Non-Energy Benefits and Non-Energy Impact (NEB/NEI) Study for the California Energy Savings Assistance (ESA) Program

Volume 1

DRAFT

JULY 2019

Prepared for:
San Diego Gas & Electric Company, Southern California Gas Company,
Southern California Edison Company, and Pacific Gas and Electric Company

Prepared by:
Primary Author: Lisa A. Skumatz, PhD, Skumatz Economic Research Associates, Inc.
Co-authors: Dana D'Souza, and Michael Santulli, Skumatz Economic Research Associates, Inc.
and
Molly Podolefsky and Jessica Minor-Baetens, Navigant Consulting, Inc.

Submitted by:
Skumatz Economic
Research Associates, Inc.
762 Eldorado Dr.,
Superior CO 80027
303.494.1178
www.serainc.com

with assistance from subconsultant:
Navigant Consulting, Inc.
1375 Walnut Street, Suite 100
Boulder, CO 80302
303.728.2500
www.navigant.com

Contents

Executive Summary

Background

For almost two decades, the California investor-owned utilities (IOUs)[1] have made efforts to apply non-energy benefits or non-energy impacts (NEBs/NEIs)[2] to their Energy Savings Assistance (ESA) programs. In conjunction with cost-effectiveness tests, the utilities have relied on the Low-Income Public Purpose Test (LIPPT), referred to in this report as the 2001 NEB 1.0 model, [3] to assist in monetizing the NEBs for the programs. In 2003, the original 2001 NEB 1.0 model was updated to allow the ESA's program-wide NEB categories to be applied at the measure level based on measure savings contributions.

In 2010, the IOUs commissioned a study evaluating the opportunities to improve the estimation of NEBs associated with the ESA programs to assess their status.[4] This study gauged the existing ESA NEB modeling work against the available literature; it also examined NEBs that were valuable to the ESA participants and program and that should be added to the estimation work. The study also explored revisions that should be made to improve the basis for estimating NEBs. Based on that work, several potential changes were recommended to improve the model:

- Switching to a financial basis for computing some NEBs (e.g., operations and maintenance, or O&M/lifetime)
- Adding more granularity in participant NEBs to reflect progress in the literature
- Conducting work to add more NEBs related to health, in particular
- Considering adjusting NEB estimates to reflect differences in climate zones, measures, demographics, and other factors, as feasible

In 2017, the IOUs conducted a review of the ESA measures and, through a working group, developed the *Health Comfort and Safety Assessment* (HCSA). The assessment ranked the ESA measures according to the extent they met a set of health comfort and safety criteria. The results were provided to this study to inform further development of measure-specific NEBs.

In 2018, the IOUs requested proposals to conduct a study to update and enhance the ESA program NEBs. The California IOUs hired Skumatz Economic Research Associates (SERA) and its subcontractor Navigant Consulting, Inc. (together the consultant team) to conduct this project.

---

[1] The California IOUs are Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E), Southern California Edison Company(SCE), and Southern California Gas Company (SoCalGas).

[2] NEBs or NEIs and a variety of other terms are used to reflect the net positive and negative impacts of programs beyond energy. For simplicity, the report generally uses NEBs because that was the term used in the RFP; both positive and negative effects are included in the NEBs estimated in the project and model.

[3] The LIPPT was a cost-effectiveness test incorporating participant and utility NEBs. The LIPPT was developed in 2001 at the direction of the California Public Utilities Commission (CPUC) in Decision 01-03-028 for the California Low Income Energy Efficiency Program (now known as the ESA Program). Although this specific cost-effectiveness test was not adopted, the NEBs developed for it were listed in Decision 01-12-020, and NEBs continued to be calculated in the LIPPT model for incorporation in cost-effectiveness tests authorized for the low-income segment. The LIPPT project was conducted by TecMarketWorks and Skumatz Economic Research Associates (SERA); the 2001 NEB 1.0 model was developed by Skumatz Economic Research Associates, Inc. (SERA).

[4] See Skumatz et al., 2010c

Findings

After extensive review, analyses of NEB benefits, and logical assessment, this project yielded a list of updated NEBs and new NEBs available to incorporate into ESA program cost-effectiveness analysis. There are strengths and weaknesses of the NEB results estimated as a part of this project including the NEB estimates, the allocations to measures, and the modeling. The figures below summarize the strengths and weaknesses of these activities.

