asthma-related child hospitalizations = # of reduced asthma-related child hospitalizations per 1,000 units=4.2[44] * frequency of re-admittance=1 * average hospital cost for child asthma-related hospitalization=$7,569[45]/1000
  = $32 per year per unit weatherized
  - Reduction in asthma-related hospitalizations = 3.1% (not statistically significant)[46]

- Benefit of reduction in high-cost asthma patients = # of persons served by WAP in PY 2008 * asthma prevalence for adults and children * reduction in high-cost patients=11.8% not statistically significant[47] * difference in high- and low-cost patients after extracting the ED visit, hospitalization, and indirect costs already claimed=$3,221[48]
  = $137 per year per unit weatherized.49

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[35] This cannot be calculated from data provided in the report.
[36] Estimate; no source.
[37] Massachusetts Center for Health Information and Analysis.
[38] National WAP Occupant Survey.
[39] National WAP Occupant Survey.
[40] Based on national statistics; source unnamed.
[41] National WAP Occupants Survey.
[42] This cannot be calculated from data provided in the report.
[43] Massachusetts Center for Health Information and Analysis.
[44] This cannot be calculated from data provided in the report.
[45] Massachusetts Center for Health Information and Analysis.
[46] National WAP Occupant Survey.
[47] National WAP Occupant Survey.
[48] National WAP Occupant Survey.
[49] This cannot be calculated from data provided in the report.

- Total Household Benefit = Total Benefit=$332 per year per unit weatherized * factor for out-of-pocket medical expenses=43%[50] * factor for privately-insured or uninsured households 7%[51]
  = $9.99 per year per unit weatherized.

Cold-Related Thermal Stress

The following methodology was used to estimate the program impact on cold-related thermal stress.

- Types of treatment: a = hospitalization, b = ED visit, c = physician office visit
- Medical coverage types: p1 = Medicare, p2 = Medicaid, p1 = Private/Other, p1 = Uninsured (i.e., OOP)

- Eq. 1: # Treatments Avoided (a, b, c) = # of WAP units completed in PY 2008 * decreased rate of seeking medical care * % of type of medical treatment sought for cold and heat-related thermal stress (a, b, c)
- Eq. 2: % of Annual Medical Costs (p1, p2, p3, p4) for WAP population (a, b, c) = (% of WAP population by medical coverage type * % of medical costs by payer for U.S. population)/ (% of U.S. population by medical coverage type)
- Eq. 3: Benefit = Eq. 1 * Eq. 2 * Average cost for treatment (a, b, c)
- Eq. 4: # avoided deaths = % of hospitalizations resulting in deaths (U.S. population) * # of hospitalizations prevented by WAP in PY 2008
- Eq. 5: Total Benefit (including avoided deaths) = Eq. 4 * VSL
- Eq. 6: % Reduction in Thermal Stress = decreased rate of seeking medical care due to weatherization (Cold Climate Zone) * % of hospitalizations sought for cold-related thermal stress (national rate) * % of hospitalizations from thermal stress resulting in deaths (national rate)

Using data from the National WAP Occupant Survey and national statistics, the authors estimated the total household benefit of reduced cold-related thermal stress as follows.

- Total household benefit of reduced cold-related thermal stress = [Total household benefit (excluding avoided deaths)=$4.67] + [Household benefit of avoided deaths due to cold-related thermal stress=$458.64]
  = $463.31 per year per unit weatherized

- Total household benefit (excluding avoided deaths) due to cold-related thermal stress = [Household benefit for reduced hospitalizations=$1.72] + [Household benefit for reduced ED visits=$2.65] + [Household benefit for reduced physician office visits=$0.30]
  = $4.67 per year per unit weatherized

[50] Healthy Policy Commission (HPC) (2014). 2014 Cost Trends Report. Boston, MA; http://www.mass.gov/anf/budget-taxes-and-procurement/oversight-agencies/health-policy-commission/2014-cost-trends-report.pdf

[51] Healthy Policy Commission (HPC) (2014). 2014 Cost Trends Report. Boston, MA; http://www.mass.gov/anf/budget-taxes-and-procurement/oversight-agencies/health-policy-commission/2014-cost-trends-report.pdf

- Household benefit of avoided deaths due to cold-related thermal stress = [Rate of reduction in cold-related thermal stress death=0.0047724%] * [Value of Statistical Life (VSL)=$9.6 million[52]]
  = $458.54 per year per unit weatherized

- Rate of reduction in cold-related thermal stress deaths = [Decreased rate of seeking medical care due to cold-related thermal stress (cold climate region)=1.9%[53]] * [% of hospitalizations sought for cold-related thermal stress (national rate)=10%[54]] * [% of hospitalizations from cold-related thermal stress resulting in death (national rate)=2.5%[55]]
  = 0.0047724%

Heat-Related Thermal Stress

The same methodology used to estimate the program impact on cold-related thermal stress was used to estimate the program impact on heat-related thermal stress. Using data from the National WAP Occupant Survey and national statistics, the authors estimated the total household benefit of reduced heat-related thermal stress as follows.

- Total household benefit of reduced heat-related thermal stress = [Total household benefit (excluding avoided deaths)=$8.28] + [Household benefit of avoided deaths due to heat-related thermal stress=$137.65]
  = $145.93 per year per unit weatherized

- Total household benefit (excluding avoided deaths) due to heat-related thermal stress = [Household benefit for reduced hospitalizations=$7.62] + [Household benefit for reduced ED visits=$0.56] + [Household benefit for reduced physician office visits=$0.10]
  = $8.28 per year per unit weatherized

- Household benefit of avoided deaths due to heat-related thermal stress = [Rate of reduction in heat-related thermal stress death =0.00143382%] * [Value of Statistical Life (VSL) = $9.6 million]
  = $137.65 per year per unit weatherized

- Rate of reduction in heat-related thermal stress deaths = [Decreased rate of seeking medical care due to heat-related thermal stress (cold climate region)=2.8%[56]] * [% of

[52] VSL of $9.6 million (2016 dollars) from U.S. Department of Transportation memo: *Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in U.S. Department of Transportation Analyses.*
[53] National WAP Occupant Survey, data for cold climate region.
[54] Data for 2008 mined by authors from Medical Expenditure Panel Survey (MEPS) and the Healthcare Cost and Utilization Project (HCUO) databases: http://meps.ahrq.gov/mepsweb/ and http://www.ahrq.gov/research/index.html
[55] Data for 2013 mined by authors from Medical Expenditure Panel Survey (MEPS) and the Healthcare Cost and Utilization Project (HCUO) databases: http://meps.ahrq.gov/mepsweb/ and http://www.ahrq.gov/research/index.html
[56] National WAP Occupant survey, data for cold climate region

hospitalizations sought for heat-related thermal stress (national rate)=4%[57]] * [% of hospitalizations from heat-related thermal stress resulting in death (national rate)=1.28%[58]]
= 0.00143382%

Missed Days of Work

The following methodology was used to estimate the program impact on missed days of work and monetize the impact.

- Total benefit = [% of WAP households with an unemployed primary wage earner=34%[59]] * [Reduction in missed days of work=4.0[60]] * [Average hourly wage in MA=$17.17[61]] * [8 hours/day]
  = $186.81 per year per unit weatherized

- Total household benefit = [Total benefit] * [% of low-income workers without sick leave=80%[62]]
  = $149.45 per year per unit weatherized

2. Residential and Low-Income Non-Energy Impacts Study (Massachusetts).[63]

This study estimated health-related impacts for low-income and non-low-income program participants using a participant survey. Participants were asked if they experienced any of the following health impacts, either positive (improved) or negative (declining).

- Health, general
- Health, asthma or other chronic health condition
- Health, colds and flu

Respondents were then asked more detailed questions about the impact of the program on their health. This included estimating the monetary value of these health-related impacts either directly in dollars per year or as a percentage of the estimated energy bill savings the measures they installed typically achieved. Responses to the health-related questions (general, asthma/chronic conditions, and colds/flu) were combined and results presented as an overall health-related impact.

After removing outliers, the sample from which health-related impacts were estimated was 195 low-income households and 176 non-low-income households. Estimates of

[57] Data for 2008 mined by authors from Medical Expenditure Panel Survey (MEPS) and the Healthcare Cost and Utilization Project (HCUO) databases: http://meps.ahrq.gov/mepsweb/ and http://www.ahrq.gov/research/index.html
[58] Data for 2013 mined by authors from Medical Expenditure Panel Survey (MEPS) and the Healthcare Cost and Utilization Project (HCUO) databases: http://meps.ahrq.gov/mepsweb/ and http://www.ahrq.gov/research/index.html
[59] National WAP Occupant Survey; unclear if national sample or cold climate region subsample.
[60] National WAP Occupant survey, data for cold climate region.
[61] 2014 wage data for renters in Massachusetts. Source not provided
[62] National Partnership, http://www.nationalpartnership.org; webpage referenced by authors not found
[63] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

health-related impacts were scaled to the respondent's estimate of the value of the total NEI of participating in the program.

- Health-related benefit (general, asthma/chronic, and cold/flu) per year per low-income (LI) participant = $19, or 4% of bill savings ($5 to $33, or 1% to 5% of bill savings, at 90% confidence level)

  Note: In their review of the primary research done by Three-Cubed (2016), the authors of this study (NMR Group) recommended replacing the estimate of $19 per year per low-income household for health-related impacts with the health-related impacts listed in the Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study (Massachusetts).[64]

- Health-related benefit (general, asthma/chronic, and cold/flu) per year per Non-Low-Income (NLI) Participant in Retrofit Program = $4, or 3% of bill savings (-$3 to $12, or 1% to 4% of bill savings, at 90% confidence level)

3. <u>Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure (Massachusetts)</u>[65]

   This study updated previous estimates of health-related impacts by the authors (NMR 2011)[66] for non-low-income residential heating system, cooling system, heating and cooling system, and heating and water heating system measures to account for replacing equipment on failure and "snapback" effects. [The previous estimates of health-related impacts were presented as an overall health-related impact covering general health, asthma/chronic illness, and cold/flu.] The general formula used to adjust the health-related NEI values by measure type is shown below. The following example demonstrates the calculation for health-related impacts resulting from Central AC/Heat Pump cooling system measures.

   - ROF-Adjusted NEI Value per Year for Total Health-Related Impacts = Full NEI Value per Year for Total Health-Related Impacts=$0.13 / 2
     = $0.07
     - The study estimated that 100% of the value of total health-related impacts was due to energy efficiency of the installed measure; therefore, there was no difference between the replace on failure (ROF) NEI value and the full NEI value.
     - The study made a final adjustment to account for potential "snapback" in usage by discounting the total health-related impacts value by one-half.

[64] Hawkins, Tonn, Rose, Clendenning, and Abraham (2016). Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by Three-Cubed and NMR Group, Inc. August 5, 2016.

[65] Clendenning and Abraham (2013). Massachusetts Residential Non-Energy Impacts (NEIs): Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure. Memo by NMR Group, Inc. to Tetra Tech and National Grid. July 15, 2013.

[66] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

The table below provides the ROF-adjusted NEI value per year for total health-related impacts for measures examined in the study.

Table III-2
MA Early Replacement Study Medical Impact Estimates

Measure Category	Measure	ROF-Adjusted NEI Value ($/Year)
Cooling System	Central AC/Heat Pump	$0.07
Heating & Cooling System	Ductless Mini-split	$0.08
Heating System	Boilers >90% & <96% AFUE	$0.78
	Boilers >=96% AFUE	$0.78
	Furnaces >=95% AFUE	$0.78
Heating & Hot Water System	Integrated Boiler/Water Heater	$0.03

4. Ohio REACH Final Evaluation Report[67]
This study estimated the impact of weatherization on health and safety issues in the homes using pre/post participant survey and differences-in-differences analysis of participants and non-participants (i.e., those who did not receive program services). The program-induced impact on H&S issues was determined as follows.
   - Program Impact (Net Change) = Gross Change for Treated Clients – Gross Change for Untreated Clients
     - Gross Change for Treated Clients = Pre-Survey Incidence (%) for Treated Clients – Post-Survey Incidence (%) for Treated Client
     - Gross Change for Untreated Clients = Pre-Survey Incidence (%) for Untreated Clients – Post-Survey Incidence (%) for Untreated Clients

While this study estimated the program-induced impact on H&S issues in the home, these impacts were not monetized. The following H&S impacts were estimated:

Table III-3
OH Low-Income WAP Study Medical Impact Estimates

Impact	Net Change (Percentage Points)	Statistical Significance
Has asthma	2	NO
Asthma - visited doctor	2	NO
Asthma - visited emergency room	-1	NO
Allergies	6	NO
Allergies - medicine	11	95%

[67] APPRISE Incorporated (2010). Ohio Residential Energy Assistance Challenge Option Program (REACH) Final Evaluation Report. June 2010.

Impact	Net Change (Percentage Points)	Statistical Significance
Allergies - symptoms	6	NO
Bronchitis or lung disease	3	NO
Bronchitis - visited emergency room	8	95%
Household health - somewhat or very healthy	-4	NO

5. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin)[68]
   Health-related impacts were estimated in this study using a participant survey and relative valuation methodology. The following question battery provides an example of what participants were asked.
   - NEI category = Frequency or intensity of chronic conditions (e.g. asthma)
     - Overall, have you noticed any change in the frequency or intensity of chronic conditions such as asthma from the measures installed under the Weatherization Program? [If "yes", probe for positive or negative change.]
     - [If positive change impact] Think about the value you experienced from this benefit – would you say it is or more value, less value, or the same value to you as any possible energy savings you may have received from the program? [If more or less valuable, probe for much less, somewhat less, somewhat more, or much more valuable]
     - [If negative change impact] Is the impact of this change to you more costly, less costly, or the same cost as the possible energy savings? [If more or less costly, probe for much less, somewhat less, somewhat more, or much more costly.]
     - [If positive or negative change impact but can't assign a relative value] On a scale of 0 to 5 with 0 meaning "not at all important" and 5 meaning "extremely important", how important to you is the [positive/negative] change in the frequency or intensity of chronic conditions such as asthma?

   The table below provides estimates of the health-related impacts examined by this study.

[68] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.

Table III-4
WI Low-Income WAP Study Medical Impact Estimates

Non-Energy Impact	Share of Total Benefits	Annual Benefit ($/participant)	
		Low	High
Freq./intensity of chronic conditions (e.g. asthma)	3%	$9	$12
Freq./intensity of other illnesses	2%	$5	$6
Headaches for you or other residents	2%	$5	$6
Doctor or hospital visits and related costs	2%	$4	$5
Number of sick days lost from work/school	1%	$4	$5
Medication costs	<1%	$1	$1

6. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[69]
   This study estimated NEIs related to health from the participant-perspective using a participant survey.
   - The survey instrument was not included in the report, therefore, the specific questions asked of respondents are not known.
   - For each type of NEI that was considered in the study, respondents were generally asked whether they experienced a change in that NEI category as a result of the program.
   - If the respondent indicated that there was a change, s/he was then asked about the value of that change relative to their estimated energy savings.

   The health impact values are presented in the table below.

Table III-5
CO Low-Income Energy Efficiency Study Health Impact Estimates

Program	Annual Benefit ($/Participant)
Energy Savings Kits	$6.50
Multifamily Weatherization	$42.11
Non-Profit Energy Efficiency	$500.45
Single-Family Weatherization	$44.02

[69] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.

B. *Safety Impacts*

The following impacts are examined in this section.

- Carbon Monoxide Poisoning
- Home Fires
- Unspecified (General Safety)

The following studies provide estimates of impacts on home safety.

1. Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study (Massachusetts).[70]
2. The Low-Income Public Purpose Test (LIPPT) – Final Report – Updated for Version 2.0 (California)[71]
3. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin)[72]
4. Ohio REACH Final Evaluation Report[73]

Descriptions of the methodologies used to calculate safety impacts from these studies are provided below.

1. Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study (Massachusetts).[74]

   This study estimates impacts on carbon monoxide poisoning and home fires.

   Carbon Monoxide Poisoning

   The impacts on carbon monoxide poisoning were estimated as follows.

   - Benefits Per Year over Five-Year Lifetime per Unit Weatherized
     - Total benefit = $38.85
     - Total household benefit = $36.98
     - Total societal benefit = $1.87
     - The report recommended adoption of the total household benefit of $36.98 per year per unit weatherized over a five-year lifetime (or $183.30 one-time benefit per unit weatherized) for safety benefits of reduced carbon monoxide poisoning.

[70] Hawkins, Tonn, Rose, Clendenning, and Abraham (2016). Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by Three-Cubed and NMR Group, Inc. August 5, 2016.

[71] TecMarket Works, Skumatz Economic Research, and Megdal and Associates (2001). The Low-Income Public Purpose Test – Final Report – Updated for Version 2.0. Prepared for RRM Working Group, Cost Effectiveness Committee. May 25, 2001.

[72] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.

[73] APPRISE Incorporated (2010). Ohio Residential Energy Assistance Challenge Option Program (REACH) Final Evaluation Report. June 2010.

[74] Hawkins, Tonn, Rose, Clendenning, and Abraham (2016). Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by Three-Cubed and NMR Group, Inc. August 5, 2016.

The general methodology used is described below. Full details were not provided in the report.

- The number of ED, hospitalizations, and deaths from CO poisoning nationally was estimated.
- The number of ED, hospitalizations, and deaths from CO poisoning potentially prevented by WAP was estimated.
- Studies that estimated the preventative performance of CO monitors were evaluated.
- Results from the preceding steps were combined to estimate the number of ED visits, hospitalizations, and deaths from CO poisoning that could be prevented and attributable to WAP.
- The monetary values of preventing the ED visits, hospitalizations, and deaths were estimated utilizing medical costs for the treatment of carbon monoxide poisoning.
- Benefits were divided into household benefits and societal benefits by applying primary payer information from HCUP and MEPS Household Component Event Files. Cases paid by Medicare and Medicaid were considered societal benefits, while uninsured cases were household benefits. Cases in which the primary payer was private/other were split between societal and household according to out-of-pocket (OOP) payment proportions from MEPS.

The input data for Massachusetts or cold climate region were as follows.

- Percent of weatherized home using fossil fuel heating sources (MA) = 86%[75]
- Average household size of weatherized households (cold climate region) = 2.41[76]
- Percent of households below 200 percent of the federal poverty level (MA, 2014) = 27%[77]
- Average medical costs for ED visits and hospitalizations used in the National WAP Evaluation were adjusted from national costs to Massachusetts costs for 2008, then inflation-adjusted to 2014 dollars, using medical care price indices from the Bureau of Labor Statistics.

