Know Their Significance First: How Understanding the Value of Non-Energy Impacts of Energy Efficiency Programs Can Shape Future Investment Towards Equitable Outcomes

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ABSTRACT

Energy efficiency programs serving low-income households represent significant public investment in California. However, the full impact remains unclear, as evaluations have largely relied on secondary data from other states. While energy savings are well documented, the value of non-energy impacts (NEIs)—particularly those related to health, comfort, and safety (HCS)—remains poorly understood. This knowledge gap hampers informed decisions about program investments and their role in achieving equity goals. California's Energy Savings Assistance (ESA) Program, which serves over 400,000 low-income households annually, provides an ideal case study to apply rigorous methods for estimating the values of these NEIs.

This paper presents results from a study designed to measure and value HCS impacts from the ESA Program. Rather than assuming these impacts provide positive value, the study used a web-based survey to explore if, how, and to what extent these non-energy impacts affect participant households. The research design included participant and comparison groups and employed two complementary stated preference methods—willingness-to-pay and conjoint analysis—to estimate the value of selected NEIs.

The study surveyed 1,303 low-income households across climate zones and ESA measure packages, supporting statewide estimation of NEI incidence and value and exploratory subgroup analysis. This approach offers program administrators and policymakers a framework for assessing how different ESA measures may contribute to non-energy outcomes reported by participants.

The paper contributes to efforts to improve equity-focused energy program design by strengthening the evidence base for evaluating NEIs in California's low-income energy efficiency programs.

Introduction

California's Energy Savings Assistance (ESA) Program represents one of the nation's largest and longest-running efforts to reduce energy burden among low-income households. Currently serving over 400,000 households annually with no-cost weatherization and energy efficiency measures, the program has operated since the 1980s with the dual goals of reducing energy costs and improving health, comfort, and safety (HCS) for vulnerable populations.

Despite this substantial investment and decades of operation, critical questions remain about the program's full value proposition. While energy savings have been documented extensively, the non-energy impacts (NEIs) – particularly those related to HCS – have largely been valued using secondary data from other states with different climates, housing stocks, and populations. As the U.S. Department of Energy notes, "The U.S. Department of Energy (DOE) Weatherization Assistance Program (WAP) reduces energy costs for low-income households by increasing the energy efficiency of their homes, while ensuring their health and safety" (U.S. DOE). However, California's unique climate and demographic characteristics may result in different NEI patterns than those observed in colder regions where most prior research has been conducted.

This knowledge gap has significant implications for program design and resource allocation. According to the Rocky Mountain Institute, weatherizing homes can save “occupants an average of almost $300 annually on energy bills and provides total benefits, including health and safety, of over $13,000. (Weatherization) can also reduce non-financial stressors by improving comfort, and in some cases reducing noise or pests" (RMI 2020). Understanding California-specific NEI values becomes critical for accurate cost-effectiveness calculations and equitable program delivery. Moreover, as utilities and regulators increasingly focus on environmental justice and the equitable distribution of clean energy benefits, rigorous measurement of NEIs becomes essential for assessing whether programs truly serve their intended populations effectively.

Background

The Evolution of NEI Research

The recognition that energy efficiency programs produce benefits beyond energy savings has evolved considerably over the past two decades. Early weatherization research focused primarily on energy savings and cost-effectiveness from a utility perspective. However, as Tonn, Marinic, and Rose (2024) observe, "Low-income residential energy efficiency programs save energy and can yield numerous co-benefits or non-energy impacts (NEIs)," leading to increased attention on comprehensive benefit accounting.

Several states have pioneered methods for quantifying NEIs. The New York State Energy Research and Development Authority (NYSERDA) has used conjoint analysis to assess NEIs since 2006 (Wobus et al. 2007). Massachusetts has been particularly influential, developing frameworks that monetize health improvements, comfort benefits, and safety enhancements (NMR Group 2011). Connecticut's recent studies have employed sophisticated stated preference methods, including conjoint analysis, to value comfort and health benefits from air sealing and insulation measures (NMR Group 2023). However, these studies were conducted in cold climates with different housing characteristics than California.