Figure ES.1: Overall Study Informed ESA Program NEB Revisions

NEB and Model Modifications	NEB and Model Limitations
• On a qualitative basis, these NEBs are updated using the most suitable available information and data sources, and input values are borrowed from the most similar and recent programs and publications. • NEB estimates are within the ranges of NEB estimates developed for other similar programs. • NEBs are linked to logical and analytical connections to underlying measures.	• Many NEBs use time-sensitive information and benefit from periodic updates. • NEBs would benefit from more utility-specific information to improve estimates (starting values on levels for arrearages, debt, calls, notices, and other data). • NEBs would benefit from more California-specific information rather than data borrowed from other programs or states. • Participant NEBs, in particular, would benefit from more defensible connections to the program and measures, potentially via current surveys and analysis for the ESA program. • NEBs would be stronger if the publicly available literature included more recent analyses of some concepts and inputs (some source data dates to 2001/2005). • NEBs would be stronger if more literature also tackled the logical relationships, input concepts, and computations for these NEBs.

Figure ES.2: NEB Allocation Revisions

Allocation Modifications	Allocation Limitations
• Allocation incorporates available information on measure-based NEBs. • Allocation incorporates recent work statistically linking NEBs and measures for residential participant NEBs, providing additional justification. • Allocation incorporates flexibility and logical relationships between NEBs and measures. • Allocation addresses the limitations of the current NEB allocation method that assigns NEBs using a savings-based methodology. • Allocation provides opportunity for low-/non-savings measures to provide NEBs.	• Allocation would benefit from current measure-based surveys with ESA participants and nonparticipants. • Allocation would benefit from additional quantitative information on magnitude and linkage of the measure-stratified NEBs. • Allocations would benefit from additional research/treatment/understanding of NEBs for measures with zero or negative savings. • Allocations would benefit from differentiating strength of measure-based versus program-based allocations to accommodate measure changes within the program and across years. • Allocation could become stronger as more literature becomes available that addresses the

Allocation Modifications	Allocation Limitations
	issue and mechanism alternatives for allocation and as the concepts developed and used in this study are reviewed and enhanced by the research community.

Figure ES.3: 2001 NEB 1.0 Model Revisions to NEB 2.0

Model Revisions	Potential Model Limitations and Next Steps
• Includes modified list of NEBs to support cost-effectiveness tests associated with the ESA program and provides space for future changes. • Increases attention to health and safety NEBs, which are important to the ESA program. • Excludes NEBs addressed by revisions to the avoided costs. • Simplifies data entry and updating and assembles the data into one main sheet. • Includes detailed documentation of sources. • Minimizes need for regular utility data updates. • Provides color- and number-coding for updating data. • Reduces steps to run the model. • Includes more user-friendly documentation and improved navigation between model sheets. • Includes sensitivity analysis capabilities related to including/excluding NEBs or measures, and benchmarking or modifying the NEB values. • Updates dollar values automatically to program year. • Allows users to easily modify the measures included in the NEB estimate and scales the associated NEB estimates. • Incorporates steps to allocate program-wide NEBs to ESA program measures based on best research available rather than ad hoc user assignments. • Allows users to select measure groupings/end use and water measure codes from drop-down menus. • Supports modeling for up to 5 program years. • Avoids concerns related to confidential data sharing. • Includes dashboards and updated look and feel.	• Basic model operations are much easier than the earlier model, but the underlying model capabilities and relationships are necessarily more complex, so full understanding of the model requires more knowledge and training. • Model based on available allocation information that may or may not apply to California ESA program benefits. • Model includes imprecise allocations to simplify process or where supporting data is lacking. Additional research and data to support allocation methodology refinements would be helpful. • Model includes NEBs that are both expansive and conservative. The model will benefit as more literature becomes available, and advancements are made in understanding and calculating additional NEBs. • Calculations and inputs for all steps of the modeling may not be clear to new or casual users of the model.

In summary, this project eliminated six[5] NEBs modeled in the 2001 NEB 1.0 model and added 24 new NEBs into the NEB 2.0 model. The updated NEB 2.0 model consists of 46 NEBs for consideration for IOU calculations. The newly created NEB concepts require additional research and verification to ensure

[5] *Including three utility-perspective NEBs (collection cost, emergency gas service, and transmission / distribution), one societal NEB (emissions / environmental adder), and two participant NEBs (program rebate, and transaction costs).*

accuracy, reliability, and confidence. After review, a total of 21 were accepted for inclusion in the NEB 2.0 model.