<u>Home Fires</u>

The impacts on home fires poisoning were estimated as follows.

- Benefits per Year per Unit Weatherized
  - Total benefit = $111.71
  - Total household benefit = $93.84
  - Total societal benefit = $17.87
  - The report recommended adoption of the total household benefit for safety benefits of reduced home fires. The referenced study was partially based on measures not currently installed by the PAs (e.g. chimney sweep), so the report recommended that 61.25% of the total household benefit ($57.48 per year per unit weatherized), with the 61.25% reflecting the reduction in fire risk due specifically to measures

[75] Department of Energy and EVnrionmental Affairs, Commonwealth of Massachusetts; webpage referenced by authors not found

[76] National WAP Occupant Survey, data from cold climate region.

[77] The Kaiser Family Foundation, data for 2014; http://kff.org/other/state-indicator/population-up-to-200-fpl/

installed by the PAs (safety inspection, replacement, and/or installation of smoke detectors).

The general methodology used is described below. Full details were not provided in the report.

- Mine the National Fire Incident Reporting System (NFIRS) database for primary fires in one- to four-unit residential buildings.
- Determine cause of the fires and drop cases with unknown or invalid causes.
- Identify relevant fire incidents by the presence of weatherization-preventable contributors to fire.
- Match zip code-level housing and poverty data with each fire to construct sample weights to estimate fire frequency among households under 200 percent of federal poverty level.
- Develop weights for fires and subsequent damages to estimate totals.
- Estimate probabilities of fire occurring in WAP homes using fire incidents and total homes among single-family households whose income was less than 200 percent of the poverty level
- Apply the probabilities to the number of single-family and mobiles homes that received WAP services in PY 2008.
- Estimate fires prevented and monetize (using average medical costs for ED visits and hospitalizations adjusted from national costs to Massachusetts costs, and inflation-adjusted from 2008 dollars to 2014 dollars).

The authors estimated the following fire-related reductions.

- 0.0087 deaths per year per 1,000 units weatherized
- 0.013 hospitalizations per year per 1,000 units weatherized
- 0.4 ED visits per year per 1,000 units weatherized
- 0.25 physician office visits per year per 1,000 units weatherized

2. <u>The Low-Income Public Purpose Test (LIPPT) – Final Report – Updated for Version 2.0 (California)</u>[78]

   This study estimated the following NEI value from the participant-perspective:

   - Benefits per Year per Low-Income Participant = [(Average annual deaths from CO problems=0.0000030[79] * Value of statistical life=$6 million[80]) + (Average annual illnesses from CO problems=0.0001500[81] * Cost for each serious illness (stroke and heart attack)=$50,000[82])] * Percent of participant homes with CO monitors

[78] TecMarket Works, Skumatz Economic Research, and Megdal and Associates (2001). The Low-Income Public Purpose Test – Final Report – Updated for Version 2.0. Prepared for RRM Working Group, Cost Effectiveness Committee. May 25, 2001.
[79] Consumer Product Safety Commission.
[80] Selected research value; source not indicated.
[81] Consumer Product Safety Commission.
[82] Goldstein (2001).

installed=0%[83] * Percent of CO problems eliminated by program efforts (assumed)=80%[84] * Adjustment factor for appropriate horizon=0.22[85]
= $0.00

- Average annual deaths from CO problems = 0.0000030 = 300 * 2.7 persons per household / population
- Average annual illnesses from CO problems = 0.0001500 = 15,000 * 2.7 persons per household / population

CO monitors were not installed through the California programs, therefore, the participant-perspective benefit claimed for this NEI was $0.00 per year per low-income participant.

For illustrative purposes, the study demonstrated the participant benefits of reduced CO poisoning if 50 percent of program participants received CO monitors; under this scenario, the value of this NEI was $2.27 per participant per year (over a 10-year measure life).

For illustrative purposes, the study also demonstrated an alternative methodology for participant-level benefits of reduced CO poisoning, as follows:

- Benefits per Year per Low-Income Participant = [Cost of CO Monitor=$30.00[86]] * [Percent of participants with CO monitors installed=50%[87]] * * [Adjustment factor for appropriate horizon=0.22[88]]
  = $3.34

This study estimated the following NEI value from the societal-perspective (public benefits); this includes the NEI value of other Health and Safety (H&S) measures.

- Benefits per Year per Low-Income Participant = [(Cost of H&S equipment installed through the program=$0 * Percent of participant homes with H&S equipment installed=0%) + (Cost of CO monitors installed through the program=$0.00 * Percent of participant homes with CO monitors installed=0%)] * Adjustment factor for appropriate horizon=0.16[89]
  = $0.00

  CO monitors and other H&S measures were not installed through the California programs, therefore, the societal-perspective benefit claimed for this NEI was $0.00 per year per low-income participant. For programs that do install CO monitors or other H&S measures, the assumption used in the algorithm above was that the value

[83] At the time of the study, California programs did not install CO monitors, and therefore, the recommended benefit value for California was $0.00.
[84] Assumed percent of CO problems eliminated by program efforts.
[85] Derived from horizon and discount assumptions in "Program Assumptions Table"'.
[86] From "Program Assumptions Table".
[87] From "Program Design Assumptions"; for illustrative purposes only.
[88] Derived from horizon and discount assumptions in "Program Assumptions Table"'.
[89] Derived from horizon and discount assumptions in "Program Assumptions Table"'.

of H&S benefits for the installation of H&S measures was approximated by the installed costs of the measures. California rejected other valuation methods, based on estimates of reduced H&S incidents, because the data were deemed less reliable and were not California or program-based.

3. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin)[90]
   Safety-related impacts were estimated in this study using a participant survey and relative valuation methodology. Participants were asked the following question battery regarding safety in their homes.
   - Overall, have you noticed any change in the safety of your home from the measures installed under the Weatherization Program? [If "yes", probe for positive or negative change.]
   - [If positive change impact] Think about the value you experienced from this benefit – would you say it is or more value, less value, or the same value to you as any possible energy savings you may have received from the program? [If more or less valuable, probe for much less, somewhat less, somewhat more, or much more valuable]
   - [If negative change impact] Is the impact of this change to you more costly, less costly, or the same cost as the possible energy savings? [If more or less costly, probe for much less, somewhat less, somewhat more, or much more costly.]
   - [If positive or negative change impact but can't assign a relative value] On a scale of 0 to 5 with 0 meaning "not at all important" and 5 meaning "extremely important", how important to you is the [positive/negative] change in the safety of your home?

   The table below provides estimates of the safety-related impacts examined by this study.

Table III-6
WI Low-Income WAP Study Safety Impact Estimates

Non-Energy Impact	Share of Total Benefits	Annual Benefit ($/participant)	
		Low	High
Safety of your home	8%	$20	$26

4. Ohio REACH Final Evaluation Report (Ohio)[91]
   This study estimated the impact of weatherization on health and safety issues in the homes using pre/post participant survey and differences-in-differences analysis of participants

[90] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.
[91] APPRISE Incorporated (2010). Ohio Residential Energy Assistance Challenge Option Program (REACH) Final Evaluation Report. June 2010.

and non-participants (i.e., those who did not receive program services). The program-induced impact on H&S issues was determined as follows.

- Program Impact (Net Change) = Gross Change for Treated Clients – Gross Change for Untreated Clients
  - Gross Change for Treated Clients = Pre-Survey Incidence (%) for Treated Clients – Post-Survey Incidence (%) for Treated Client
  - Gross Change for Untreated Clients = Pre-Survey Incidence (%) for Untreated Clients – Post-Survey Incidence (%) for Untreated Clients

The following safety impacts were estimated, but they were not monetized.

Table III-7
OH Low-Income WAP Study Safety Impact Estimates

Impact	Net Change (Percentage Points)	Statistical Significance
Reported unsafe or unhealthy home condition	-26	99%
Unsafe condition (unprompted) - mold	-10	NO
Unsafe condition (unprompted) - drafty	-12	99%
Smoke in home	-6	99%
Do not use exhaust fan when showering	-26	99%
Do not use exhaust fan when cooking	-6	NO
Warm up car in garage	1	NO
Use kitchen stove or oven to heat home	-22	99%
Any mold	-18	95%
Mold in kitchen	1	NO
Mold in bathroom	-12	90%
Mold in basement	-18	95%
Pests	-1	NO
Used baits or poison	-3	NO
Poison still in home	8	99%

C. *Comfort Impacts*

The following impacts are examined in this section.

- Thermal Comfort/Home Productivity
- Quieter Indoor Environment
- General/Overall Comfort

The following studies provide estimates of comfort impacts.

1. Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study (Massachusetts).[92]
2. Residential and Low-Income Non-Energy Impacts Study (Massachusetts).[93]
3. Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure (Massachusetts)[94]
4. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin)[95]
5. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[96]
6. Ohio REACH Final Evaluation Report (Ohio)[97]

The methodologies for the home comfort impacts are described below.

1. Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study (Massachusetts).[98]

   This study estimates the value of reduction in productivity losses due to sleep loss. The reviewers of this study recommending adopting this "productivity due to improved sleep" benefit in part and adding it to an existing benefit for "thermal comfort" already claimed by the PAs. The basis for this partial adoption and addition to an existing benefit was due to the potential for overlap between the "productivity due to improved sleep" benefit and

[92] Hawkins, Tonn, Rose, Clendenning, and Abraham (2016). Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by Three-Cubed and NMR Group, Inc. August 5, 2016.

[93] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

[94] Clendenning and Abraham (2013). Massachusetts Residential Non-Energy Impacts (NEIs): Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure. Memo by NMR Group, Inc. to Tetra Tech and National Grid. July 15, 2013.

[95] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.

[96] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.

[97] APPRISE Incorporated (2010). Ohio Residential Energy Assistance Challenge Option Program (REACH) Final Evaluation Report. June 2010.

[98] Hawkins, Tonn, Rose, Clendenning, and Abraham (2016). Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by Three-Cubed and NMR Group, Inc. August 5, 2016.

"thermal comfort" benefit already claimed. The study reviewers categorized this combined benefit as "total thermal comfort".

- Benefits per Year per Unit Weatherized
  - Total benefit = $37.75
  - Total household benefit = $37.75
  - Total societal benefit = $0.00
  - The report recommended partial adoption of the total household benefit for comfort-related benefits resulting in increased home productivity. Due to potential overlap between this NEI estimated and the NEI of thermal comfort already included in the NEI benefits,[99] the report recommended adoption of half of the NEI value for increased home productivity ($18.88) in addition to the NEI value of $101 currently claimed for thermal comfort. A value of $119.88 per year per unit weatherized was recommended for "total thermal comfort".

- Total household benefit = % decrease in at least one bad day of rest or sleep=5.0%[100] * (Cost per year per employee in productivity losses due to sleep problems=$2,500[101]/Average national hourly wage rate=22.62[102]) * (Wage rate for general housekeepers=$12.71[103]) * (Average hours per week of housework=21.5[104]/40 hours per week)
  = $37.75 per year per unit weatherized

2. Residential and Low-Income Non-Energy Impacts Study (Massachusetts).[105]
   This study estimated impacts on thermal comfort and indoor noise levels.

   Thermal Comfort
   This study estimated impacts on thermal comfort for low-income and non-low-income program participants using a participant survey. Participants were asked a battery of questions to elicit their estimate of the value of changes in home comfort. Respondents were generally asked the following questions.
   - Whether, in terms of the temperature and draftiness of their home, their home was more comfortable, less comfortable, or there was no difference in the comfort level of their homes because of the energy efficiency improvements that were made.

[99] NMR Group (2011). Massachusetts Special and Cross-Sector Studies Area: Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for Massachusetts Program Administrators. http://ma-eeac.org/wordpress/wp-content/uploads/Special-and-Cross-Sector-Studies-AreaResidential-and-Low-Income-Non-Energy-Impacts-Evaluation-Final-Report.pdf
[100] National WAP Occupant Survey, data for cold climate region.
[101] Business Insider, http://www.businessinsider.com/workers-lack-of-sleep-costs-employers-millions-of-dollars-each-year-2011-1
[102] Bureau of Labor Statistics, 2010 national data.
[103] Bureau of Labor Statistics, MA data, http://www.bls.gov/oes/current/oes372012.htm
[104] Bureau of Labor Statistics.
[105] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

- The relative value – either positive or negative – of the change in home comfort compared to an estimate of the annual energy bill savings typically achieved by homes installing the same measures. Respondents could respond in absolute dollar terms or as a percentage of the estimate of annual energy savings provided by the interviewer.

After removing outliers, the sample from which comfort-related impacts were estimated was 172 low-income households and 165 non-low-income households. Estimates of thermal comfort impacts were scaled to the respondent's estimate of the value of the total NEI of participating in the program.

- Thermal comfort benefit per year per low-income (LI) participant = $101, or 20% of bill savings ($67 to $134, or 13% to 27% of bill savings, at 90% confidence level)

  Note: In their review of the primary research done by Three-Cubed (2016), the authors of this study (NMR Group) recommended replacing the estimate of $101 per year per low-income household for thermal comfort benefits with the "total thermal comfort" value of $119.88 per year per unit weatherized in the Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study (Massachusetts).[106]

- Thermal comfort benefit per year per non-low-income (NLI) participant in Retrofit Programs = $125, or 37% of bill savings ($95 to $154, or 29% to 45% of bill savings, at 90% confidence level)

<u>Indoor Noise</u>

This study estimated impacts on quieter indoor environment for low-income and non-low-income program participants using a participant survey. Respondents were asked a battery of questions to elicit their estimate of the value of a quieter indoor environment due to a decrease in noise coming from outside the home. Respondents were generally asked the following questions.

- Whether, in terms of the indoor environment, their home was quieter, noisier, or there was no difference in the indoor noise level of their homes because of the energy efficiency improvements that were made.
- The relative value of the change in noise level in their indoor environment compared to an estimate of the annual energy bill savings typically achieved by homes installing the same measures. Respondents could respond in absolute dollar terms or as a percentage of the estimate of annual energy savings provided by the interviewer.

After removing outliers, the sample from which noise level impacts were estimated was 193 low-income households and 183 non-low-income households. Estimates of quieter indoor environment impacts were scaled to the respondent's estimate of the value of the total NEI of participating in the program.

[106] Hawkins, Tonn, Rose, Clendenning, and Abraham (2016). Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by Three-Cubed and NMR Group, Inc. August 5, 2016.

- Quieter indoor environment benefit per year per low-income (LI) participant = $30, or 4% of bill savings ($16 to $45, or 3% to 6% of bill savings, at 90% confidence level)
- Quieter indoor environment benefit per year per non-low-income (NLI) participant in Retrofit Programs = $31, or 11% of bill savings ($18 to $44, or 6% to 15% of bill savings, at 90% confidence level)

3. Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure (Massachusetts)[107]
This study estimated impacts on thermal comfort and indoor noise levels.

Thermal Comfort
This study updated previous results from the authors (NMR 2011)[108] for non-low-income residential heating system, cooling system, heating and cooling system, and heating and water heating system measures to account for replacing equipment on failure and "snapback" effects. The general formula used to adjust the thermal comfort NEI values by measure type is shown below. The following example demonstrates the calculation for Central AC/Heat Pump cooling system measures.

- ROF-Adjusted NEI Value per Year for Thermal Comfort = Full NEI Value per Year for Thermal Comfort=$3.92 / 2
  = $1.96
  - The study estimated that 100% of the value of thermal comfort impacts was due to energy efficiency of the installed measure. Therefore, there was no difference between the replace on failure (ROF) NEI value and the full NEI value.
  - The study made a final adjustment to account for potential "snapback" in usage by discounting the thermal comfort impacts value by one-half. The discount to account for "snapback" was meant to be a conservative approach. However, the study does not provide details on how this discount factor was determined.

The table below provides the ROF-adjusted NEI value per year for thermal comfort impacts for measures examined in the study.

[107] Clendenning and Abraham (2013). Massachusetts Residential Non-Energy Impacts (NEIs): Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure. Memo by NMR Group, Inc. to Tetra Tech and National Grid. July 15, 2013.
[108] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

Table III-8
MA Early Replacement Study Thermal Comfort Estimates

Measure Category	Measure	ROF-Adjusted Thermal Comfort Value ($/Year)
Cooling System	Central AC/Heat Pump	$1.96
Heating & Cooling System	Ductless Mini-split	$2.53
Heating System	Boilers >90% & <96% AFUE	$24.32
	Boilers >=96% AFUE	$24.32
	Furnaces >=95% AFUE	$24.32
Heating & Hot Water System	Integrated Boiler/Water Heater	$0.92

Indoor Noise

This study updated previous estimates by the authors (NMR 2011)[109] of quieter indoor environment resulting from non-low-income residential heating system, cooling system, heating and cooling system, heating and hot water system, and hot water system measures to account for replacing equipment on failure (ROF). The general formula used to adjust NEI values by measure type is shown below. The following example demonstrates the calculation for Central AC/Heat Pump cooling system measures.

- ROF-Adjusted NEI Value per Year for Quieter Indoor Environment = [(Attribution factor for EE portion of NEI=67%, based on professional judgment/review of NEI literature by authors * Full NEI Value per Year for Quieter Indoor Environment=$2.83) * ROF%=35.4%, replace on failure rate claimed by the PAs for this measure] + [Full NEI Value per Year for Quieter Indoor Environment=$2.83 * (1 – ROF%=35.4%)]
  = $2.50 per year

The table below provides the ROF-adjusted NEI value per year for quieter indoor environment for measures examined in the study.

Table III-9
MA Early Replacement Study Noise Estimates

Measure	Full NEI Value	EE Portion of NEI	ROF NEI Value	Percent ROF	ROF-Adjusted Noise Value ($/Year)
Central AC/Heat Pump	$2.83	67%	$1.90	35.4%	$2.50
Ductless Mini-Split	$1.42	67%	$0.95	1.3%	$1.41

[109] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

4. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin)[110]
This study estimated impacts on indoor noise and overall home comfort.

Indoor Noise
Impacts related to quieter indoor environment were estimated in this study using a participant survey and relative valuation methodology. The following question battery provides an example of what participants were asked.

- Overall, have you noticed any change in the noise from appliances or noise inside your home from the measures installed under the Weatherization Program? [If "yes", probe for positive or negative change.]
- [If positive change impact] Think about the value you experienced from this benefit – would you say it is or more value, less value, or the same value to you as any possible energy savings you may have received from the program? [If more or less valuable, probe for much less, somewhat less, somewhat more, or much more valuable]
- [If negative change impact] Is the impact of this change to you more costly, less costly, or the same cost as the possible energy savings? [If more or less costly, probe for much less, somewhat less, somewhat more, or much more costly.]
- [If positive or negative change impact but can't assign a relative value] On a scale of 0 to 5 with 0 meaning "not at all important" and 5 meaning "extremely important", how important to you is the [positive/negative] change in the noise from appliances or noise inside your home?