California’s Unique Context

California's ESA Program operates in a distinct climate context that may affect both the occurrence and value of NEIs compared to similar programs in other regions. Unlike programs in many other areas of the U.S., California's ESA Program serves households in hot, dry deserts to mild coastal areas, potentially affecting the types and magnitudes of comfort benefits compared to those identified in other states with different climates.

The California investor-owned utilities (IOUs) have relied on NEI valuation estimates from NEI studies (SERA and Navigant Consulting Inc. 2019; APPRISE Inc. 2021), which rely on outdated literature reviews for many of the NEI values. Nearly all current HCS NEI values leverage findings from a 2010 NEI study from Xcel Energy of Colorado (Skumatz 2010), and the NEI values are not based on new primary data collection within California.

It is important that this study brings California-specific estimates of NEI incidence and attribution to ESA participation—especially pertaining to winter comfort—because California’s climate is different from other states, including Colorado (where the current ESA Program NEI values originated). California’s major population centers experience significantly milder winters than many other regions of the United States, which affects the potential impact of heating-related energy efficiency improvements. Based on data from the National Oceanic and Atmospheric Administration (NOAA), Los Angeles averages approximately 1,085 heating degree days (HDD) annually, while San Francisco averages around 2,405 HDD. By comparison, Denver, Colorado, averages approximately 5,777 HDD (NWS n.d.). This three- to five-fold difference in heating requirements suggests that participants in California programs may be less likely to perceive comfort improvements associated with heating-related measures due to the relatively low baseline need for space heating. California's more mild winter climate may reduce the likelihood that participants perceive significant changes in indoor comfort during the winter, which in turn may limit the perceived value of weatherization and HVAC-related program measures.

Furthermore, approximately 27% of energy use in California homes is for heating and 4% for air conditioning (U.S. EIA 2009a). The current NEIs are based on research from Colorado, where 54% of home energy use is for heating and 1% for air conditioning (U.S. EIA 2009b). Since California households use proportionally less energy for heating and slightly more on cooling than homes in Colorado, it may be inappropriate to use Colorado-derived NEI values for California's ESA Program.

Methodology

Study Design

The research team conducted a literature review to identify the types of HCS-related benefits considered relevant to energy efficiency and weatherization programs (like ESA). Based on the literature review and the direction to estimate new NEI values based on current survey data from ESA participants, we determined that this NEI study should focus on HCS benefits that may result when participants receive ESA measures and that participant surveys could realistically address. The metrics in Table 1 are grouped based on broader NEI categories included in the IOUs' ESA cost effectiveness calculators.

Table 1. Studied non-energy impacts categories and metrics

NEI category	NEI metric
Participant comfort	Increased comfort in winter
	Increased comfort in summer
	Reduced draftiness
Reduced noise in homes	Noises from indoor sources
	Noises from outside sources
Participant health[1]	Improved indoor air quality
	Symptom improvement among household members with chronic health conditions

Source: Evergreen Economics 2025

Safety-related NEIs were excluded from the list of metrics covered by this study because of the difficulty incorporating safety-related impact questions into primary research with program participants. The study does include an examination of health-related NEIs but does not provide a comprehensive health-specific NEI valuation as the primary research conducted is not inclusive of all potential health benefits (only air quality benefits and symptom improvement for certain chronic health conditions).

The study addressed all ESA measures, oversampling for larger and more expensive measures (such as replacing or repairing cooling and heating equipment). Some of these larger measures have low

[1] Not all aspects of the health NEI were included in the study.

(or no) energy savings and have been included in the ESA Program's measure mix as they are assumed to lead to HCS improvements based on research from other regions.

The study employed a quasi-experimental design with treatment and comparison groups (comprised of low-income households) to isolate program effects from external factors such as weather variations or broader economic changes. The research involved:

1. Treatment Group: 865 households that participated in ESA during 2023 and Q1 2024
2. Comparison Group: 438 low-income households (CARE[2]/FERA[3] participants) who had not participated in ESA since 2018

This design allowed us to control for factors affecting all low-income households while identifying changes specifically attributable to ESA participation.