Figure ES.4: Count of NEBs Included in ESA NEB Models and Accepted for Cost-Effectiveness (C/E Calculations

	Number of NEBs in Inventory	Included in 2001 NEB 1.0 Model	Accepted for Inclusion in C/E 2001 NEB 1.0 Calculations	Deleted from 2001 NEB 1.0 Model	Included for Modeling in ESA NEB 2.0	Accepted for Inclusion in NEB 2.0
Utility NEBs	32	11	8	3	9	5
Societal NEBs	32	4	0	1	10	1
Participant NEBs	72	12	11	2	27	15
Total NEBs	**136**	**27**	**19**	**6**	**46**	**21**

Recommendations

This work reflects progress to improve the NEBs, their underpinnings, and the California ESA NEB 2.0 model. Additional primary data collection is recommended to enhance capabilities and fill gaps. Recommendations for additional work (in ranked order) include the following:

- **Support ongoing data needs to update NEB 2.0 as needed:** Review the data update schedule, periodically review the literature for new reports, and focus on NEBs with high values or those based on older data.
- **Conduct additional review and verification of the proposed NEBs and valuation to vet the benefits and acceptance of the NEBs:** NEBs are complex and difficult to isolate and estimate. However, NEBs work is becoming more important as the traditional cost-effectiveness models re increasingly viewed as not sufficiently comprehensive. Many NEBs will benefit from continued discussion and testing to improve reliability and confidence.
- **Conduct a well-designed, California ESA-specific survey with both treatment and control groups**: Current, California-specific information is needed to support estimates of a variety of participant NEBs. The survey should be designed to identify which and how NEBs are associated with program interventions – to what extent did those who received a measure show benefits over a comparable customer who did not receive the measure from ESA. The proper sample design will allow the survey address an array of supporting research needs. The sampling for the survey should allow estimation of measure-based NEBs; include health and safety NEBs; include subsampling for demographic, climate zone, and housing type subsets; and include a focus on developing an estimate of hardship NEBs. Significant findings from the survey should be incorporated into the 2019 California ESA NEBs 2.0 model as they become available.
- **Conduct a new arrearage study to provide updated and local data for outdated data in the model:** This pre-/post- control group study is inexpensive and quick to complete. The study should use data from one to four of the utilities to develop statistically reliable estimates of the starting value for payment-related data, and the program's effects on arrearages, phone calls, notices, shutoff and reconnects, and other utility bill payment-related impacts attributable to the program.
- **Research true medical costs to get more defensible information on quantifying health and**

safety values: Health and safety NEB estimates have historically relied on somewhat imprecise estimates of illness-related medical costs and often did not address concepts related to who pays (private insurance, government insurance, out of pocket). Continual improvements and additional data on medical-related topics would improve ESA program NEB estimates.

- **Estimate California economic multipliers by subarea to improve the model and better reflect differences in NEBs between utilities**: California IOU territories are large and differ substantially in industry mix. Although statewide economic effects were estimated for another project and used in this project,[6] regional modeling would better reflect the program's effects for each IOU.
- **Research climate zone measure variations to support model improvements**: Conduct a detailed review of the Database of Energy Efficiency Resources (DEER) to examine the high and low values for energy savings for program measures based on climate zone and incorporate differential savings for the four IOUs.
- **Research potential new end uses to support the model and update measure attribution methodology:** Conduct a market study to identify likely new measures, but especially new end uses that may be considered for the ESA program in the future. The project may involve expert interviews, Delphi approaches, or other market intelligence work. Use the results to refine the model's drop-down menus used for new measures and to allocate the NEBs to those measures.
- **Review policy and dockets to inform which NEBs are priorities:** Conduct a review of California filings and dockets to identify and confirm policy goals that can be reflected by NEBs and develop NEB calculations for any new NEBs identified.

[6] Skumatz Economic Research Associates, Inc. (SERA) used the Regional Input-Output Modeling System (RIMS II) using 2016 data to conduct this statewide analysis.