The table below provides estimates of noise impacts examined by this study.

Table III-10
WI Low-Income WAP Noise Impacts

Non-Energy Impact	Share of Total Benefits	Annual Benefit ($/Participant)	
		Low	High
Noise from appliances or noise inside home	6%	$19	$24
Amount of noise from outside home	5%	$13	$17

Comfort
Comfort-related impacts were estimated in this study using a participant survey and relative valuation methodology. The following question battery provides an example of what participants were asked with respect to the frequency or intensity of chronic conditions (e.g. asthma)

[110] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.

- Overall, have you noticed any change in your home's overall comfort from the measures installed under the Weatherization Program? [If "yes", probe for positive or negative change.]
- [If positive change impact] Think about the value you experienced from this benefit – would you say it is or more value, less value, or the same value to you as any possible energy savings you may have received from the program? [If more or less valuable, probe for much less, somewhat less, somewhat more, or much more valuable]
- [If negative change impact] Is the impact of this change to you more costly, less costly, or the same cost as the possible energy savings? [If more or less costly, probe for much less, somewhat less, somewhat more, or much more costly.]
- [If positive or negative change impact but can't assign a relative value] On a scale of 0 to 5 with 0 meaning "not at all important" and 5 meaning "extremely important", how important to you is the [positive/negative] change in your home's overall comfort?

The table below provides estimates of the comfort impacts examined by this study.

Table III-11
WI Low-Income WAP Comfort Impacts

Non-Energy Impact	Share of Total Benefits	Annual Benefit ($/Participant)	
		Low	High
Home's overall comfort	16%	$44	$56

5. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[111]
This study estimated impacts on comfort and productivity.

Comfort
This study estimated NEIs related to comfort from the participant-perspective using the following methodology.
- Program impacts on participant comfort were estimated using a participant survey.
- The survey instrument was not included in the report, therefore, the specific questions asked of respondents are not known.
- For each type of NEI that was considered in the study, respondents were generally asked whether they experienced a change in that NEI category (e.g., changes in "comfort"), either positive or negative, as a result of the program.
- If the respondent indicated that there was a change, s/he was then asked about the value of that change in "comfort" relative to their estimated energy savings.

The table below provides estimates for comfort-related impacts.

[111] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.

Table III-12
CO Low-Income Energy Efficiency Comfort Impacts

Program	Annual Benefit for Comfort-Related Impacts ($/Participant)
Energy Savings Kits	$3.13
Multifamily Weatherization	$20.77
Non-Profit Energy Efficiency	$233.46
Single-Family Weatherization	$20.66

Productivity

Increased worker productivity was estimated using a participant survey in which respondents were asked whether they experienced improved health resulting in less missed days at work/increased productivity because of the program, and if so, whether the impact was positive or negative, and by how much relative to their estimated energy savings. The following values were estimated using this methodology.

- Energy Savings Kits = $0.00 per participant per year
- Multifamily Weatherization = $0.00 per participant per year
- Non-Profit Energy Efficiency = $171.54 per participant per year
- Single-Family Weatherization = $0.00 per participant per year

6. Ohio REACH Final Evaluation Report (Ohio)[112]

This study estimated the impact of weatherization on comfort using pre/post participant survey and differences-in-differences analysis of participants and non-participants (i.e., those who did not receive program services). The program-induced impact on was determined as follows.

- Program Impact (Net Change) = Gross Change for Treated Clients – Gross Change for Untreated Clients
  - Gross Change for Treated Clients = Pre-Survey Incidence (%) for Treated Clients – Post-Survey Incidence (%) for Treated Client
  - Gross Change for Untreated Clients = Pre-Survey Incidence (%) for Untreated Clients – Post-Survey Incidence (%) for Untreated Clients

The following comfort impacts were estimated, but they were not monetized.

[112] APPRISE Incorporated (2010). Ohio Residential Energy Assistance Challenge Option Program (REACH) Final Evaluation Report. June 2010.

Table III-13
OH Low-Income WAP Study Comfort Estimates

Impact	Net Change (Percentage Points)	Statistical Significance
Home comfort - somewhat or very comfortable	-10	90%
Drafty in winter	-21	99%
Cannot heat home to comfortable temperature	-2	NO
Home was uncomfortably cold	4	NO
Have air conditioner	-8	90%
Cannot cool home to comfortable temperature	-8	NO
Home was uncomfortably warm	-15	99%

D. Affordability Impacts

The following impacts are examined in this section.

- Short-Term High-Interest Loans
- Hardship Benefits
- Transaction Costs

The following studies provide estimates of impacts on affordability.

1. Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study (Massachusetts).[113]
2. The Low-Income Public Purpose Test (LIPPT) – Final Report – Updated for Version 2.0 (California)[114]
3. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[115]
4. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin)[116]

[113] Hawkins, Tonn, Rose, Clendenning, and Abraham (2016). Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by Three-Cubed and NMR Group, Inc. August 5, 2016.

[114] TecMarket Works, Skumatz Economic Research, and Megdal and Associates (2001). The Low-Income Public Purpose Test – Final Report – Updated for Version 2.0. Prepared for RRM Working Group, Cost Effectiveness Committee. May 25, 2001.

[115] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.

[116] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.

Estimates of these benefits are described below.

1. Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study (Massachusetts).[117]
   This report estimated the impact on use of high-interest loans as follows.
   - Benefits per Year per Unit Weatherized
     - Total benefit = $4.72
     - Total household benefit = $4.72
     - Total societal benefit = $0.00
     - The report recommended that they do not adopt the affordability benefits of reduced use of short-term, high interest loans because the benefit of this NEI derives from customer bill savings, and 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.

   - Total household benefit = % reduction in households using short-term, high interest loans=6.45%[118] * Average interest payments/loan fees=$73.18
     = $4.72 per year per unit weatherized
     - Average interest payments/loan fees based on National WAP Occupant Survey results of average loan of $335, and households taking out one short-term interest loan per year and paying back the loan in one month with a 25% monthly interest rate; updated to 2014 dollars = $73.18[119]

2. The Low-Income Public Purpose Test (LIPPT) – Final Report – Updated for Version 2.0 (California)[120]
   The study estimated the impacts on high-interest loans and on transactions costs.

   High-Interest Loans
   Benefits per Year per Low-Income Participant = [Sum of participant NEI=$25.75,[121]] * [Multiplier assumed for hardship benefits beyond those measured elsewhere=10%[122]] * [Adjustment factor for appropriate horizon=1.0[123]]
   = $2.57

   - The sum of participant NEIs was from the Willingness to Pay (WTP) survey/summary sheet. It includes participant benefits from shutoffs, reconnects, moving, property

[117] Hawkins, Tonn, Rose, Clendenning, and Abraham (2016). Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by Three-Cubed and NMR Group, Inc. August 5, 2016.
[118] National WAP Occupant Survey, data for cold climate region.
[119] National WAP Occupant Survey, data for national sample.
[120] TecMarket Works, Skumatz Economic Research, and Megdal and Associates (2001). The Low-Income Public Purpose Test – Final Report – Updated for Version 2.0. Prepared for RRM Working Group, Cost Effectiveness Committee. May 25, 2001.
[121] From WTP survey.
[122] From WTP survey.
[123] Derived from horizon and discount assumptions in "Program Assumptions Table"'.

value benefits, health and safety benefits, and others. It excludes other "soft" benefits like comfort, and excludes program rebates if any. Additional details were not provided.

- Information on the derivation of the value of the multiplier for hardship benefits beyond those measured elsewhere was not provided.

The study describes this benefit as representing a reduction in general hardship to the participant from program participation, resulting in greater control over their bill and reduced worries and concerns from this source. Low-income weatherization programs help reduce bills and improve the ability of participants to meet bill payment obligations and avoid a number of negative outcomes.

- The benefit was valued using a WTP survey. Respondents were asked to think about the benefits they received from the following impacts and indicate how much they would be willing to pay for the changes they perceived: reduced shutoffs and reconnect incidents, reduced moving (to new homes), increased property value benefits, improved health and safety benefits, and other impacts.
- For example, respondents were asked the following questions regarding shutoff and reconnect notices: When you think about the benefit from reduced shutoff and reconnect notices you received from the program, what is the maximum amount you might be willing to pay for these benefits?

<u>Transactions Costs</u>

Benefit per Year per Low-Income Participant = [Ave. number of CFLs per household=0.5[124]] * [Percent of households with CFLs installed=100%[125]] * [Estimated value of transaction costs from CFLs=$1.25[126]] * [Adjustment factor for appropriate horizon=0[127]]
= $0.00

Researchers have hypothesized that transaction cost savings from weatherization programs result from participants not having to educate themselves about conservation measures, not having to locate the items in the marketplace for purchase, and the reduction in transaction costs from having efficient products more widely available.

The study recommended *excluding* the NEI of avoided transaction costs because the underlying data were weak. Therefore, the study claims a value of $0.00 per year per participant for this NEI.

[124] From "Program Assumptions Sheet".
[125] From "Program Assumptions Sheet".
[126] From Feldman (1998).
[127] Derived from horizon and discount assumptions in "Program Assumptions Table"'.

3. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[128]
   This study estimated hardship impacts and transaction costs impacts.

   Hardship
   This study estimated impacts on hardship and knowledge/control over bills from the participant-perspective using a participant survey.
   - For "knowledge/control over bills," the specific questions asked of respondents are not known because the survey instrument was not included in the report.
   - Respondents were generally asked whether they experienced a change in that NEI category, either positive or negative, as a result of the program.
   - If the respondent indicated that there was a change, s/he was then asked about the value of that change in the NEI relative to their estimated energy savings.

   The table below provides the estimated values for "knowledge/control over bills" impacts.

Table III-14
CO Low-Income Energy Efficiency Study Knowledge/Control Over Bills Estimates

Program	Annual Benefit for Knowledge/Control Over Bills ($/Participant)
Energy Savings Kits	$6.48
Multifamily Weatherization	$51.48
Non-Profit Energy Efficiency	$428.34
Single-Family Weatherization	$43.06

   - For "hardship" impacts not included elsewhere, the participant survey included a question battery about the value of NEIs associated with changes in hardship, defined as "ability to pay energy/other bills; pressure related to bills or debt; financial hardship; household moves/stability; safety of the home; and other hardship effects".
   - Respondents were asked about the share of these effects that were not included in the NEI categories addressed earlier in the survey. The table below provides the share of "hardship" benefits not accounted for in other NEI categories, and the estimated values for "hardship" impacts.

Table III-15
CO Low-Income Energy Efficiency Study Hardship Estimates

Program	Share Not in other NEIs	Annual Benefit for Hardship Impacts ($/Participant)
Energy Savings Kits	0.11	$4.64

[128] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.

Multifamily Weatherization	0.26	$66.87
Non-Profit Energy Efficiency	0.63	$1,669.95
Single-Family Weatherization	0.26	$61.76

Transactions Costs

This study estimated transaction-related impacts from the participant-perspective of customer reconnections and customer calls using program data collected from the utility for an arrearage analysis.

- Program data were used to estimate the program-induced change and monetize impacts related to arrearage values, customer contacts, power shutoffs, power reconnections, and write-offs.
  - Data for program participants were collected from the utility, which provided up to a year of "pre" data and several months of "post" data.
  - The "pre" and "post" data were averaged to simulate a year pre/post program participation.

- Impacts of reduced reconnections and customer calls from the participant-perspective were estimated as follows. These represent gross impacts because a suitable comparison group was unavailable.
  - Reconnections (value per participant per year) = [average reconnections per year per low-income customer (utility data) * estimated program-induced reduction in reconnections (arrearage analysis) * reconnection fee (utility data)] / participants
  - Customer calls (value per participant per year) = [average calls per low-income customer (utility data) * estimated program-induced percentage reduction in calls (arrearage analysis) * average time per call in minutes (utility data) * minimum wage/60 minutes] / participants

- The table below provides the number of program participants, average number of reconnections and customer calls per year per low-income customer, estimated program-induced impact, and estimated values for reduced reconnections and customer calls. The reconnection fee and average time per call, both from utility data, were not provided in the report.

Table III-16
CO Low-Income Energy Efficiency Study Transactions Estimates

Program	Energy Saving Kits	Multifamily Wx	Non-Profit Energy Efficiency	Single-Family Wx
Participants	34,667	1,383	11	3,128
Reconnections				
Ave. # per year per LI cust.	0.109	0.14	0.14	0.077
Reduction due to program	-53.2%	-8.6%	-34.2%	-31.2%
Annual benefit ($/part.)	$4.63	$0.54	$2.13	$1.57

Program	Energy Saving Kits	Multifamily Wx	Non-Profit Energy Efficiency	Single-Family Wx
Participants	34,667	1,383	11	3,128
Customer Calls				
Ave. # per year per LI cust.	3.034	2.911	2.911	2.639
Reduction due to program	-21.1%	-15.7%	-24.7%	-17.6%
Annual benefit ($/part.)	$0.08	$0.06	$0.09	$0.06

3. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report[129]
   Affordability and hardship-related impacts were estimated in this study using a participant survey and relative valuation methodology. The following question battery provides an example of what participants were asked.

   - Overall, have you noticed any change in your ability to pay your energy or other bills from the measures installed under the Weatherization Program? [If "yes", probe for positive or negative change.]
   - [If positive change impact] Think about the value you experienced from this benefit – would you say it is or more value, less value, or the same value to you as any possible energy savings you may have received from the program? [If more or less valuable, probe for much less, somewhat less, somewhat more, or much more valuable]
   - [If negative change impact] Is the impact of this change to you more costly, less costly, or the same cost as the possible energy savings? [If more or less costly, probe for much less, somewhat less, somewhat more, or much more costly.]
   - [If positive or negative change impact but can't assign a relative value] On a scale of 0 to 5 with 0 meaning "not at all important" and 5 meaning "extremely important", how important to you is the [positive/negative] change in your ability to pay your energy or other bills?

   The table below provides estimates of the affordability and hardship-related impacts examined by this study.

Table III-17
WI WAP Study Hardship Estimates

Non-Energy Impact	Share of Benefits	Annual Benefit ($/Participant)	
		Low	High
Ability to control energy bill or understanding of energy use	11%	$28	$36
Ability to pay energy/other bills	8%	$22	$29
Number of bill payment or shutoff notices received	3%	$9	$12

[129] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.

Non-Energy Impact	Share of Benefits	Annual Benefit ($/Participant)	
		Low	High
Number of calls to utility related to bills	NA	$4	$6
Likelihood of moving because of energy costs	<1%	$1	$1

E. Operation and Maintenance Impacts

The following impacts are examined in this section.

- Home Durability
- Equipment Maintenance
- Lighting Maintenance
- Tenant Complaints

The following studies provide estimates of impacts on operations and maintenance.

1. Residential and Low-Income Non-Energy Impacts Study (Massachusetts).[130]
2. Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure (Massachusetts)[131]
3. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[132]
4. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin)[133]
5. Mid-Atlantic Technical Reference Manual Version 6.0 (Mid-Atlantic)[134]

The methodologies and results from these studies are described below.

[130] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

[131] Clendenning and Abraham (2013). Massachusetts Residential Non-Energy Impacts (NEIs): Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure. Memo by NMR Group, Inc. to Tetra Tech and National Grid. July 15, 2013.

[132] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.

[133] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.

[134] Shelter Analytics (2016). Mid-Atlantic Technical Reference Manual Version 6.0. Prepared for Northeast Energy Efficiency Partnerships, Inc. (NEEP) by Shelter Analytics. May 2016.

1. Residential and Low-Income Non-Energy Impacts Study (Massachusetts).[135]
This study estimated impacts on home durability, equipment maintenance, lighting maintenance, and tenant complaints.

Home Durability
This study estimated impacts on home durability/need for repairs for low-income and non-low-income program participants using a participant survey. Participants were asked a battery of questions to elicit their estimate of the value of changes in home durability. Respondents were generally asked the following.

- Whether their home was more durable and less prone to needing repairs, less durable and more prone to needing repairs, or there was no difference in the durability of their home because of the energy efficiency improvements that were made.
- The relative value of the change in home durability compared to an estimate of the annual energy bill savings typically achieved by homes installing the same measures. Respondents could respond in absolute dollar terms or as a percentage of the estimate of annual energy savings provided by the interviewer.

After removing outliers, the sample from which the impacts were estimated was 185 low-income households and 173 non-low-income households. Estimates of home durability impacts were scaled to the respondent's estimate of the value of the total NEI of participating in the program.

- Home durability benefit per year per low-income (LI) participant = $35, or 8% of bill savings ($21 to $48, or 5% to 11% of bill savings, at 90% confidence level)

- Home durability benefit per year per non-low-income (NLI) participant in Retrofit Programs = $49, or 12% of bill savings ($30 to $67, or 8% to 16% of bill savings, at 90% confidence level)

This study also estimated home durability impacts for owners of low-income multifamily buildings using results from a survey of owners. Building owner respondents were asked a battery of questions to elicit their estimate of the value of changes in home durability. Building owner respondents were generally asked the same questions as those outlined above for household participants to estimate the value of home durability impacts.

The home durability benefit per year per housing unit for owners was estimated to be $36.85. Estimates were based on relative valuation by owners/managers representing 22 of the 27 low-income multifamily buildings in the owner survey sample.

Equipment Maintenance
This study estimated impacts on equipment maintenance for low-income and non-low-income program participants using a participant survey. Respondents were asked a battery

[135] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

of questions to elicit their estimate of the value of changes in equipment maintenance costs. Only respondents who replaced equipment received this battery of questions. Respondents were generally asked the following questions.

- Whether, in terms of the maintenance requirements or reliability of their heating and cooling equipment, their heating and cooling equipment required less maintenance and was more reliable, required more maintenance and was less reliable, or there was no difference in the maintenance requirements or reliability of their heating and cooling equipment because of the energy efficiency improvements that were made.
- The relative value of the change in equipment maintenance requirements compared to an estimate of the annual energy bill savings typically achieved by homes installing their measures. Respondents could respond in absolute dollar terms or as a percentage of the estimate of annual energy savings provided by the interviewer.

After removing outliers, the sample from which the impacts were estimated was 122 low-income households and 117 non-low-income households. Estimates of equipment maintenance impacts were scaled to the respondent's estimate of the value of the total NEI of participating in the program.