Furthermore, the study team was particularly interested in exploring the use of conjoint analysis alongside other contingent valuation methods to assess NEI value from ESA participation. Our review of literature during the scoping of the research found that the conjoint analysis method may be particularly helpful in assessing NEI value among low-income households because, "it reduces the strategic bias of respondents by making the dollar value estimate an indirect function of the preferences demonstrated through the choices they make… this method presents respondents with more familiar real-world choice scenarios which may be easier for them to complete than contingent valuation or 'scaling'-type questions." (Wobus et al. 2007).

Sampling Strategy

We stratified the sample by measure groups to ensure adequate representation of different intervention types:

- Basic Measures: Lighting and water-saving devices (n=120)
- Enclosure: Air sealing, insulation, windows/doors (n=210)
- Appliances: Water heaters, refrigerators (n=105)
- Heating: Furnace repair/replacement, duct sealing (n=234)
- Cooling: AC replacement/installation, evaporative coolers (n=196)
- Non-treated homes comprising the comparison group (n=438)

For ESA participants, the participant survey sample frame consisted of all households that participated in the ESA Program in 2023 and Q1 2024. The participant group sample frame was stratified by measure group and IOU. For the comparison group, the study used stratified random sampling from each IOU to select comparison respondents covering the geographies represented by ESA participants to account for regional differences in weather and air quality.

Survey Development

Given the challenges of measuring subjective outcomes like comfort, we invested substantial effort in survey development:

1. Literature Review: We examined survey instruments from Massachusetts, Connecticut, and national weatherization studies, adapting questions to California's context.

[2] California Alternate Rates for Energy program.
[3] Family Electric Rate Assistance program.

2. Pre-testing: We conducted a pre-test with 40 ESA participants, followed by in-depth interviews with 27 pre-test respondents to understand their interpretation of the questions.
3. Refinements: Based on pre-test findings, we adjusted temperature comfort questions to focus on "comfortable" versus "uncomfortable" rather than specific temperature differentials, which proved confusing to respondents.

The pre-test and follow-up interviews led to several important adjustments to the survey, including discarding the use of specific temperature differentials (i.e., 5°F too warm) when asking about the value of winter and summer comfort. The valuation questions were adjusted to align with the incidence and attribution questions that focused on “comfortable” versus “uncomfortable” (without specifying temperature differentials). Additional adjustments to the survey included applying randomization to the willingness-to-pay (WTP) question dollar amounts and clarifications to the conjoint survey instructions.

Throughout the survey instrument and testing process, the research team ensured that the average length of survey time did not exceed 20 minutes to ensure higher quality responses and increase the response rate.

Measurement Approach

They study involved analysis of participant and comparison group survey data to develop estimates of how often ESA treatments result in comfort, noise, and health-related benefits, separating program impacts from factors like changing weather. The research team also developed regression models for WTP and conjoint analyses to estimate monetary values for comfort, noise, and air quality NEI metrics. By combining the frequency of benefits with their values and weighting based on typical measure combinations in ESA (in 2023 and Q1 2024), the research team estimated average comfort, noise, and air quality benefit values for the program.

Incidence and Attribution

For each potential NEI, we employed a two-step approach, seeking to identify if and to what degree ESA measures lead to NEIs. The steps included:

1. Incidence Analysis: The incidence analysis determined which ESA measure bundles produced statistically significant improvements in NEIs compared to changes observed in the comparison group. This analysis sought to inform the following question: what proportion of participants experienced improvements in comfort, noise, or air quality?
2. Attribution Analysis: When a respondent said they saw an improvement in a metric, they were asked to identify which factors were relevant to that improvement and then rank them. The attribution analysis quantifies the extent to which the observed improvements are attributable to specific ESA Program measures, relative to any external factors that also caused improvements. The analysis sought to determine the following: what portion of observed improvements could be attributed to ESA measures versus other factors?

This combined incidence and attribution approach recognized that multiple factors affect home conditions. For example, a participant might experience improved winter comfort due to a combination of ESA-installed insulation, a warmer winter, and behavioral changes.

Valuation Methods

We employed two complementary stated preference methods, including WTP survey questions and a conjoint battery of survey questions for conjoint analysis.

Willingness-to-pay (WTP). The survey asked respondents who experienced improvements a series of traditional contingent valuation questions asking how much they would pay to maintain those benefits. We used a double-bounded dichotomous choice format, starting with an initial bid (e.g., $5/month for air quality improvements) followed by a higher or lower bid based on the initial response.

Conjoint analysis: The survey also collected data to support a conjoint analysis. The conjoint analysis was based on survey responses to a series of questions that forced the respondent to make choices between combinations of benefits. Participants chose between hypothetical scenarios combining different levels of:

- Monthly utility bill credits ($1, $10, or $25)
- Indoor air quality (good vs. moderate)
- Summer/winter comfort (comfortable vs. uncomfortable)
- Draftiness (little to none vs. drafty)
- Noise levels (very little vs. some noise)

This method forced trade-offs between attributes, revealing relative values without requiring direct payment considerations.

Statistical Analysis

We employed several analytical approaches:

1. We compared changes in the treatment group to changes in the comparison group to isolate program effects (i.e., incidence and attribution).
2. For WTP analysis, we used a logistic regression for modeling the probability of accepting a given bid amount as a function of the amount and participant characteristics.
3. For conjoint analysis, we estimated a binary logistic regression model for each group (treatment and comparison) where the dependent variable indicated which scenario was chosen. To translate the estimated coefficients into monetary values, the research team used the delta method to calculate marginal willingness-to-pay (MWTP) for each comfort attribute.[4]

Ultimately, the research team opted to combine the incidence and attribution analysis with the MWTP values from the ESA participant conjoint analysis results for NEI valuation to calculate NEIs from ESA participation.

The research team believes the conjoint analysis may provide a better representation of the value individuals place on each of the comfort, noise, and air quality NEIs, as the comparison between alternative sets of attributes better replicates the actual process of making a purchase decision. The conjoint approach used by the study team also does not require low-income households to consider paying for a benefit, but rather reveals what characteristics are more and less important, consistent with insights from Wobus et al. (2007). Furthermore, other research indicates that income elasticity of WTP is lowest in the lowest-income brackets, meaning households with limited resources show much smaller

[4] MWTP represents the additional amount a household would be willing to pay for an improvement in the attribute.

increases in stated values for environmental improvements than higher-income households; this causes cost-benefit analyses to understate the benefits of such policies for low-income groups (Drupp et al. 2024).

The research team also compared the conjoint analysis results from ESA participants and the comparison group households and noted that the MWTP was considerably lower from the survey of comparison homes than the participant homes. The research team concluded that since ESA Program participants opt into the program—which requires some level of their time and inconvenience (depending on the scale of their participation) in exchange for ESA Program benefits—they may value ESA Program benefits differently than non-participants (who comprise the comparison group households). Alternatively, ESA participants may better understand the value of the benefits after receiving the benefit. As a result, the research team determined that using the MWTP from the participant conjoint was most appropriate. More research would be needed to understand why ESA participants value the studied benefits more than similar non-participant households.

Results

Incidence of Benefits

Our analysis revealed that while most ESA participants did not perceive improvements in comfort, noise, or air quality, statistically significant minorities did experience benefits:

- Winter Comfort: Among participants receiving major heating measures (new equipment, ceiling insulation), 18% reported improved winter comfort. Of the improvement, 58% was attributable to ESA measures based on participant rankings of contributing factors.
- Summer Comfort: For major cooling measures, 17% of recipients reported improved summer comfort, with 46% of the improvement attributable to ESA. This lower attribution rate reflects that many participants also made behavioral changes or purchased fans independently.
- Draftiness: This showed the strongest program effect, with 14% of participants receiving major draft-reducing measures (windows/doors) reporting improvements, and 73% of the improvement attributed to ESA.
- Indoor Air Quality: Only 9% of participants receiving major air quality measures perceived improvements, with just 31% attributed to ESA. This suggests that indoor air quality may be influenced more by external factors or that participants have difficulty perceiving gradual air quality changes.
- Noise Reduction: The lowest incidence at 6% was for both appliance noise and outdoor noise reduction, though participants who experienced these benefits valued them highly.