- Equipment maintenance benefit per year per low-income (LI) participant = $54, or 12% of bill savings ($34 to $74, or 8% to 16% of bill savings, at 90% confidence level)
- Equipment maintenance benefit per year per non-low-income (NLI) participant in Retrofit Programs = $124, or 36% of bill savings ($92 to $157, or 25% to 46% of bill savings, at 90% confidence level)

This study also estimated equipment maintenance impacts for owners of low-income multifamily buildings using results from a survey of owners. Building owner respondents were asked a battery of questions to elicit their estimate of the value of changes in equipment maintenance costs. Only building owner respondents who replaced equipment received this battery of questions. Building owner respondents were generally asked the same questions as those outlined above for household participants to estimate the value of equipment maintenance impacts.

The equipment maintenance benefit per year per housing unit for building owners was estimated to be $3.91. Estimates were based on relative valuation by owners/managers representing 4 of the 27 low-income multifamily buildings in the owner survey sample.

Lighting Maintenance

This study estimated impacts on lighting maintenance for owners of low-income multifamily buildings using a survey. Building owner respondents were asked a battery of questions to elicit their estimate of the value of changes in lighting maintenance costs. [Only building owner respondents who replaced equipment received this battery of questions.] Building owner respondents were generally asked the following:

- Whether, after installing the energy efficient lighting, their lighting required less maintenance, required more maintenance, or there was no difference in the lighting maintenance requirements. [Note: the question stem identified for building owner

respondents that the energy efficient lighting they installed, in addition to saving energy, generally has a longer lifetime and may require less maintenance than incandescent lighting.]

- The relative value of the change in lighting maintenance requirements compared to an estimate of the annual energy bill savings typically achieved by buildings installing the same measures. Building owner respondents could respond in absolute dollar terms or as a percentage of the estimate of annual energy savings provided by the interviewer.

The lighting maintenance benefit per year per housing unit for building owners was estimated to be $66.73. Estimates were based on relative valuation by owners/managers representing 12 of the 27 low-income multifamily buildings in the owner survey sample.

Tenant Complaints

This study estimated impacts on tenant complaints for owners of low-income multifamily buildings using a survey. Building owner respondents were asked a battery of questions to elicit their estimate of the value of reduced tenant complaints. Building owner respondents were generally asked the following:

- Whether, in terms of the number of complaints made by their tenant, their tenant made fewer complaints, more complaints, or there was no difference in the number of complaints made because of the energy efficiency improvements.
- The relative value – either positive or negative – of the change in the number of tenant complaints compared to an estimate of the annual energy bill savings typically achieved by buildings installing the same measures. Building owner respondents could respond in absolute dollar terms or as a percentage of the estimate of annual energy savings provided by the interviewer.

The tenant complaint benefit per year per housing unit for building owners was estimated to be $19.61. Estimates were based on relative valuation by owners/managers representing 20 of the 27 low-income multifamily buildings in the owner survey sample.

2. Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure (Massachusetts)[136]

This study updated previous estimates by the authors (NMR 2011)[137] of increased home durability resulting from non-low-income residential heating system, cooling system, heating and cooling system, heating and hot water system, and hot water system measures to account for replacing equipment on failure (ROF). The general formula used to adjust NEI values by measure type is shown below. The following example demonstrates the calculation for Central AC/Heat Pump cooling system measures.

[136] Clendenning and Abraham (2013). Massachusetts Residential Non-Energy Impacts (NEIs): Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure. Memo by NMR Group, Inc. to Tetra Tech and National Grid. July 15, 2013.

[137] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

- ROF-Adjusted NEI Value per Year for Increased Home Durability = (Attribution factor for EE Portion of NEI=33% * Full NEI Value per Year for Quieter Indoor Environment=$1.54) * ROF%=35.4% + [Full NEI Value per Year for Quieter Indoor Environment=$1.54 * (1 – ROF%=35.4%)]
  = $1.17 per year

  - The attribution factor for EE portion of the NEI was based on professional judgment/review of NEI literature by authors.
  - The Replace on Failure (ROF) was claimed as 35.4% by the PAs for this measure.

The table below provides the ROF-adjusted NEI value per year for home durability for measures examined in the study.

Table III-18
MA Early Replacement Study Home Durability Estimates

Measure Category	Measure	Full NEI Value	EE Portion of NEI	ROF NEI Value	ROF %	ROF-Adjusted NEI Value
Cooling	Central AC/Heat Pump	$1.54	33%	$0.51	35.4%	$1.17
Heating & Cooling	Ductless Mini-Split	$1.98	33%	$0.65	1.3%	$1.96
Heating	Boilers >90% & <96% AFUE	$17.42	33%	$5.75	86.5%	$7.33
	Boiler >=96% AFUE	$17.42	33%	$5.75	86.8%	$7.30
	Furnaces >=95% AFUE	$17.42	33%	$5.75	88.4%	$7.10
Heating & Hot Water	Integrated Boiler/Water Heater	$0.72	33%	$0.24	67.9%	$0.39
Hot Water	Storage Water Heater	$2.13	33%	$0.70	58.4%	$1.30
	Tankless Water Heater	$2.13	33%	$0.70	63.4%	$1.23

3. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[138]
   This study estimated NEIs related to appliance function from the participant-perspective using a participant survey.
   - The survey instrument was not included in the report, therefore, the specific questions asked of respondents are not known.
   - For each type of NEI that was considered in the study, respondents were generally asked whether they experienced a change in that NEI category either positive or negative, as a result of the program.
   - If the respondent indicated that there was a change, s/he was then asked about the value of that change relative to their estimated energy savings.

[138] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.

- The NEI categories included in the survey were reorganized to provide the categories of most interest to the study sponsor. "Appliance Function" was created from lighting, noise, and maintenance categories. The table below provides estimates for the "Appliance Function" impact.

Table III-19
CO Low-Income Energy Efficiency Study Appliance Function Estimates

Program	Annual Benefit for Appliance Function ($/Participant)
Energy Savings Kits	$9.40
Multifamily Weatherization	$63.48
Non-Profit Energy Efficiency	$576.62
Single-Family Weatherization	$62.14

4. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin)[139]
This study estimated impacts on equipment maintenance and lighting maintenance.

Equipment Maintenance
Equipment maintenance impacts were estimated in this study using a participant survey and relative valuation methodology. The following question battery provides an example of what participants were asked.

- Overall, have you noticed any change in equipment performance or features from the measures installed under the Weatherization Program? [If "yes", probe for positive or negative change.]
- [If positive change impact] Think about the value you experienced from this benefit – would you say it is or more value, less value, or the same value to you as any possible energy savings you may have received from the program? [If more or less valuable, probe for much less, somewhat less, somewhat more, or much more valuable]
- [If negative change impact] Is the impact of this change to you more costly, less costly, or the same cost as the possible energy savings? [If more or less costly, probe for much less, somewhat less, somewhat more, or much more costly.]
- [If positive or negative change impact but can't assign a relative value] On a scale of 0 to 5 with 0 meaning "not at all important" and 5 meaning "extremely important", how important to you is the [positive/negative] change in equipment performance or features?

The table below provides estimates of the equipment maintenance impacts examined by this study.

[139] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.

Table III-20
WI WAP Study Equipment Maintenance Estimates

Non-Energy Impact	Share of Total Benefits	Annual Benefit ($/Participant)	
		Low	High
Reliability/amount to maintain new equipment	7%	$19	$24
Equipment performance or features	5%	$14	$18

Lighting Maintenance

Lighting quantity or quality impacts were estimated in this study using a participant survey and relative valuation methodology. Participants were asked the following question battery.

- Overall, have you noticed any change in the quantity or quality of lighting from the measures installed under the Weatherization Program? [If "yes", probe for positive or negative change.]
- [If positive change impact] Think about the value you experienced from this benefit – would you say it is or more value, less value, or the same value to you as any possible energy savings you may have received from the program? [If more or less valuable, probe for much less, somewhat less, somewhat more, or much more valuable]
- [If negative change impact] Is the impact of this change to you more costly, less costly, or the same cost as the possible energy savings? [If more or less costly, probe for much less, somewhat less, somewhat more, or much more costly.]
- [If positive or negative change impact but can't assign a relative value] On a scale of 0 to 5 with 0 meaning "not at all important" and 5 meaning "extremely important", how important to you is the [positive/negative] change in the quantity or quality of lighting?

The table below provides estimates of the lighting quantity or quality and related impacts examined by this study.

Table III-21
WI WAP Study Lighting Maintenance Estimates

Non-Energy Impact	Share of Total Benefits	Annual Benefit ($/participant)	
		Low	High
Quantity or quality of your lighting	7%	$19	$25

5. Mid-Atlantic Technical Reference Manual Version 6.0 (Mid-Atlantic)[140]

[140] Shelter Analytics (2016). Mid-Atlantic Technical Reference Manual Version 6.0. Prepared for Northeast Energy Efficiency Partnerships, Inc. (NEEP) by Shelter Analytics. May 2016.

This TRM estimates the O&M cost savings for the following residential lighting measures.

- CFL lamps (residential interior & in-unit multifamily; multifamily common areas; and residential exterior),
- CFL fixtures (residential interior & in-unit multifamily; multifamily common areas; and residential exterior)
- Solid State Lighting (residential interior & in-unit multifamily; and multifamily common areas).

The TRM estimates the Net Present Value (NPV) for these measures using a 5% real discount rate. The general methodology used is described below with an example demonstrating the calculation.

Due to provisions in the Energy Independence and Security Act of 2007 (EISA) that requires certain efficiency criteria for all lamps by January 1, 2020, the measure lives for CFL Lamps and CFL Fixtures included in this analysis should be adjusted according to the year in which they were implemented. For example, a residential interior CFL lamp with a five-year measure life implemented in 2015 should be counted with a five-year measure life for this analysis. The same lamp implemented in 2016 should be counted with a four-year measure life for this analysis, and the same lamp implemented in 2017 should be counted with a three-year measure life for the analysis. Accordingly, NEI value estimates impacted by the provisions of EISA show separate NPV values for O&M impacts based on the year the measure was implemented (2015, 2016, or 2017).

- Step 1: Determine number of replacement lamps (baseline and EE measure) per year over the measure lifetime=varies by measure type
- Step 2: Determine the replacement costs (baseline and EE measure) per year = Multiply Step 1 by the component cost (lamp cost=varies by measure type)
- Step 3: Determine the avoided replacement costs per year = replacement costs per baseline measure – replacement costs per EE measure
- Step 4: Calculate the NPV of the avoided replacement costs from Step 3 then multiply by the installation rate (ISR) for the measure=varies by measure

The following example demonstrates the calculation for Residential Interior & In-Unit Multifamily CFL Lamps.

- Annual Operating Hours = 898 hours
- Measure Life = 5 years
- Baseline Life = 1,000 hours, or 1.1 years (1,000 / 898)
- Baseline Replacement Lamp Cost = $1.40 per replacement
- Replacement Cost Per Year = $1.26 ($1.40 / 1.1 years baseline life)
- Discount Rate = 5.0%
- Installation Rate (ISR) = 0.86

Table III-22
Mid-Atlantic TRM Lighting Equipment Estimates

Program Year	Replacement Cost Per Year					NPV (R=5%, ISR=0.86)
	2015	2016	2017	2018	2019	
PY 2015	$0.00	$1.26	$1.26	$1.26	$1.26	$3.83
PY 2016	$0.00	$0.00	$1.26	$1.26	$1.26	$2.94
PY 2017	$0.00	$0.00	$0.00	$1.26	$1.26	$2.01

F. Water Usage Impacts

The following studies provide estimates of impacts of decreased water usage.

1. Assessment of Energy and Cost Savings for Homes Treated under Wisconsin's Home Energy Plus Weatherization Program (Wisconsin).[141]
2. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin).[142]
3. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[143]

Below we describe how these studies estimated the water savings.

1. Assessment of Energy and Cost Savings for Homes Treated under Wisconsin's Home Energy Plus Weatherization Program (Wisconsin).[144]
   This study described a cost savings methodology from water conservation measures (low-flow showerheads and faucet aerators) by applying a representative water and sewer rate to typical water savings based on an engineering approach. Some, but not all inputs were specified, and the "representative water and sewer rate" was unavailable. Formulas were not specified and estimates were not provided.

   This study estimated the value of water conservation measures (low-flow showerheads and faucet aerators) to be $17 to $19 per year per household.

[141] Ashleigh Keene, Scott Pigg, and Robert Parkhurst (2017). Assessment of Energy and Cost Savings for Homes Treated under Wisconsin's Home Energy Plus Weatherization Program. Prepared for Wisconsin Department of Administration, Division of Energy, Housing and Community Resources. Research by Seventhwave; submitted by Wisconsin Energy Conservation Corporation. March 24, 2017.
[142] Lisa Skumatz, John Gardner, Laura Schauer, and Pam Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Prepared for Wisconsin Department of Administration, Division of Energy. Prepared by Skumatz Economic Research Associates (SERA), Inc.; contributions by PA Government Services. September 30, 2005.
[143] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.
[144] Ashleigh Keene, Scott Pigg, and Robert Parkhurst (2017). Assessment of Energy and Cost Savings for Homes Treated under Wisconsin's Home Energy Plus Weatherization Program. March 24, 2017.

The representative water and sewer rate was $7.50 per 1,000 gallons (median water and sewer rate for about 400 municipalities in Wisconsin, based on "Residential Water Use: Cost and Savings Calculator for WI").

The following inputs were used for water usage and cost savings from showerheads.

- Number of household members per participating home = 2.5
- Number of showers per person per day = 0.75
- Length per shower (in minutes) = 7.5
- Reduction in shower flow rate (in gallons/minute) = 0.5

The following inputs were used for water usage and cost savings from faucet aerators.

- Number of household members per participating home = 2.5
- Water usage per person per day (in gallons) = 14
- Fixture flow affected by the restrictor replacement = 50%
- Reduction in flow = 50%

2. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin).[145]
This study estimates the water bill savings resulting from water heating measures that also reduce the amount of water used. Water bill savings were estimated using research from the water conservation literature and "Water Plan" model, and a survey of 10 indicator communities in the State of Wisconsin. Water bill savings were estimated as follows.
   - Annual water bill savings = [Estimated water savings from program=2,140 gallons per household per year or 2.9 hundred cubic feet (ccf) per household per year[146]] * [Water rate=$1.71 per ccf[147]]
     = $4.89 per household per year

Impacts on water bill costs also were estimated in this study using a participant survey and relative valuation methodology. The study does not address the potential for double-counting this benefit using these two methodologies. Participants were asked the following question battery about environmental impacts.

- Overall, have you noticed any change in your impact on the environment from the measures installed under the Weatherization Program? [If "yes", probe for positive or negative change.]
- [If positive change impact] Think about the value you experienced from this benefit – would you say it is or more value, less value, or the same value to you as any possible energy savings you may have received from the program? [If more or less valuable, probe for much less, somewhat less, somewhat more, or much more valuable]

[145] Lisa Skumatz, John Gardner, Laura Schauer, and Pam Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. September 30, 2005.
[146] Computation of average gallon savings from SERA research from the water conservation literature and "Water Plan" model. Almost half (47%) of program participants received low-flow faucet aerators and about one-third (37%) received low-flow showerheads.
[147] Water rate based on SERA survey of 10 indicator communities in Wisconsin.

- [If negative change impact] Is the impact of this change to you more costly, less costly, or the same cost as the possible energy savings? [If more or less costly, probe for much less, somewhat less, somewhat more, or much more costly.]
- [If positive or negative change impact but can't assign a relative value] On a scale of 0 to 5 with 0 meaning "not at all important" and 5 meaning "extremely important", how important to you is the [positive/negative] change in your impact on the environment?

The table below provides estimates of the water usage impacts examined by this study.

Table III-23
WI WAP Water Savings Estimates

Non-Energy Impact	Share of Total Benefits	Annual Benefit ($/Participant)	
		Low	High
Water Bill Costs	3%	$8	$10

3. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[148]
   This study estimated the water and wastewater usage reduction impact resulting from the Energy Savings Kits program for low-income households using an engineering approach. This was their only program that included water measures.

   - Water and wastewater savings = [% of households receiving aerators (program data) * water savings per aerator in gallons (literature) + (% of households receiving low-flow showerheads (program data) * water savings per showerhead in gallons (literature)] * [water rate per unit + sewer rate per unit (from utility or research)] = $22.81 per participant per year

G. *Economic Impacts*

The following studies provide estimates of the macroeconomic impacts of residential energy efficiency programs.

1. New Jersey Natural Gas 2015 SAVEGREEN Evaluation – Final Report (New Jersey)[149]
2. South Jersey Gas 2016 Energy Efficiency Program Evaluation Final Report (New Jersey)[150]
3. Ohio EPP Process Evaluation Final Report (Ohio)[151]

[148] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.
[149] APPRISE Incorporated (2015). New Jersey Natural Gas 2015 SAVEGREEN Evaluation Final Report. December 2015.
[150] APPRISE Incorporated (2016). South Jersey Gas 2016 Energy Efficiency Program Evaluation Final Report. August 2016.
[151] APPRISE Incorporated (2003). Ohio EPP Process Evaluation Final Report. October 2003.

4. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin)[152]
5. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[153]
6. Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report (New York)[154]
7. Economic Impacts of Green Jobs Green New York (GJGNY) Program Report (New York)[155]

The estimation methodology and results from each of these studies is described below.

1. New Jersey Natural Gas 2015 SAVEGREEN Evaluation – Final Report (New Jersey)[156]
   This study estimates the macroeconomic impact from NJNG SAVEGREEN's Residential Enhanced Rebate (Rebate) and Residential Home Performance with Energy Star On-Bill Financing and Rebate (HPwES OBRP) programs.

   Output and employment changes were calculated using the following formulas.
   - Output Change ($) = Expenditures * (Output Multiplier with Program – Output Multiplier without Program)
     = $9,864,167 total output impact of both programs (Rebate and HPwES OBRP)

   - Employment Change (job years) = (1/$1,000,000) * Expenditures * (Employment Multiplier with Program – Employment Multiplier without Program)
     = 495 total jobs impact of both programs (Rebate and HPwES OBRP)

   To calculate the macroeconomic impact of the program, a simplified model of the savings and expenditures that result from the program was developed. The model output represents the net economic impact since it considers how funds would be spent in the absence of the program. The list below is a simplified list of all sources of economic impact for the Rebate and HPwES programs.
   - NJNG Administrative Spending data were provided by NJNG.
   - NJNG Program Incentives were estimated using the number of participants provided by NJNG and program average costs per participant.