Monetary Valuation

The conjoint analysis revealed substantial values for NEIs when they occur:

- Winter/Summer Comfort: $242 per year (about $20/month)
- Draftiness Reduction: $160 per year (about $13/month)
- Noise Reduction: $137 per year (about $11/month)
- Indoor Air Quality: $129 per year (about $11/month)

These values are notably higher than those found using the WTP method, which yielded values 60-80% lower. This difference likely reflects budget constraints among low-income participants affecting their stated willingness to pay directly, while the conjoint method captures values through trade-offs without invoking payment.

Program Level Impact

The study found that some ESA participants perceived comfort-, noise-, and air quality-related improvements after receiving relevant measures from the ESA Program. While the percentage of ESA participants who perceived a comfort, noise, or air quality improvement was low, a significant number of those who perceived an improvement attributed it to ESA.

Combining incidence, attribution, and individual values yields modest per-participant benefits for the full ESA Program in 2023:

- Comfort NEIs: $9 per participant per year
- Noise NEIs: $1 per participant per year
- Air Quality NEIs: $1 per participant per year

Geographic and Demographic Variation

To better understand if ESA led to improvements in comfort, noise, or air quality reductions among certain subgroups of the overall population, Evergreen investigated the following topics:

- Differences in the incidence of improved summer comfort among participants who received major and minor cooling-related measures by areas with high cooling needs (based on CDD) vs. areas with low cooling needs.
- Differences in the incidence of improved winter comfort among participants who received major and minor heating-related measures by areas with high heating needs (based on HDD) vs. areas with low heating needs.
- Differences in the incidence of improved indoor air quality among participants who received major and minor air quality-related measures, using Pacific Gas and Electric as a proxy for Northern California compared to Southern California (comprised of all other IOUs).
- Differences in the incidence of draftiness among participants who received major and minor draftiness measures between the mild climates (low heating and low cooling) and other climates (high heating and/or high cooling).

Additionally, the research team investigated whether there are differences in the MWTP for comfort, noise, and air quality benefits based on conjoint analysis across the following subgroups:

- By IOU
- Households with elderly members compared to households without elderly members

There were no statistically significant differences in the incidences of improvements or the MWTP values based on the subgroup analyses.

Health Impacts – Symptoms of Chronic Conditions

While 45% of ESA participants reported household members with chronic health conditions (asthma, arthritis, chronic obstructive pulmonary disease [COPD], autoimmune diseases), compared to 38% of comparison households, we found no significant differences in symptom improvement between groups. Only 1% of participants with health conditions attributed any symptom improvement to ESA measures, suggesting limited direct health benefits through the pathways measured.

Discussion

Heterogenous Benefits

The low incidence rates (6-18%) suggest that NEIs are not universal benefits but occur for specific subsets of participants. This finding challenges the implicit assumption in many program designs that weatherization and energy efficiency measures deliver HCS benefits to all or most participants. Instead, our results reveal a more complex reality where the majority of participants—82-94% depending on the measure type—do not perceive improvements in comfort, air quality, or noise levels following program participation and receiving relevant measures.

This heterogeneity in benefit realization has implications for how California's IOUs should conceptualize and market these programs. Rather than positioning NEIs as guaranteed co-benefits of energy efficiency investments, programs may need to acknowledge that these improvements will be experienced by only a minority of participants, even when high-quality measures are properly installed.

Cost-Effectiveness Implications

Using our California-specific values rather than imported values from other states, along with a different method for attributing NEIs to participants, may implicate ESA Program cost effectiveness (or the cost effectiveness of certain measures). While this study did not address overall program or measure cost effectiveness, it is possible that:

1. Some measures currently justified primarily by assumed NEIs may no longer pass cost-effectiveness screens.
2. Resources might be better targeted to measures with demonstrated NEI production.
3. Program design might shift toward measures producing more recognized benefits.

However, our study's focus on a limited set of participant-recognized benefits does not address all NEIs, nor all cost effectiveness considerations (i.e., the study did not consider overall measure cost effectiveness, but rather provides updates to key inputs). Benefits such as improved property values, reduced maintenance needs, or long-term health improvements were outside our scope but may provide additional value, in addition to other components of cost effectiveness such as energy savings.

Environmental Justice Considerations

Our findings raise important equity questions that challenge fundamental assumptions about how low-income energy efficiency programs deliver benefits:

1. Benefit Distribution: With only 12% of participants experiencing any attributed comfort or air quality improvements, are programs achieving equitable benefit distribution?
2. Measure Allocation: Should programs prioritize measures with higher NEI incidence even if energy savings are lower?
3. Targeting: Could pre-screening identify households more likely to experience NEIs, improving program efficiency?

As the Rocky Mountain Institute (2022) notes, "WAP is a good investment because it directly addresses the problem of energy affordability and equity," but our results suggest that non-energy benefits may be more concentrated than previously assumed.

Limitations

Important limitations of the study include several methodological and scope constraints that should be considered when interpreting our results. While our research provides valuable insights into the real-world impacts of California's ESA Program, the study design necessarily involved trade-offs between comprehensiveness and feasibility. These limitations do not invalidate our findings but rather provide important context for understanding what our results can and cannot tell us about the full spectrum of NEIs from low-income weatherization programs. The following constraints shaped both our methodology and the conclusions we can draw from the data:

- Reliance on self-reported survey data may introduce challenges including recall bias, difficulty attributing changes to specific causes, and potential shifts in perceptions if participants were re-surveyed. The study did not look to external sources such as weather data to validate customer responses.
- Methodological constraints in the conjoint analysis may include predetermined attribute levels that may not capture all participant experiences and assumptions that participants value each dollar equally regardless of their income level, which may not be accurate.
- Precision of benefit estimates may be affected by limited sample sizes for certain subgroups and measure combinations, constraining conclusions about specific segments.
- Important impacts fell outside the study's scope, including safety issues (fire hazards, carbon monoxide poisoning) and comprehensive health assessments, due to survey length constraints and privacy concerns.

Despite these limitations, the study provides valuable insights while acknowledging the inherent complexities of quantifying NEIs resulting from participation in low-income energy efficiency programs.

Conclusions

This study provides the first rigorous, California-specific estimates of NEIs from low-income weatherization programs based on primary data collected from California households. Our findings reveal a more nuanced picture than previous analyses suggested:

1. NEIs are real but relatively rare: While participants who experience comfort, noise, or air quality improvements value them highly ($129-$242/year), only 6-18% of participants experience these benefits from any given measure type (Evergreen Economics 2025).
2. Attribution matters: When improvements occur, 18-73% can be attributed to program measures (depending on the NEI and relevant measures received), with the remainder due to weather, behavior changes, or other factors (Evergreen Economics 2025).
3. Method affects measurement: Conjoint analysis yields values two to three times higher than WTP for the same benefits, suggesting that method choice significantly affects NEI estimates for low-income populations.
4. Limited health pathway: Despite high rates of chronic health conditions among participants, direct symptom improvement from ESA measures was negligible through the pathways measured. Additional health-related research is needed to better understand if ESA is providing health benefits to participants.

These findings have important implications for program design and policy. While NEIs provide real value to some participants, they may not justify measures lacking cost-effective energy savings to the degree previously assumed. Program designers might consider:

- Targeting measures with higher NEI incidence rates, if NEIs are an objective
- Developing screening tools to identify households likely to experience NEIs
- Exploring alternative delivery methods to increase benefit recognition

As California pursues aggressive climate goals while centering equity, understanding the true distribution and value of program benefits becomes critical. Our research suggests that while the ESA Program provides important benefits beyond energy savings, these benefits are neither universal nor uniformly distributed. Future program design should acknowledge this heterogeneity while seeking ways to maximize benefits for all participants.

This research also highlights the importance of localized NEI research. Values derived from programs in other states may not translate to California's unique context. As states develop increasingly sophisticated approaches to valuing energy efficiency programs, locally relevant research becomes essential for accurate benefit accounting and equitable resource allocation.

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