[152] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.
[153] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.
[154] Rohit Vaidya and Beth Poulin (2013). Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by NMR Group, Inc. November 2013.
[155] Elizabeth Johnston, Federico Garcia, and Daniel Vickery (2013). Economic Impacts of Green Jobs Green New York (GJGNY) Program Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by ICF International, Inc. November 2013.
[156] APPRISE Incorporated (2015). New Jersey Natural Gas 2015 SAVEGREEN Evaluation Final Report. December 2015.

- Customer Net Costs were estimated using average project cost minus rebates, times the number of participants.
- Participant Natural Gas Savings for the average participant were estimated with an energy usage impact analysis with usage data provided by NJNG, multiplied by the cost per unit of natural gas ($0.95/Therm), discounted over the lifetime of the measure (15 years, 3% discount rate).
- Spending Location was assumed to be within New Jersey for all of these sources.
- Each source of economic impact was matched with the appropriate industry multiplier from the Regional Input-Output Modeling System II (RIMS-II), produced by the Bureau of Economic Analysis (BEA).
- RIMS-II Type II multipliers were used because these include not only direct and indirect effects but also induced effects. To account for local supply conditions, the multipliers were adjusted for Monmouth County and Ocean County, NJ.

2. South Jersey Gas 2016 Energy Efficiency Program Evaluation Final Report (New Jersey)[157]

   This study estimates the macroeconomic impact from SJG's Residential HVAC Loan Program (HVAC) and Residential Home Performance with Energy Star Loan Program (HPwES).

   Output and employment changes were calculated using the following formulas.

   - Output Change ($) = Expenditures * (Output Multiplier with Program – Output Multiplier without Program)
     = $833,312 total output impact of both programs (HVAC and HPwES)

   - Employment Change (job years) = (1/$1,000,000) * Expenditures * (Employment Multiplier with Program – Employment Multiplier without Program)
     = 133 total jobs impact of both programs (HVAC and HPwES)

   To calculate the macroeconomic impact of the program, a simplified model of the savings and expenditures that result from the program was developed. The model output represents the net economic impact since it considers how funds would be spent in the absence of the program. The list below is a simplified list of all sources of economic impact for the HVAC and HPwES programs.

   - SJG Administrative Spending data were provided by SJG.
   - SJG Program Incentives were estimated using the number of participants (program data), average loan amounts (program data), and average rebate amounts (program data and program rules).
   - Customer Net Costs of each project was estimated using the average project cost minus the rebate and loan amounts.
   - Participant Natural Gas Savings for the average participant were estimated through energy usage impact analysis with usage data provided by SJG, multiplied by the cost

[157] APPRISE Incorporated (2016). South Jersey Gas 2016 Energy Efficiency Program Evaluation Final Report. August 2016.

per unit of natural gas ($1.227/ccf), discounted over the lifetime of the measure (15 years, 3% discount rate).

- It was assumed that all spending from these sources occurred within New Jersey.
- Each source of economic impact was matched with the appropriate industry multiplier from the Regional Input-Output Modeling System II (RIMS-II), produced by the Bureau of Economic Analysis (BEA).
- RIMS-II Type II multipliers were used because these include not only direct and indirect effects but also induced effects. To account for local supply conditions, the multipliers were adjusted for Atlantic County, Burlington County, Camden County, Cape May County, Cumberland County, Gloucester County, and Salem County, NJ.

3. Ohio EPP Process Evaluation Final Report (Ohio)[158]

This study estimates the macroeconomic impact from Ohio's Electric Partnership Program (EPP). The study utilized expenditure multipliers developed from a literature review of other usage reduction programs and other government programs to develop an estimate for the projected economic impacts of the EPP. The following impacts were estimated for the program.

- Output increases from program expenditures (net change): $580,267
- Employment increases from program expenditures: 227 jobs
- Output increases from program net benefits (net change): $389,259

The EPP expenditures result in two sets of economic benefits:

- Expenditure of state funds: Program expenditures on energy conservation replace funds that otherwise would be spent subsidizing electric bills of PIPP customers. Because expenditures on energy conservation are more likely to be spent on labor, and are more likely to be spent on in-state supplies, these expenditures have a greater multiplier effect for Ohio's economy than does subsidizing electric bills of PIPP customers. The positive economic impact from these expenditures is the following.
  - Economic benefit from EPP expenditures = [(Multiplier for energy conservation – Multiplier for electric expenditures) * EPP expenditures in Ohio] – (Multiplier for electric expenditures * EPP expenditures outside of Ohio)

- Reduction in ratepayer subsidy: In addition to substituting expenditures on the program for expenditures on electricity, an additional reduction in expenditures on electricity results in the form of a reduced PIPP rider and therefore reduced subsidy by the Ohio ratepayers. Because Ohio ratepayers spend less on electricity as a result of the program, they have more disposable income to spend on other consumer goods. However, because some of the program net benefits were saved rather than spent, the positive economic impact from this effect is the following.
  - Economic benefit from EPP net benefits = [(Multiplier for consumer goods – Multiplier for electric expenditures) * net benefits spent] – (Multiplier for electric expenditures * net benefits saved)

[158] APPRISE Incorporated (2003). Ohio EPP Process Evaluation Final Report. October 2003.

Details on the estimation are descried below.

- Program expenditures were broken down by category.
- The study estimated the percent of expenditures, by category, which occurred within Ohio.
- Lifetime savings and net benefits of the EPP program were estimated for audits completed from the beginning of the program through March 2003.
- Economic multipliers were based on a literature review of input-output models for the State of Ohio.[159]

The following is an example of the calculation of output and employment increases for EPP expenditures.

- Net Change in Output for "Measures" Spending Category = [Increase in output in Ohio=$1,363,424] – [Missed increase in output due to spending outside of Ohio=$698,815]
  = $664,609
  - Increase in output in Ohio = ([Multiplier with the EPP=1.74] – [Default Multiplier=1.43]) * [Expenditures in Ohio=$4,398,142]
    = $1,363,424
  - Missed increase in output due to spending outside of Ohio = [Default Multiplier=1.43] * [Expenditures outside of Ohio=$488,682]
    = $698,815
- Net Change in Employment for "Measures" Spending Category = [Increase in employment in Ohio=155.3] – [Missed increase in employment due to spending outside of Ohio=3.4]
  = 151.9
  - Increase in employment in Ohio = ([Multiplier with the EPP=42.2/$1,000,000] – [Default Multiplier=6.9/$1,000,000]) * [Expenditures in Ohio=$4,398,142]
    = 155.3
  - Missed increase in employment due to spending outside of Ohio = [Default Multiplier=6.9/$1,000,000] * [Expenditures outside of Ohio=$488,682]
    = 3.4

[159] Output multipliers from from Sporleder, Thomas L., Jeffrey D. Layman, and Jessica E. Esch (2001) "Estimated Increases in Ohio Economic Activity from a New Ethanol Processing Facility," Ohio State University, Agricultural, Environmental, and Development Economics, Report Series AEDE-RP-007-01. Employment multipliers come from Laitner, Skip, John DeCicco, Neal Elliott, Howard Geller, and Marshall Goldberg (1994) "Energy Efficiency as an Investment in Ohio's Economic Future," American Council for an Energy-Efficient Economy, Washington, D.C.

4. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin)[160]
   This study estimates the economic impact of the Weatherization Assistance Program in Wisconsin. An input-output model was used to estimate impact on economic output, labor income, and employment (jobs). The following multipliers were taken from the literature[161]. While the report from which these multipliers were taken was Wisconsin-based, the study authors do not discuss these multipliers in detail.
   - Output multiplier = 1.057
   - Labor income multiplier = 0.577
   - Employment multiplier = 0.000023

   These multipliers were applied to the average spending per program participant ($4,837) to derive the program lifetime total economic impact. Because the weatherization program has an average measure lifetime of 15 years, the study authors divided the program lifetime total economic impact by 15 to obtain the per-participant, per-year economic impacts of the program. These impacts were not discounted.
   - Change in economic output per participant per year = [Average spending per participant=$4,837] * [Output multiplier=1.057] / 15 years
     = $341

   - Change in labor income per participant per year = [Average spending per participant=$4,837] * [Labor income multiplier=0.577] / 15 years
     = $187

   - Change in employment (jobs) per participant per year = [Average spending per participant=$4,837] * [Employment multiplier=0.000023]
     = 0.11

5. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[162]
   This study estimated the macroeconomic impact of low-income energy efficiency programs on jobs using the following methodologies.
   - Job impacts were estimated using a third-party input-output model for program-relevant industry sectors, netting out the jobs/economic activity that would have occurred in the absence of the program (assuming the funds would have been spent on energy generation.

[160] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.
[161] Economic multipliers taken from: Sherman, Mike, Lisa Petraglia, and Glen Weisbrod, (Economic Development Research Group Inc.), State of Wisconsin Department of Administration Division of Energy, Low-income Public Benefits Evaluation, Economic Development Benefits, Final Report. May 2, 2003.
[162] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.

- A negative sign on the output and jobs multipliers indicates that the program included mostly (or all) measures that were not made in Colorado.
- A positive sign on the output and jobs multipliers indicates that the program resulted in net job and economic activity, beyond the levels that would have occurred in the power generation in the absence of the program.

The table below provides the output and jobs multipliers and estimated impacts for each program.

Table III-23
CO Low-Income Energy Efficiency Economic Impact Estimates

Program	Output Multiplier	Jobs Multiplier	Job Impact Value ($/Participant per Year)
Energy Savings Kits	–1.07	–0.24	–$1.26
Multifamily Weatherization	+0.35	+0.27	$7.93
Non-Profit Energy Efficiency	+0.35	+0.27	$301.63
Single-Family Weatherization	+0.35	+0.27	$18.69

6. Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report (New York)[163]
This study estimated the job impacts from Green Jobs Green New York Program (GJGNY). Job impacts were estimated using a combination of primary data collected from stakeholders through in-depth interviews and surveys, and secondary data from program databases, state agencies, and community-based organizations (CBOs). NMR Group conducted surveys of a random sample for the largest respondent groups listed below.
- Home Performance with Energy Star (HPwES) contractors
- Multifamily Performance Program (MPP) participants
- MPP performance partners

NMR Group attempted to interview all group members from the other respondent groups. The table below provides details on the survey respondent groups and number of completes for residential program activities. [Workforce Development & Training and Outreach and Marketing activities are included in this section of the report but could be included under the section on Commercial & Industrial Non-Energy Impacts since these program activities are not specific to residential or commercial programs.]

Table III-24
NY Green Jobs Green New York Economic Impact Surveys

[163] Rohit Vaidya and Beth Poulin (2013). Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by NMR Group, Inc. November 2013.

GJGNY Program/ Activity	Respondent Group	Number Surveyed	Population
Workforce Development & Training	WFD Training Partners	8	14
	WFD Training Partners/On-the-Job Training	22	36
Outreach and Marketing	CBO Training & Implementation Contractor	1	1
	GJGNY Marketer	1	1
	CBOs	18	18
Home Performance with Energy Star	Contractors	71	407
	Loan Processors & Providers	5	7
	Implementation Contractor	1	1
	Quality Assurance Contractor	1	1
Multifamily Performance Program	Performance Partners	25	39
	Participants	40	268
	Implementation Contractor	1	1
	Quality Assurance Contractor	1	1

The following general methodology for determining the job impacts of the GJGNY Program was described in the study. The estimation procedures included isolation of the GJGNY Program impacts from other ratepayer-funded programs, and results were extrapolated to the population where appropriate. The table below indicates the attribution factor assigned to each program component.

Table III-24
NY Green Jobs Green New York Economic Impact Attribution

Program Component	Attribution Factor for Program-Induced Impact	Source
GJGNY Marketing	100%	100% GJGNY Funded
Community-Based Organizations (CBOs)	100%	100% GJGNY Funded
CBO Training and Implementation	100%	100% GJGNY Funded
Workforce Development Training Partners	100%	100% GJGNY Funded
WFD On-the-Job Training Partners	100%	100% GJGNY Funded
HPwES Loan Processors and Providers	100%	100% GJGNY Funded
HPwES Program Contractors	Varies by Contractor	Survey Responses
HPwES Implementation Contractor	5.3%	% funded by GJGNY
HPwES QA Contractor	7.5%	% funded by GJGNY
MPP Performance Partners	7.5%	% funded by GJGNY
MPP Program Participants	7.5%	% funded by GJGNY
MPP Implementation Contractor	6.3%	% funded by GJGNY

Program Component	Attribution Factor for Program-Induced Impact	Source
MPP QA Contractor	9.9%	% funded by GJGNY

The following job impacts were estimated.

- 2013 New FTEs is the total number of new FTE positions added because of the GJGNY Program, from program inception through May/June of 2013. Interview respondents were asked how many FTEs they expected to hire in the next two years (by 2015) because of GJGNY activities. (Respondents who were unsure their companies' contracts with GJGNY would be extended were asked to assume that their work would continue.)
- 2013 Retained FTEs is the total number of existing FTE positions retained that would otherwise have been let go, from program inception through May/June of 2013.
- 2013 Up-Skilled and Up-Wage FTEs is the total number of existing FTE positions with increased responsibilities and wages because of the GJGNY Program, from program inception through May/June of 2013.
- 2015 Direct FTEs is the 2013 Direct FTEs (2013 New FTEs plus 2013 Retained FTEs), plus an estimate of new FTE positions that would be added because of GJGNY activities by 2015.

Job impacts were estimated for the following groups based on the survey and interview responses.

- WFD (non-OJT) Training Partners
- CBO Training & Implementation Contractor
- GJGNY Marketer
- CBOs
- Contractors
- Loan Processors & Providers
- Implementation Contractor
- Quality Assurance (QA) Contractor
- Performance Partners
- Participants
- Implementation Contractor
- QA Contractor
- Assessment Contractors
- Project Expeditor
- Lenders

Job impacts for trainees of WFD OJT Training Partners were estimated using secondary data provided by NYSERDA.

- Program tracking data (e.g., CRIS database, CBO SharePoint site)
- New York State Department of Labor (DOL) jobs for OJT positions.
- NYSERDA records for OJT positions.
- NYSERDA New Hires list for OJT jobs.

- Training partner data.
- 2013 Pace University study.[164]

The following table displays the results for the 2013 and 2015 Direct FTEs, by program initiative.

Table III-25
NY Green Jobs Green New York Job Impact Estimates

Program Initiative	2013 Direct FTEs	2015 Direct FTEs
WFD & Training	213.6	1,069.0
Outreach and Marketing	160.6	725.5
HPwES Program [Residential Program]	495.9	737.5
MPP Program [Residential Program]	28.7	49.8

The study notes: While the assignment of FTE impacts to specific program initiative is generally clear-cut, employee and hiring company names for trainees influenced by the CBOs and training partners were not available. Trainee FTEs could not be cross-checked against FTEs reported by HPwES contractors. Since it is possible that there is some overlap in FTEs, the numbers for individual initiatives should be viewed as general estimates that provide an indication of overall magnitudes rather than precise values.

7. Economic Impacts of Green Jobs Green New York (GJGNY) Program Report[165]
This study estimated the total economic impact of the job impacts of the GJGNY Program in New York. Using job and wage data from Phase I of the research,[166] the study used the IMPLAN Version 3.0 input-output model to conduct the economic analysis. Results of the study are presented in this section of the report but could be included under the section on Commercial & Industrial Non-Energy Impacts since the GJGNY Program includes a commercial program and other activities that are cross-cutting and not specific to residential programs.

In order to use the Phase I results from NMR with the IMPLAN model, the study authors took the following approach.

- NAICS to IMPLAN Crosswalk. ICF reviewed and analyzed the industry sectors (NAICS codes) associated with the direct jobs estimates from Phase I and created a

[164] PACE Energy and Climate Center (2013). Making the Right Connections: Ways to Improve Workforce Training to Better Meet Employer Needs in the Green Jobs-Green New York Program. Prepared for The New York State Energy Research and Development Authority.
[165] Elizabeth Johnston, Federico Garcia, and Daniel Vickery (2013). Economic Impacts of Green Jobs Green New York (GJGNY) Program Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by ICF International, Inc. November 2013.
[166] Rohit Vaidya and Beth Poulin (2013). Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by NMR Group, Inc. November 2013.

crosswalk with the IMPLAN industry sectors. This involved collapsing NAICS codes into the broader sectors used in the IMPLAN model.

- FTE to "Bodies" Conversion. The IMPLAN model accounts for the number of "bodies" employed, with no distinction between a part-time worker and full-time worker (i.e., each is considered one "body"). The Phase I research estimated full-time equivalent (FTE) positions, not jobs, to account for proportions of jobs supported by the GJGNY Program. To account for this difference, the study authors converted direct FTE estimates into job figures using a conversion tool provided by IMPLAN, which provide FTE-to-jobs ratios for each IMPLAN sector code. These ratios represent the percent of jobs in an industry that are full-time.
- Annualizing Income by Sector. The wage estimates from the Phase I research were provided as hourly wages. To calculate the annual income associated with all jobs in a sector, the study authors annualized the hourly wages (x 2,080, the number of full-time hours in a year), and multiplied that figure by the number of jobs in the sector.
- Estimating Wage Data. For some industries, wage estimates were not collected in the Phase I research. In these instances, the study authors used averages of other survey data or industry-specific wage data reported in the 2012 Quarterly Census of Employment and Wages (QCEW), New York State Department of Labor.

The following table displays the results for the 2013 jobs impacts by direct, indirect, induced, and overall effect.

Table III-25
NY Green Jobs Green New York Economic Impact Estimates

Impact Type	Jobs	Labor Income	GSP	Output	Jobs Multiplier	GSP Multiplier
Direct Effect	969	$54,104,000	$63,380,000	$130,295,000	1.64	1.97
Indirect Effect	268	$17,628,000	$27,035,000	$40,590,000	1.64	1.97
Induced Effect	348	$19,464,000	$34,443,000	$52,361,000	1.64	1.97
Total Effect	1,585	$91,196,000	$124,858,000	$223,246,000	1.64	1.97

H. Property Value Impacts

The following studies provide estimates of impacts of increased housing property value.

1. Residential and Low-Income Non-Energy Impacts Study (Massachusetts).[167]
2. Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure (Massachusetts)[168]

[167] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

[168] Clendenning and Abraham (2013). Massachusetts Residential Non-Energy Impacts (NEIs): Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure. Memo by NMR Group, Inc. to Tetra Tech and National Grid. July 15, 2013.

3. The Low-Income Public Purpose Test (LIPPT) – Final Report – Updated for Version 2.0 (California)[169]
4. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[170]
5. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin)[171]

The methodologies and estimates from each of these studies is provided below.

1. Residential and Low-Income Non-Energy Impacts Study (Massachusetts).[172]
   This study estimated impacts on property value for low-income and non-low-income program participants using a participant survey. Respondents who owned their homes were asked a battery of questions to elicit their estimate of the value of changes in property value. Respondents were generally asked the following.
   - 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 improvement, a lower value, or the same value?
   - The relative value – either positive or negative – of the change in property value compared to an estimate of the annual energy bill savings typically achieved by homes installing their measures. Respondents could respond in absolute dollar terms or as a percentage of the estimate of annual energy savings provided by the interviewer.

   After removing outliers, the sample from which the impacts were estimated was 143 low-income households and 157 non-low-income households. Property value estimates were not scaled to the respondent's estimate of the value of the total NEI of participating in the program because, as a one-time NEI value, it was excluded from the survey question about total annual value of NEIs.
   - Property value one-time benefit per low-income participant = $949 ($495 to $1,404 at 90% confidence level)

   - Property value one-time benefit per non-low-income participant in Retrofit Programs = $1,998 ($1,493 to $2,502 at 90% confidence level)

[169] TecMarket Works, Skumatz Economic Research, and Megdal and Associates (2001). The Low-Income Public Purpose Test – Final Report – Updated for Version 2.0. Prepared for RRM Working Group, Cost Effectiveness Committee. May 25, 2001.
[170] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.
[171] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.
[172] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

This study also estimated property value impacts and increased marketability for owners of low-income multifamily buildings using results from a survey of owners. Building owner respondents who replaced equipment were asked a battery of questions to elicit their estimate of the value of changes in property value. Building owner respondents were generally asked the same questions as those outlined above for household participants to estimate the value of property value impacts.

The one-time property value benefit per housing unit for building owners was estimated to be $17.03. Estimates were based on relative valuation by owners/managers representing 22 of the 27 low-income multifamily buildings in the owner survey sample.

Building owner respondents were asked a battery of questions to elicit their estimate of the value of changes in building marketability. Building owner respondents were generally asked the following:

- 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, or there is no difference?
- The relative value – either positive or negative – of the change in building marketability compared to an estimate of the annual energy bill savings typically achieved by buildings installing the same measures. Building owner respondents could respond in absolute dollar terms or as a percentage of the estimate of annual energy savings provided by the interviewer.

The increased marketability/ease of finding renters benefit per year per housing unit for building owners was estimated to be $0.96. Estimates were based on relative valuation by owners/managers representing 21 of the 27 low-income multifamily buildings in the owner survey sample.

2. Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure (Massachusetts)[173]

   This study updated previous estimates by the authors (NMR 2011)[174] of increased property value resulting from non-low-income residential heating system, cooling system, heating and cooling system, heating and hot water system, and hot water system measures to account for replacing equipment on failure (ROF). The general formula used to adjust NEI values by measure type is shown below. The following example demonstrates the calculation for Central AC/Heat Pump cooling system measures.

   - ROF-Adjusted NEI Value (One-Time Benefit) for Increased Property Value = [(Attribution factor for EE Portion of NEI=33%%, based on professional judgment/review of NEI literature by authors * Full NEI Value per Year for Increase

[173] Clendenning and Abraham (2013). Massachusetts Residential Non-Energy Impacts (NEIs): Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure. Memo by NMR Group, Inc. to Tetra Tech and National Grid. July 15, 2013.

[174] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

Property Value=$62.65) * ROF%=35.4%%, replace on failure rate claimed by the PAs for this measure] + [Full NEI Value per Year for Quieter Indoor Environment=$62.65 * (1 – ROF%=35.4%)]
= $51.56 (one-time benefit)

The table below provides the ROF-adjusted NEI value (one-time) for property value for measures examined in the study.

Table III-26
MA Early Replacement Property Value Impact Estimates

Measure Category	Measure	Full NEI Value	EE Portion of NEI	ROF NEI Value	ROF%	ROF-Adjusted NEI
Cooling	Central AC/Heat Pump	$62.65	33%	$31.33	35.4%	$51.56
Heating & Cooling	Ductless Mini-Split	$80.69	33%	$40.35	1.3%	$80.19
Heating	Boilers 90%-96% AFUE	$678.52	33%	$339.26	86.5%	$385.23
	Boiler >=96% AFUE	$678.52	33%	$339.26	86.8%	$384.21
	Furnaces >=95% AFUE	$678.52	33%	$339.26	88.4%	$378.61
Heating & Hot Water	Boiler/Water Heater	$29.17	33%	$14.59	67.9%	$19.27
Hot Water	Storage Water Heater	$82.56	33%	$41.28	58.4%	$58.47
	Tankless Water Heater	$82.56	33%	$41.28	63.4%	$56.39

3. <u>The Low-Income Public Purpose Test (LIPPT) – Final Report – Updated for Version 2.0 (California)</u>[175]
   Benefit per Year per Low-Income Participant = [Cost of housing improvements=$80.00[176]] * [Percent of customers receiving improvement=100%[177]] * [Adjustment factor for appropriate horizon=0.22[178]]
   = $17.80

   - This study recommends that the best estimate of the increase in property value attributable to low-income weatherization programs is the assessed valuation improvement. As a proxy for the assessed valuation improvement, the study recommends using the cost of the repairs made to the home. The benefit valuation from this source specifically excludes any energy savings contributions to avoid double-counting.

[175] TecMarket Works, Skumatz Economic Research, and Megdal and Associates (2001). The Low-Income Public Purpose Test – Final Report – Updated for Version 2.0. Prepared for RRM Working Group, Cost Effectiveness Committee. May 25, 2001.
[176] From "Program Assumptions Table".
[177] From "Program Assumptions Table".
[178] Derived from horizon and discount assumptions in "Program Assumptions Table"'.

- To be conservative, the study included estimates of the most reliable and defensible aspects of property value improvements from the program, excluding any separate aesthetic or other improvements.

4. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[179]
   This study estimated the increase in property value resulting from low-income energy efficiency programs. Program impacts were estimated using a participant survey in which respondents were asked whether they experienced an impact because of the program, and if so, whether the impact was positive or negative, and by how much relative to their estimated energy savings. The following values were estimated using this methodology.
   - Energy Savings Kits = $3.26 per participant per year
   - Multifamily Weatherization = $24.25 per participant per year
   - Non-Profit Energy Efficiency = $173.91 per participant per year
   - Single-Family Weatherization = $21.43 per participant per year

5. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin)[180]
   Property value impacts were estimated in this study using a participant survey and relative valuation methodology. Participants were asked the following question battery regarding the appearance of their home or property value.
   - Overall, have you noticed any change in the appearance of your home or property value from the measures installed under the Weatherization Program? [If "yes", probe for positive or negative change.]
   - [If positive change impact] Think about the value you experienced from this benefit – would you say it is or more value, less value, or the same value to you as any possible energy savings you may have received from the program? [If more or less valuable, probe for much less, somewhat less, somewhat more, or much more valuable]
   - [If negative change impact] Is the impact of this change to you more costly, less costly, or the same cost as the possible energy savings? [If more or less costly, probe for much less, somewhat less, somewhat more, or much more costly.]
   - [If positive or negative change impact but can't assign a relative value] On a scale of 0 to 5 with 0 meaning "not at all important" and 5 meaning "extremely important", how important to you is the [positive/negative] change in the appearance of your home or property value?

   The table below provides estimates of the property value and related impacts examined by this study.

[179] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.
[180] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.

Table III-27
WI WAP Property Value Impact Estimates

Non-Energy Impact	Share of Total Benefits	Annual Benefit ($/Participant)	
		Low	High
Appearance of home or property value	6%	$17	$22

I. Utility Rates and Arrearage Reduction Impacts

The following studies provide estimates of impacts of rate discounts and the benefits that accrue to utilities resulting from a decrease in the quantity of energy sold at a discounted rate and estimates of impacts of reduced carrying costs of arrearages that accrue as benefits to utility.

1. Residential and Low-Income Non-Energy Impacts Study (Massachusetts).[181]
2. The Low-Income Public Purpose Test (LIPPT) – Final Report – Updated for Version 2.0 (California)[182]
3. Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs (Maryland)[183]
4. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[184]

The methodologies and results from these studies are described below.

1. Residential and Low-Income Non-Energy Impacts Study (Massachusetts).[185]
   Benefit per Year per Low-Income Participant = Average program energy savings per low-income participant (PA data) * [full rate per unit energy ($) – discounted rate per unit energy ($)]

   The report did not provide an estimate of the rate discount benefit; an estimate can be determined using program data from the Program Administrator and the Program Administrator's rate discount.

   The report recommended applying the utility-perspective benefit of rate discounts to programs in which low-income participants pay discounted rates.

[181] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.
[182] TecMarket Works, Skumatz Economic Research, and Megdal and Associates (2001). The Low-Income Public Purpose Test – Final Report – Updated for Version 2.0. Prepared for RRM Working Group, Cost Effectiveness Committee. May 25, 2001.
[183] Itron, Inc. (2014). Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs. August 5, 2014.
[184] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.
[185] NMR Group (2011). Massachusetts Special and Cross-Cutting Research Area: Residential and Low-Income Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators by NMR Group, Inc. May 15, 2011.

2. The Low-Income Public Purpose Test (LIPPT) – Final Report – Updated for Version 2.0 (California)[186]
   Benefit per Year per Low-Income Participant = [Net energy (bill) savings per participant=$48.45[187]] * [Rate Subsidy=15%[188]] * [Percent of Participants Receiving Subsidy=100%] * [Adjustment factor for appropriate horizon=1.0[189]]
   = $7.27

   Lower bills for low-income participants reduce the amount of rate-subsidized energy, reducing the subsidy from other ratepayers. This NEI is applicable to programs with rate-subsidized participants (e.g. the CARE program in California).

3. Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs (Maryland)[190]
   Lifetime Present Value Arrearage Carrying Cost per Limited Income Program Participant = (Annual kWh Savings per Program Participant=1,945 kWh[191] * Statewide electric rate=$0.13/kWh[192] * Arrearage Reduction Value=2%[193]) summed and discounted=5% over the weighted average measure life for program participants
   = $55

   The study uses an Arrearage Reduction Value based on a literature review and assumes that the value is applicable to the EmPOWER Limited Income program in Maryland. The study recommends incorporating the $55 benefit to the present value benefits when calculating the TRC benefit/cost ratio for EmPOWER Limited Income programs.

4. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[194]
   This study estimated impacts on arrearages and customer shutoffs, reconnections, notices, and customer calls from the utility-perspective using program data from the utility.

   Data on the number of customer contacts (calls), shutoffs, reconnections, notices, write-offs, and arrearage values were collected from the utility for several months pre/post-

[186] TecMarket Works, Skumatz Economic Research, and Megdal and Associates (2001). The Low-Income Public Purpose Test – Final Report – Updated for Version 2.0. Prepared for RRM Working Group, Cost Effectiveness Committee. May 25, 2001.
[187] Assumed value for bill savings from program.
[188] Rate subsidy value from California utility data sheet.
[189] Derived from horizon and discount assumptions in "Program Assumptions Table".
[190] Itron, Inc. (2014). Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs. August 5, 2014.
[191] 2011 EmPOWER Limited Income Program evaluation.
[192] Average statewide residential electric rate (2013) from Electric Power Monthly, U.S. Energy Information Administration.
[193] Recommendation from SERA, Inc., based on results of 15 arrearage reduction studies. SERA, Inc. (2010). Non-Energy Benefits Report. May 2010.
[194] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.

participation and averaged to simulate a year pre/post-participation. These utility-perspective values represent gross impacts because a suitable comparison group was unavailable. Impacts were estimated according to the following specifications.

- Carrying cost on arrearages (interest) (value per participant per year) = average arrearage per low-income customer (utility data) * estimated program-induced percentage reduction in arrearages (arrearage analysis) * utility interest rate (utility provided)
  = $0.86 (Energy Savings Kits); $2.37 (Multifamily Weatherization); $31.39 (Non-Profit Energy Efficiency); $5.25 (Single-Family Weatherization)

- Shutoffs (value per participant per year) = average shutoffs per low-income customer (utility data) * estimated program-induced percentage reduction in shutoffs (arrearage analysis) * marginal cost of shutoff to utility
  =$1.48 (Energy Savings Kits); $1.99 (Multifamily Weatherization); $1.49 (Non-Profit Energy Efficiency); $0.94 (Single-Family Weatherization)

- Reconnections (value per participant per year) = average reconnections per low-income customer (utility data) * estimated program-induced percentage reduction in reconnections (arrearage analysis) * (marginal cost of reconnection to utility – reconnection fee paid by residents)
  = –$1.60 (Energy Savings Kits); –$0.33 (Multifamily Weatherization); –$1.32 (Non-Profit Energy Efficiency); –$0.66 (Single-Family Weatherization)

- Notices (value per participant per year) = average notices per low-income customer (utility data) * estimated program-induced percentage reduction in notices (arrearage analysis) * marginal cost of notices to utility
  = $0.10 (Energy Savings Kits); $0.04 (Multifamily Weatherization); $0.31 (Non-Profit Energy Efficiency); $0.07 (Single-Family Weatherization)

- Customer calls (value per participant per year) = average calls per low-income customer (utility data) * estimated program-induced percentage reduction in calls (arrearage analysis) * marginal cost per call to utility
  = $1.87 (Energy Savings Kits); $1.33 (Multifamily Weatherization); $2.10 (Non-Profit Energy Efficiency); $1.36 (Single-Family Weatherization)

In addition, the study estimated the impact of bad debt written off and reduction in emergency gas service calls from the utility-perspective, however, selected research values were used in place of utility data. Therefore, these values are not presented here.

J. *Transmission & Distribution Impacts*

The following study provided estimates of impacts of avoided transmission and distribution (T&D) system losses and the benefits that accrue as benefits to utilities.

1. The Low-Income Public Purpose Test (LIPPT) – Final Report – Updated for Version 2.0 (California)[195]

   Benefit per Year per Low-Income Participant = [Net energy savings from program per participant=308 kWh/year[196]] * [Utility avoided cost per kWh=$0.0057[197]] * [Adjustment factor for appropriate horizon=1.0[198]]
   = $1.77 (but claimed value = $0.00)

   The study recommended *excluding* the NEI of avoided T&D system losses because the energy savings figures applied in the LIPPT incorporate these avoided costs. Therefore, the study claims a value of $0.00 per year per participant for this NEI.

K. *Environmental Impacts – Avoided Emissions*

The following studies provide estimates of impacts of avoided emissions.

1. The Low-Income Public Purpose Test (LIPPT) – Final Report – Updated for Version 2.0 (California)[199]
2. Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs[200]
3. New Jersey Natural Gas 2015 SAVEGREEN Evaluation Final Report (New Jersey)[201]
4. South Jersey Gas 2016 Energy Efficiency Program Evaluation Final Report (New Jersey)[202]
5. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report[203]
6. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[204]

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[195] TecMarket Works, Skumatz Economic Research, and Megdal and Associates (2001). The Low-Income Public Purpose Test – Final Report – Updated for Version 2.0. Prepared for RRM Working Group, Cost Effectiveness Committee. May 25, 2001.
[196] Assumed value for energy savings from program.
[197] CBEE/CPUC, statewide C/E input values.
[198] Derived from horizon and discount assumptions in "Program Assumptions Table".
[199] TecMarket Works, Skumatz Economic Research, and Megdal and Associates (2001). The Low-Income Public Purpose Test – Final Report – Updated for Version 2.0. Prepared for RRM Working Group, Cost Effectiveness Committee. May 25, 2001.
[200] Itron, Inc. (2014). Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs. August 5, 2014.
[201] APPRISE Incorporated (2015). New Jersey Natural Gas 2015 SAVEGREEN Evaluation Final Report. December 2015.
[202] APPRISE Incorporated (2016). South Jersey Gas 2016 Energy Efficiency Program Evaluation Final Report. August 2016.
[203] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.
[204] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.

The methodology and estimates from these studies are described below.

1. The Low-Income Public Purpose Test (LIPPT) – Final Report – Updated for Version 2.0 (California)[205]
   This study estimates the value of avoided air emissions using "environmental adders," based on agreed-upon values adopted by the CPUC for use in cost effectiveness computations.
   - Benefit per Year per Low-Income Participant = [(Net energy savings per average participant=308 kWh/year[206] * Environmental adder per kWh=$0.0071[207]) + (Net energy savings per average participant=20 therms/year[208] * Environmental adder per therm=$0.0622[209])] * Adjustment factor for appropriate horizon=1.0[210]
     = $3.39 (but claimed value = $0.00)

   The study recommended excluding the NEI of avoided emissions because the energy savings figures applied in the LIPPT incorporate these avoided costs. Therefore, the study claims a value of $0.00 per year per participant for this NEI.

2. Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs[211]
   This study estimates the benefits of avoided air emissions (NOx, SO2, and CO2) from EmPOWER program savings in both the Residential and C&I sectors. The study notes that the air emissions benefit per kWh estimated in this analysis can be applied to any program's electric savings (with the exception of programs specific to obtaining peak savings).
   - Benefits per kWh ($/kWh) = Total Air Emissions Benefits ($) / [Total MWh Savings * 1000]
     - Total Air Emissions Benefits = MWh Savings * Emissions Intensity (lbs./MWh) * [Unit Damage Costs ($/lb.) – Unit Emissions Taxes/Fees Paid by Utilities ($/lb.)]

   Total Air Emissions Benefits and Benefits per kWh saved were estimated separately for CO2, NOx, and SO2.
   - Present Value of CO2 Benefits per Year per kWh saved = $0.67/kWh saved ($50.2 million PV over measure life)
   - Present Value of NOx Benefits per Year per kWh saved = $0.03/kWh saved ($1.9 million PV over measure life)

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[205] TecMarket Works, Skumatz Economic Research, and Megdal and Associates (2001). The Low-Income Public Purpose Test – Final Report – Updated for Version 2.0. Prepared for RRM Working Group, Cost Effectiveness Committee. May 25, 2001.
[206] From "Program Assumptions Table".
[207] From CBEE/Utility Filings for PY 2001.
[208] From "Program Assumptions Table".
[209] From CBEE/Utility Filings for PY 2001.
[210] Derived from horizon and discount assumptions in "Program Assumptions Table"'.
[211] Itron, Inc. (2014). Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs. August 5, 2014.

- Present Value of SO2 Benefits per Year per kWh saved = $0.36/kWh saved ($26.7 million PV over measure life)
- Present Value of Total Air Emissions Benefits per Year per kWh saved = $1.06/kWh saved ($78.8 million PV over measure life)

The study obtained emissions intensities data for CO2, NOx, and SO2 from PJM Environmental Information Services Electricity Generation Attribute Tracking System (EGAT). The study assumes that the EmPOWER MWh reductions coincide with the PJM average generation profile.

The study estimated CO2 damages per ton using the social cost of carbon from the Interagency Task Force212 ("central value" with a 3 percent discount rate), adjusting the value to 2013 dollars, and subtracting the 2013 Regional Greenhouse Gas Initiative (RGGI) allowance price because these allowances prices were counted in utility avoided generation cost forecasts. CO2 emissions reductions were also adjusted to reflect the projected reduction in CO2 intensity resulting from generation fuel mix changes in the future.

The study estimated NOx and SO2 damages per ton using damage per kWh values from the National Research Council (NRC 2010)[213] and adjusting the values in the following ways.

- Converting damage costs from simple averages to weighted average damage costs;
- Adjusting historical emissions intensities in NRC from 2005 values to 2013 values to account for power plant improvements and changes in generation fuel mix;
- Adjusting future emissions intensities assumptions in NRC to account for updated projected changes in generation fuel mix (but not future power plant improvements since those will presumably result in additional costs to utilities); and
- Converting damage costs from 2007 dollars to 2013 dollars.

This study provides air emissions benefits for three scenarios developed by the Cost Effectiveness Working Group for the EmPOWER Potential Study – Enhanced, Business as Usual, and Aggressive. The results were based on the Enhanced Scenario, the mid-case scenario representing the best estimate of the air emissions benefits saved by the EmPOWER programs. A real discount rate of 3.0% was used along with a CO2 price of $45/ton (after RGGI allowances) and only 50% of CO2 and criteria emissions counted. The study recommends including a 1.1 cents per kWh ($2014) environmental adder for cost-effectiveness analyses for all EmPOWER programs, with a price inflation escalator for each year of the measure life.

[212] Interagency Working Group on Social Cost of Carbon. U.S. Government, Technical Support Document – Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis – Under Executive Order 12866, May 2013.

[213] National Research Council Study (2010), *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use, Committee on Health, Environmental, and Other External Costs and Benefits of Energy Production and Consumption*.

- These values should be multiplied by the kWh saved in each year for the life of each measure to calculate the annual nominal air emissions benefits.
- These benefits should be multiplied by the net-to-gross (NTG) ratio for each measure or program and discounted like other benefits.

3. New Jersey Natural Gas 2015 SAVEGREEN Evaluation Final Report (New Jersey)[214]
This study estimates the value of avoided air emissions (CO2, SO2, NOx, PM2.5, and VOCs) for two gas efficiency programs – Residential Enhanced Rebate (Rebate) and Residential Home Performance with Energy Star On-Bill Refinancing Program (HPwES OBRP).
   - Program First Year Savings = CO2-eq savings + SO2 savings + NOx savings + PM2.5 savings + VOC saving
     - Pollutant First Year Savings = Gas Savings * Emissions Rate for Pollutant (CO2, SO2, NOx, PM2.5, or VOC) * Marginal Damage Value of Avoided Emissions for Pollutant (CO2, SO2, NOx, PM2.5, or VOC)

   - Program Lifetime Savings were discounted by 3% over a 15-year measure life.
   - The emissions rate for CO2-eq is the near-term value for upstream emissions from National Research Council (2010).
   - Emissions rates for SO2, NOx, PM2.5, and VOCs were from the EPA (1998). The NOx emissions rate is the uncontrolled value for residential furnaces, and the PM2.5 emissions rate is the value for filterable emissions.

   - The marginal damage value of CO2-eq emissions is the social cost of carbon from the Office of Management & Budget's (OMB) 2013 report, "The Social Cost of Carbon" – the most recent estimate of the social cost of carbon (SCC) by the OMB at the time of this study.
   - The marginal damage values of SO2, NOx PM2.5, and VOCs emissions were based on the Air Pollution Emission Experiments and Policy (APEEP) Model, as recommended by the National Research Council (NRC) in its 2010 report to Congress. Values from the APEEP Model for this study represent the dollar value of the emissions avoided in the State of New Jersey.
   - Marginal values were updated to 2015 dollars using the CPI-U index from BLS with data available at the time of the study.

   Emission Rate values and Marginal Damage values used in the analysis are shown in the table below.

Table III-28
NJNG Emissions Values and Marginal Damage Values

[214] APPRISE Incorporated (2015). New Jersey Natural Gas 2015 SAVEGREEN Evaluation Final Report. December 2015.

Pollutant	Emission Rate (Tons per 1,000 MMBtu)	Marginal Damage Value (2015 Dollars)
CO2-eq	62	$41.40
SO2	0.000293	$111,573
NOx	0.046	$23,023
PM2.5	0.000927	$468,563
VOC	0.00268	$44,180

Gas savings were estimated through a weather-normalized, comparison group adjusted billing analysis of natural gas usage data from the programs. First year, Lifetime, and Participant level avoided emissions are shown in the table below.

Table III-29
NJNG Gas Savings and Emissions Impacts (Program Year 2014)

Program	Natural Gas Savings (MMBtu)	Value of Emissions Reductions (Program)		Per Participant Value of emissions Reductions	
		First Year	Lifetime	First Year	Lifetime
HVAC Rebate	50,663	$213,091	$2,543,862	$31.80	$379.68
HPwES	38,032	$159,963	$1,909,622	$93.00	$1,110.25

4. South Jersey Gas 2016 Energy Efficiency Program Evaluation Final Report (New Jersey)[215]
   This study estimates the value of avoided air emissions (CO2, SO2, NOx, PM2.5, and VOCs) for two gas efficiency programs – Residential HVAC Loan (HVAC) and Residential Home Performance with Energy Star Loan Program (HPwES).

   - Program First Year Savings = CO2-eq First Year Savings + SO2 First Year Savings + NOx First Year Savings + PM2.5 First Year Savings + VOC First Year Savings
     - Pollutant (CO2-eq, SO2, NOx, PM2.5, or VOC) First Year Savings = Gas Savings * Emissions Rate for Pollutant (CO2, SO2, NOx, PM2.5, or VOC) * Marginal Value of Avoided Emissions for Pollutant (CO2, SO2, NOx, PM2.5, or VOC)

   - Program Lifetime Savings were discounted by 3% over a 15-year measure life.
   - The emissions rate for CO2-eq is the near-term value for upstream emissions from National Research Council (2010). Emissions rates for SO2, NOx, PM2.5, and VOCs were from the EPA (1998). The NOx emissions rate is the uncontrolled value for residential furnaces, and the PM2.5 emissions rate is the value for filterable emissions.
   - The marginal damage value of CO2-eq emissions is the social cost of carbon from the Office of Management & Budget's (OMB) 2013 report, "The Social Cost of Carbon"

[215] APPRISE Incorporated (2016). South Jersey Gas 2016 Energy Efficiency Program Evaluation Final Report. August 2016.

– the most recent estimate of the social cost of carbon (SCC) by the OMB at the time of this study.

- The marginal damage values of SO2, NOx PM2.5, and VOCs emissions were based on the Air Pollution Emission Experiments and Policy (APEEP) Model, as recommended by the National Research Council (NRC) in its 2010 report to Congress. Values from the APEEP Model for this study represent the dollar value of the emissions avoided in the State of New Jersey.
- Marginal values were updated to 2015 dollars using the CPI-U index from BLS with data available at the time of the study.

Emission Rate values and Marginal Damage values used in the analysis are shown in the table below.

Table III-30
SJG Emissions Values and Marginal Damage Values

Pollutant	Emission Rate (Tons per 1,000 MMBtu)	Marginal Damage Value (2015 Dollars)
CO2-eq	62	$43.32
SO2	0.000293	$110,771
NOx	0.046	$22,857
PM2.5	0.000927	$465,192
VOC	0.00268	$43,862

Gas savings were estimated through a weather-normalized, comparison group adjusted billing analysis of natural gas usage data from the programs. First year, Lifetime, and Participant level avoided emissions are shown in the table below.

Table III-31
SJG Gas Savings and Emissions Impacts (Program Year 2014-2015)

Program	Natural Gas Savings (MMBtu)	Value of Emissions Reductions (Program)		Per Participant Value of emissions Reductions	
		First Year	Lifetime	First Year	Lifetime
HVAC Rebate	14,492	$62,089	$741,213	$37.63	$449.22
HPwES	38,088	$163,309	$1,949,576	$90.33	$1,078.31

5. <u>The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin)</u>[216]

[216] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.

This study estimated the impacts of avoided air emissions for CO2, SOx, and NOx from Wisconsin's Low-Income Public Benefits Programs.

The "evaluation-verified net installed electricity savings estimate" and number of participants were not provided. As a result, the Annual Emissions Reductions and Estimated NEI Annual $ Per Participant cannot be directly verified from the Marginal Emissions Rate and the Value of Avoided Emissions.

Table III-32
WI WAP Emissions Impacts

Pollutant	Marginal Emissions Rate	Value of Avoided Emissions	Annual Emissions Reductions	Estimated NEI Annual $ Per Participant
CO2 (Generation)	2,216 lbs./MWh	$0.0163/lb.	133,301,133 lbs.	$96.58
CO2 (On-Site)	11.76 lbs./Therm			
SOx	12.2 lbs./MWh	$1.20/lb.	306,306 lbs.	$16.34
NOx	5.7 lbs./MWh	$1.73/lb.	200,639 lbs.	$15.43
Mercury	0.0489 lbs./GWh	NA	NA	NA
Total	NA	NA	NA	$128.35

- The pounds of emissions reduced were estimated using emissions rates for electric generating plants serving Wisconsin.
- The estimated generation emissions rates were derived using hourly measure emissions data from the EPA and were incorporated into a model developed by the evaluation team.
- Emissions factors for reduced use of natural gas at the customer site were also derived from EPA data. NOx and SOx emissions rates for customer site usage were not used because only small amounts of those emissions occur at the customer site.
- Wisconsin-based emissions rates and evaluation-verified net installed electricity savings were used to estimate the quantity of avoided emissions.
- Damage values from the literature were used to monetize the value of the avoided emissions. The authors indicate computing the dollars per pound of emissions as two-thirds of the average value from 15 literature sources.
- These values were used in the author's NEB-It model.

6. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[217]
   This study estimated the impacts of avoided air emissions, excluding CO2, from the societal-perspective using the author's NEB-IT model, which factors in the following inputs.

[217] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.

- State-specific generation mix from fuel sources.
- Program-estimated energy savings.
- Emissions factors from eGRID, EPA, EIA, and the IPCC.

Dollar values to monetize avoided emissions were derived from the Clean Air Conservancy, and because the low-income energy efficiency programs were not "peak"-targeting, no additional adjustments were made in that regard. Savings from avoided CO2 emissions were not counted because these were accounted for through other mechanisms by the Program Administrator.

The following values were estimated by the study.

- Energy Savings Kits = $1.28 per participant per year
- Multifamily Weatherization = $4.10 per participant per year
- Non-Profit Energy Efficiency = $81.79 per participant per year
- Single-Family Weatherization = $3.49 per participant per year

L. Environmental Impacts – Participant Valuation

The following studies estimated other environmental impacts not related to avoided air emissions.

1. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[218]
2. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report (Wisconsin)[219]

The methodology and estimates are described below.

1. Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs (Colorado)[220]

   This study estimated the value of environmental impacts from the participant-perspective using a participant survey in which respondents were asked whether they experienced an impact because of the program, and if so, whether the impact was positive or negative, and by how much relative to their estimated energy savings.

   Specifically, the participant survey asked respondents about the program's impact on "doing good for the environment". The following values were estimated by the study.

   - Energy Savings Kits = $3.38 per participant per year
   - Multifamily Weatherization = $22.13 per participant per year

[218] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.

[219] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.

[220] Lisa Skumatz (2010). Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs: Revised Report. Prepared for Xcel Energy Market Research. May 27, 2010.

- Non-Profit Energy Efficiency = $237.48 per participant per year
- Single-Family Weatherization = $21.67 per participant per year

2. The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report[221]
   Environmental impacts were estimated in this study using a participant survey and relative valuation methodology. Participants were asked the following question battery about environmental impacts.
   - Overall, have you noticed any change in your impact on the environment from the measures installed under the Weatherization Program? [If "yes", probe for positive or negative change.]
   - [If positive change impact] Think about the value you experienced from this benefit – would you say it is or more value, less value, or the same value to you as any possible energy savings you may have received from the program? [If more or less valuable, probe for much less, somewhat less, somewhat more, or much more valuable]
   - [If negative change impact] Is the impact of this change to you more costly, less costly, or the same cost as the possible energy savings? [If more or less costly, probe for much less, somewhat less, somewhat more, or much more costly.]
   - [If positive or negative change impact but can't assign a relative value] On a scale of 0 to 5 with 0 meaning "not at all important" and 5 meaning "extremely important", how important to you is the [positive/negative] change in your impact on the environment?

The table below provides estimates of the environmental impacts examined by this study.

Table III-33
Wisconsin WAP Participant Valuation of Environmental Benefits

Non-Energy Impact	Share of Total Benefits	Annual Benefit ($/Participant)	
		Low	High
Impact on the environment	2%	$4	$6

[221] Skumatz, Gardner, Schauer, and Rathbun (2005). Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report. Research by SERA, Inc. Contributions by PA Government Services, Inc. September 30, 2005.

IV. Commercial & Industrial Non-Energy Impacts

The studies that were reviewed provided estimation of residential NEIs in the following categories.

- Economic
- Operations & Maintenance

Within each section we list the studies that estimate that type of benefit and then provide a detailed description of the estimation methodology and results.

A. Economic Impacts

The following studies provide estimates of the macroeconomic impacts of programs.

1. Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report[222]
2. Economic Impacts of Green Jobs Green New York (GJGNY) Program Report[223]

The methodology and estimates are presented below.

1. Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report[224]
   This study estimates the job impacts from Green Jobs Green New York Program (GJGNY). Job impacts were estimated using a combination of primary data collected from stakeholders through in-depth interviews and surveys, and secondary data from program databases, state agencies, and community-based organizations (CBOs). NMR Group conducted surveys of a random sample for the largest respondent groups listed below.
   - Home Performance with Energy Star (HPwES) contractors
   - Multifamily Performance Program (MPP) participants
   - MPP performance partners

   NMR Group attempted to interview all group members from the other respondent groups. The table below provides details on the survey respondent groups and number of completes. [Workforce Development & Training and Outreach and Marketing activities are not included in this section of the report; impacts for these program activities are included in the section on Residential Non-Energy Impacts but could be included here under Commercial & Industrial Non-Energy Impacts.]

[222] Rohit Vaidya and Beth Poulin (2013). Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by NMR Group, Inc. November 2013.
[223] Elizabeth Johnston, Federico Garcia, and Daniel Vickery (2013). Economic Impacts of Green Jobs Green New York (GJGNY) Program Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by ICF International, Inc. November 2013.
[224] Rohit Vaidya and Beth Poulin (2013). Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by NMR Group, Inc. November 2013.

Table IV-1
NY Green Jobs Green New York Economic Impact Surveys

GJGNY Program/Activity	Respondent Group	Number Surveyed	Population
Small Commercial Energy Efficiency (SCEE) Program	Assessment Contractors	3	4
	Project Expeditor	3	3
	Lenders	4	6

The following general methodology for determining the job impacts of the GJGNY Program is described in the study. The estimation procedures included isolation of the GJGNY Program impacts from other ratepayer-funded programs, and results were extrapolated to the population where appropriate. The table below indicates the attribution factor assigned to each program component.

Table IV-2
NY Green Jobs Green New York Economic Impact Attribution

Program Component	Attribution Factor for Program-Induced Impact	Source
SCEE Assessment Contractors	100%	100% GJGNY Funded
SCEE Program Project Expeditors	100%	100% GJGNY Funded
SCEE Program Lenders	100%	100% GJGNY Funded

The following job impacts were estimated.

- 2013 New FTEs is the total number of new FTE positions added because of the GJGNY Program, from program inception through May/June of 2013. Interview respondents were asked how many FTEs they expected to hire in the next two years (by 2015) because of GJGNY activities. (Respondents who were unsure their companies' contracts with GJGNY would be extended were asked to assume that their work would continue.)
- 2013 Retained FTEs is the total number of existing FTE positions retained that would otherwise have been let go, from program inception through May/June of 2013.
- 2013 Up-Skilled and Up-Wage FTEs is the total number of existing FTE positions with increased responsibilities and wages because of the GJGNY Program, from program inception through May/June of 2013.
- 2015 Direct FTEs is the 2013 Direct FTEs (2013 New FTEs plus 2013 Retained FTEs), plus an estimate of new FTE positions that would be added because of GJGNY activities by 2015.

Job impacts were estimated for the SCEE Program based on the survey and interview responses.

The following table displays the results for the 2013 and 2015 Direct FTEs for the SCEE Program. Job impacts for WFD & Training and Marketing and Outreach and provided in the section on Residential Non-Energy Impacts, but could be included here since these program activities are not specific to residential or commercial programs. Breakdowns for 2013 New FTEs, 2013 Retained FTEs, and 2013 Up-Skilled and Up-Waged FTEs are provided in the spreadsheet analysis, along with wage data.

Table IV-3
NY Green Jobs Green New York Job Impact Estimates

Program Initiative	2013 Direct FTEs	2015 Direct FTEs
SCEE Program	7.0	9.2

The study notes: While the assignment of FTE impacts to specific program initiative is generally clear-cut, employee and hiring company names for trainees influenced by the CBOs and training partners were not available. Trainee FTEs could not be cross-checked against FTEs reported by HPwES contractors. Since it is possible that there is some overlap in FTEs, the numbers for individual initiatives should be viewed as general estimates that provide an indication of overall magnitudes rather than precise values.

2. Economic Impacts of Green Jobs Green New York (GJGNY) Program Report (New York)[225]
This study estimated the total economic impact of the job impacts of the GJGNY Program in New York. Using job and wage data from Phase I of the research,[226] the study used the IMPLAN Version 3.0 input-output model to conduct the economic analysis. Results of the study are presented in the residential section of the report but could be included under the Commercial & Industrial Non-Energy Impacts since the GJGNY Program includes a commercial program and other activities that are cross-cutting and not specific to residential programs.

B. Operations & Maintenance Impacts

The following impacts are examined in this section.

- Water Usage
- Operating Costs

The following studies provide estimates of operations and maintenance (O&M) impacts.

[225] Elizabeth Johnston, Federico Garcia, and Daniel Vickery (2013). Economic Impacts of Green Jobs Green New York (GJGNY) Program Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by ICF International, Inc. November 2013.
[226] Rohit Vaidya and Beth Poulin (2013). Assessment of Job Impacts of the Green Jobs – Green New York Program, Final Report. Prepared for New York State Energy Research and Development Authority (NYSERDA) by NMR Group, Inc. November 2013.

1. Operations Resource Assessment Service: Process and Impact Evaluation (Washington)[227]
2. Stage 2 Results – Commercial and Industrial New Construction Non-Energy Impacts Study – Final Report (Massachusetts)[228]
3. Final Report – Commercial and Industrial Non-Energy Impacts Study (Massachusetts)[229]
4. Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs (Maryland)[230]
5. Mid-Atlantic Technical Reference Manual Version 6.0 (Mid-Atlantic)[231]

The methodologies and estimates are described below.

1. Operations Resource Assessment Service: Process and Impact Evaluation (Washington)[232]

   Water Savings

   This study estimated the water savings impact of C&I "Operations Resources Assessment" (ORA) program participants using an engineering approach.

   - Benefit (Program Total) = ∑(water savings estimate per year for measure * % measure installed), summed across measures
     = 5,067,038 gallons of water saved per year

   Information on the water savings estimates for ORA-recommended conservation measures was available in a program tracking database. Information on the percent of measures installed by program participants was available in the program tracking database and through participant interviews.

   - For water measures funded through utility conservation programs, the water savings were the savings for each measure as reported in the program database.
   - For water measures financed by the customers on their own, the water savings were the percentage of the ORA-recommended savings that were realized by the customer (i.e., percent installed).

[227] Ben Coates, Dennis Pearson, and Lisa Skumatz (2000). Operations Resource Assessment Service: Process and Impact Evaluation. Prepared by Seattle City Light Evaluation Unit, Energy Management Services Division, and Skumatz Economic Research Associates. May 2000.
[228] DNV GL (2016). Stage 2 Results – Commercial and Industrial New Construction Non-Energy Impacts Study – Final Report. Prepared by DNV GL for the Massachusetts Electric and Gas Program Administrators. March 24, 2016.
[229] Tetra Tech & DNV GL (2012). Final Report – Commercial and Industrial Non-Energy Impacts Study. Prepared by Tetra Tech and DNV GL for Massachusetts Program Administrators. June 29, 2012.
[230] Itron, Inc. (2014). Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs. August 5, 2014.
[231] Shelter Analytics (2016). Mid-Atlantic Technical Reference Manual Version 6.0. Prepared for Northeast Energy Efficiency Partnerships, Inc. (NEEP) by Shelter Analytics. May 2016.
[232] Ben Coates, Dennis Pearson, and Lisa Skumatz (2000). Operations Resource Assessment Service: Process and Impact Evaluation. Prepared by Seattle City Light Evaluation Unit, Energy Management Services Division, and Skumatz Economic Research Associates. May 2000.

Total O&M Savings

This study estimated the following NEI values for non-utility benefits to C&I "Operations Resources Assessment" (ORA) using a participant survey where respondents estimated how much more or less valuable the NEIs were relative to expected energy savings.

The following table lists the categories of NEIs estimated by respondents.

Table IV-4
WA C&I NEI Categories by Measure Type

Lighting	HVAC	Water	Refrigeration
Lighting Quality	Maintenance	Bills	Maintenance
Safety/Security	Equipment Lifetime	Efficiency	Equipment Lifetime
Maintenance	Comfort	Control	Noise
Work Environment	Air Quality	Landscaping	Control
Aesthetics	Productivity	Labor	Product Life
Glare/Eyestrain	Tenant Satisfaction	Aesthetics	Water Usage
Productivity	Aesthetics	Tenant Satisfaction	Aesthetics
Control	Control	Water Flow	
Other	Environmental		

The following table presents the estimated value of non-utility NEIs to ORA participants. For "All End Uses", 50% of the value of energy savings translated to $170,000 per year per ORA participant, or $2.7 million lifetime value.

Table IV-5
WA C&I NEI Impacts by Measure Type

End Use	% of Energy Savings
Lighting	40%
HVAC	100%
Water	60%
Refrigeration	25%
All End Uses	**50%**

2. Stage 2 Results – Commercial and Industrial New Construction Non-Energy Impacts Study – Final Report (Massachusetts)[233]

[233] DNV GL (2016). Stage 2 Results – Commercial and Industrial New Construction Non-Energy Impacts Study – Final Report. Prepared by DNV GL for the Massachusetts Electric and Gas Program Administrators. March 24, 2016.

The following methodology was used to estimate NEIs associated with changes in operating costs resulting from C&I new construction projects.

- A random sample of measures from commercial and industrial (C&I) new construction (NC) projects was selected.
- Baseline conditions were defined for each sampled measure.
- Engineering/life-cycle cost analysis was used to estimate the difference in the average annual life-cycle cost between the baseline and energy efficient technologies, reflecting the operating cost NEI for each sampled measure.
- Statistical significance testing for each of the measure categories using the average NEI per unit of energy savings. [Note: while statistical significance testing was conducted, the study recommended adopting NEIs for several measure categories that were not statistically significant at the 90% confidence level.]

The sample of measures from C&I NC projects was developed using 2013 program year tracking data from the Program Administrators, in combination with data from the Dodge Players Database and tax assessors' data, to identify true NC projects; a random sample of 255 measures out of a population of 957 measures was drawn from those true NC projects. The sample consisted of the following.

- 50 custom electric measures drawn 84 population measures across nine measure types.
- 114 prescriptive electric measures drawn from 713 population measures across seven measure types.
- 30 custom gas measures drawn from 44 population measures across seven measure types.
- 61 prescriptive gas measures drawn from 116 population measures across four measure types.

The following sources were used to define appropriate baseline conditions and develop life-cycle costs.

- Project documentation
- Manufacturers' operations and maintenance manual
- Massachusetts Technical Reference Manual (TRM)
- Cost Lab software
- In-depth interviews with stakeholders
- In-house engineering staff expertise

The study provided estimates of the O&M cost savings overall for custom and prescriptive electric and gas programs, separately, as shown below. These estimates were further broken down by type of measure.

Table IV-6
MA C&I Operations & Maintenance Impact Estimates

Program	Operational Cost Savings (Annual $/kWh or $/therm)	Confidence Level

Custom Electric	$0.0060	99%
Prescriptive Electric	$0.0160	99%
Custom Gas	$0.0050	90%
Prescriptive Gas	$0.2350	Not Significant

3. Final Report – Commercial and Industrial Non-Energy Impacts Study (Massachusetts)[234]
The following methodology was used to estimate NEIs resulting from prescriptive and custom electric and gas C&I retrofit projects in Massachusetts.
   - Semi-structured in-depth interviews were conducted by energy industry experts with a sample of 2010 C&I program participants for prescriptive and custom electric and gas measures.
   - The primary source for the sample frame was the pool of respondents to the Massachusetts free-ridership (FR) and spillover (SO) study. The sampling unit was a measure at a location.
     - For prescriptive measures, a sample of 450 measures (297 electric and 153 gas measures) was selected from 1,499 measures completed by the 2010 participant FR/SO survey. Interviews were completed with respondents for 401 measures (302 electric and 99 gas measures).
     - For custom measures, a sample of 461 measures (310 electric and 151 gas custom measures) was selected from the 258 measures completed by the 2010 participant FR/SO survey and supplemented with 2010 custom program participants who did not complete FR/SO surveys. Interviews were completed with respondents for 388 measures (276 electric and 112 gas measures).
     - Since customers frequently installed multiple measures, and many customers installed measures across multiple addresses, the evaluation team first selected the sampled measures. The evaluation team then went back into the database and selected the remaining measures that linked to the sampled measure by contact name, phone number, company name, or address.

   - Data were collected on NEI types and dollar values. NEIs were calculated by reporting measure categories. The NEI question battery focused on 13 categories.
     - O&M costs, including associated labor and parts for both contractors and in-house staff
     - Administrative labor
     - Cost of supplies, materials, and materials handling
     - Transportation or materials movement costs including time, fuel costs, vehicle costs, and wages
     - Other labor costs at the company not covered in O&M, administration, materials handling, or materials movement
     - Water usage
     - Amount of product spoilage or defects

[234] Tetra Tech & DNV GL (2012). Final Report – Commercial and Industrial Non-Energy Impacts Study. Prepared by Tetra Tech and DNV GL for Massachusetts Program Administrators. June 29, 2012.

- Waste disposal costs
- Fees including insurance, inspection, permits, and legal fees
- Other costs resulting from installation of the new measure
- Sales, intended to capture basic revenue changes resulting from the new measures
- Rent revenues
- Other revenues

The calculation of participant NEIs from the survey data was done as follows:

- Translation of the qualitative interview responses into a quantitative database.
- Construction of a standard set of formulas for computing NEIs.
- Formulas were constructed for O&M, Administration, Materials Handling, and "Other" Labor NEIs.
- For other categories, respondents stated NEI values outright.

An example formula for O&M NEIs is provided below:

- NEI = (Hours per year due to Old Equipment – Hours per year due to New Equipment) * Unloaded wage per hour * Loaded Factor

During a quality control process, the evaluation team made the following adjustment for replace on failure measures, which the participant would have replaced without the program.

- Identified measures that were set for immediate replacement.
- Identified the percent of the NEI that respondents reported was due to the measure being energy efficient.
- Multiplied the estimated NEI for each measure by the percent due to it being energy efficient to estimate the amount of the NEI that did not result from the measure's newness.
- Verified NEIs were applied to all relevant measures
- Identified double-counting of NEIs
- Eliminated invalid NEIs
- Coordinated with interviewers to verify assumptions or schedule callbacks with respondents
- Imputed missing values
- Reviewed and treated outliers

The evaluation team used ratio estimates to extrapolate measure-level NEIs to the population of measures.

The study recommended that PAs in Massachusetts other than National Grid and NStar use the gross NEI per kWh or therm savings estimates, provided estimates were statistically significant. For measures corresponding to non-significant NEI estimates, the study recommended a value of $0.

4. Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs[235]
This study estimated the O&M cost savings from avoided lamp replacements and avoided labor costs associated with switching off lights as a result of installing occupancy sensors.

The following NEI values were estimated.

Table IV-7
MD C&I Operations & Maintenance Impact Estimates
Net Present Value over Nine Years

Measure	Prescriptive		SBDI	
	Labor Costs		Labor Costs	
	Included	Excluded	Included	Excluded
CFL	NA	NA	$25.89	$12.34
LF Fixture	$22.80	$13.56	$11.09	$5.81
Interior LED	$57.51	$47.95	$57.51	$47.95
Exterior LED	$170.22	$155.95	$125.85	$115.29
Occupancy Senor	$185.51	$0.00	$185.51	$0.00

The general methodology used is described below.

- Determine number of replacement lamps (baseline and EE measure) per year over the measure lifetime (varies by measure type).
- Calculate the replacement costs (baseline and EE measure) per year = Number of replacement lamps * component cost (lamp cost + labor cost, both of which vary by measure type).
- Calculate the avoided replacement costs per year = replacement costs per year for baseline measure – replacement costs per year for EE measure.
- Calculate the NPV of the avoided replacement costs.

The following example demonstrates the calculation for Prescriptive Interior LED ROB measures.

- Annual Operating Hours = 3,830 hours
- Measure Life = 35,000 hours, or 9.14 years (35,000 / 3,830)
- Baseline Life = 5,500 hours, or 1.44 years (5,500 / 3,830)
- Baseline Replacement Lamp Cost = $9.88 per replacement
- Baseline Replacement Labor Cost = $2.56 per replacement (0.13 labor hours per measure * $19.22 wage rate per hour236)

[235] Itron, Inc. (2014). Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs. August 5, 2014.
[236] From BLS "Maintenance and Repair Workers" (#49-9071); excludes "Maintenance Workers, Machinery" (#49-9043)

- Time Horizon = 9 years
- Number of Avoided Baseline Replacement Lamps = 6
- Discount Rate = 5%
- Net Present Value of Avoided Baseline Replacement Lamp (including labor costs) = $57.51 per Prescriptive Interior LED ROB measure
  - NPV of Avoided Baseline Replacement Lamp Costs = $45.67
  - NPV of Avoided Baseline Replacement Labor Costs = $11.83

5. Mid-Atlantic Technical Reference Manual Version 6.0 (Mid-Atlantic)[237]
This TRM estimates the O&M cost savings from lighting measures including delamping fixtures (permanent removal of a lamp and the associated electrical sockets from a fixture), which reduces the number of periodic lamp replacements that were required.
   - Benefit Per Year Per De-Lamped Lamp = Baseline lamp cost / baseline lamp life (in years)
     Using an illustrative example from the TRM, the benefit per year per de-lamped baseline halogen (cost = $1.40; lamp life = 1.114 years) = $1.40 / 1.114
     = $1.25

The incremental cost of this measure was assumed to be $10.80 per fixture (assuming delamping a single fixture requires 15 minutes of a common building laborer's time in Washington, D.C.; adapted from RSMeans Electric Cost Data 2008).
This TRM estimates the O&M cost savings for the following additional C&I lighting measures.
- CFL lamps (by building type)
- HPT8 (by retrofit and time of sale/new construction)
- Solid State Lighting (SSL) for grocery stores

The TRM estimates the Net Present Value (NPV) for these measures using a 5% real discount rate. The general methodology used is described below with an example demonstrating the calculation.
- Determine number of replacement lamps (baseline and EE measure) per year over the measure lifetime (varies by measure type)
- Calculate the replacement costs (baseline and EE measure) per year = Number of replacement lamps * component cost (lamp cost + labor cost, both of which vary by measure type)
- Calculate the avoided replacement costs per year = replacement costs per year for baseline measure – replacement costs per year for EE measure
- Calculate the NPV of the avoided replacement costs

The following example demonstrates the calculation for CFL Lamps installed in Grocery Stores.

[237] Shelter Analytics (2016). Mid-Atlantic Technical Reference Manual Version 6.0. Prepared for Northeast Energy Efficiency Partnerships, Inc. (NEEP) by Shelter Analytics. May 2016.

- Annual Operating Hours = 7,134
- Measure Life = 10,000 hours, or 1.40 years (10,000 / 7,134)
- Baseline Life = 1,000 hours, or 0.14 years (1,000 / 7,134)
- Baseline Replacement Lamp Cost = $1.40 per replacement
- Baseline Replacement Labor Cost = $1.54 per replacement
- Time Horizon = 1.4 years
- Number of Avoided Baseline Replacement Lamps = 9
- Discount Rate = 5%
- Net Present Value of Avoided Baseline Replacement Lamp (including labor costs) = $26.18 per CFL Lamp installed in Grocery Store
    - NPV of Avoided Baseline Replacement Lamp Costs = $12.47
    - NPV of Avoided Baseline Replacement Labor Costs = $13.71

V. Findings and Recommendations

This study included Non-Energy Impact (NEI) research that was completed in 2000 or later with original research and calculation of NEI values. While there are hundreds of reports that cover the NEI topic, many of those reports are dated and most do not calculate benefits that are specific to the program and jurisdiction studied. Many reports are literature reviews and even those that do quantify benefits usually utilize estimates that were calculated in prior studies.

This review is important because it provides information on the approaches used to measure NEIs, challenges and limitations of the various approaches, and the value ranges that have been estimated. The NEIs achieved are specific to the program design, measures, effectiveness, energy savings, characteristics of the jurisdiction, and characteristics of the population served. In most cases, original research needs to be conducted to provide a justifiable estimate of the NEIs for Connecticut's programs.

The findings from this review suggest the following areas that can most readily be applied to CT given the lower variability in the estimates. These are annual benefits per unit and apply to all weatherization programs that apply significant levels of air sealing and insulation.

- Noise Reduction Impacts: We recommend applying a value of $15 to noise.
- Comfort Impacts: We recommend applying a value of $35 for comfort.

The findings from this review suggest the following key areas for additional research and estimation.

- Medical and Health Impacts: There are many potential medical and health benefits that may arise from energy efficiency services in vulnerable low-income households. Because these benefits are sensitive to the population of customers served and the types of interventions, it is difficult to generally apply these findings to other jurisdictions. If CT's program is serving a population that has a high percentage of households with members who are vulnerable to health issues, CT should undertake pre and post-treatment survey research to estimate these benefits.

- Affordability Impacts: Low-income weatherization programs that provide significant reductions in energy usage may impact affordability for households who have difficulty with their energy bills. These impacts are related to the effectiveness of the weatherization services and should be estimated for the particular program that is evaluated. They can be estimated through analysis of collections data.

- Arrearage Carrying Cost Impacts: These should also be estimated through an analysis of customer balances and specific utility costs.

- Operations and Maintenance Impacts: These estimates are variable and will relate to the types and effectiveness of benefits delivered. They should be estimated directly for the program that is implemented.

- Water Usage Impacts: Water and sewer savings will vary depending on the measures installed and the costs for water and sewer. These costs have increased dramatically over the past few years in some jurisdictions. Therefore, these benefits should be estimated directly for the program based on estimated reduction in this usage and the local costs.

- Economic Impacts: There is a large range of estimates and these will vary depending on the level of the program investment, the types of investments, the amount invested in-state, and the multipliers for the state. Therefore, these should be estimated directly for the program based on local investments and economic multipliers.

- Environmental Impacts: These impacts are related to the effectiveness of the energy services and should be estimated for the particular program that is evaluated. They can be estimated based on the energy usage reductions for each fuel type and models that provide local valuation of these benefits based on population density.

The following benefits are difficult to estimate, do not appear to have large impacts, and should not be prioritized for analysis.

- Safety-Related Impacts
- Property Value Impacts

More NEI research is needed to assess the findings summarized in this report and to further estimate the impact of energy efficiency on NEIs. Because the findings may be used in cost-effectiveness tests and impact the level of energy efficiency investments, it is critical to conduct additional studies that provide verification or refutation of these results. Such studies need to be clear about the methodology used, assumptions made, data sources employed, and limitations of the analyses.

NEIs are real and they can be significant. While it can be challenging to estimate and monetize these benefits, it is important to do so. Connecticut should use the information in this report as a starting point to assess the potential range of benefits that can be achieved, how to prioritize NEI research, and where adjustments should be made to cost-effectiveness testing. Additional steps in this research project include development of a database to provide easier comparison of methods and results, and assessment and implementation of adjustments to those estimates that allow for better application to Connecticut's energy efficiency programs. We will also conduct a survey to quantify NEIs for a specific program or measure.

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