Terms and Definitions

CARE	California Alternate Rates for Energy
C/E	Cost-effectiveness
CFL	Compact fluorescent lamp
COBRA	CO-Benefits Risk Assessment
CO	Carbon monoxide
CPI	Consumer Price Index
CPUC	California Public Utilities Commission
DEER	Database of Energy Efficiency Resources
DRIPE	Demand reduction induced price effects
EPA	Environmental Protection Agency (US)
ESA	Energy Savings Assistance
ETS	Environmental Tobacco Smoke
EUL	Effective useful life
FERA	Family Electric Rate Assistance
HCSA	Health Comfort and Safety Assessment
HSC	Health, Safety and Comfort
HH	Household
HVAC	Heating, ventilation, and air conditioning
IMPLAN™	Name of third-party input-output model
I/O	input/output
IEA	International Energy Agency
IOU	Investor-owned utility
kWh	Kilowatt-hour
LED	Light-emitting diode
LIPPT	Low Income Public Purpose Test
LMS	Labeled Magnitude Scaling Survey
NEB	Non-energy benefit
NEEP	Northeast Energy Efficiency Partnership
NEI	Non-energy Impact
O&M	Operations and maintenance
PG&E	Pacific Gas and Electric
RIMS II™	Regional Input-Output Modeling System
RUL	Remaining useful life
SCE	Southern California Edison - footnote
SDG&E	San Diego Gas and Electric - footnote
SERA	Skumatz Economic Research Associates
SoCalGas	Southern California Gas Company
US	United States
WAP	Weatherization Assistance Program
WTP	Willingness to pay

1.0 Introduction

The Energy Savings Assistance (ESA) program offers low income households natural gas and electric measures and education to improve the energy efficiency of the home at no cost to the participant. The program was established in the 1980s as a weatherization program and has expanded over the years to include appliances, lighting, and heating and cooling measures. Eligibility for the program is based on income level and household size guidelines as set by the California Public Utilities Commission (CPUC). The program has two primary objectives:

1. Provide cost-effective energy savings that will serve as an energy resource and promote environmental benefits
2. Improve the quality of life, bill savings, safety, and comfort of its participants

The program is administered by the four California investor-owned utilities (IOUs)—Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E), Southern California Edison Company (SCE) and Southern California Gas Company (SoCalGas)—and is available to all eligible and willing customers in the IOU service areas.

Jurisdictions around the world increasingly recognize that a fair and balanced accounting of the costs and benefits of program offerings requires additional exploration of the non-energy benefits (NEBs)—those benefits beyond energy and demand savings. In particular, this applies for programs serving disadvantaged populations where NEBs are related to policy goals and are considered significant and especially meaningful to participants. Many agencies, including the International Energy Agency (IEA) and the US Environmental Protection Agency (EPA),[7] have published guidelines and sponsored working groups and workshops to quantify NEBs attributable to energy efficiency measures in recent years. Building off some of the early work conducted by the California IOUs, an increasing number of states have undertaken estimation of NEBs over the years, and approximately 27 states now consider NEBs in some form in their cost-effectiveness test process.[8]

The IOUs engaged the consultant team to assess the most appropriate, measurable, and quantifiable NEBs for current and future values in the cost-effective analyses for the California Energy Savings Assessment (ESA) program and to provide a user-friendly, updated model to calculate NEB values.

The project had the following primary objectives:

- Revise and update the NEB calculations used for cost-effectiveness analysis for the ESA program
- Justify NEBs values and calculations and identify limitations to inputs and processes that may facilitate assessments of ESA program-based NEBs
- Provide an updated workbook (i.e., NEB 2.0) to calculate the NEBs

[7] *See International Energy Agency (IEA), 2014 and US EPA, 2011.*
[8] *See NEEP, 2017.*

1.1 Prior IOU NEB Studies

The existing ESA program NEB model is based on the 2001 NEB 1.0 model, updated with a module to use savings proportions to allocate NEBs to programs. In the 2001 NEB 1.0 model, 27 NEBs were estimated and 19 utility and participant NEBs were accepted in the cost-effectiveness computations. The list of NEBs commonly included in the estimates the utilities develop for the program are listed below. Additional NEB calculation sheets are included in the model but are not used; some have been determined to be replaced with data from the avoided cost model (e.g., transmission and distribution savings, environmental emissions benefits). The utilities have omitted others for reasons of aged inputs (i.e., economic impacts), irrelevance based on policies and procedures (i.e., collection costs), lack of data or concern about input values (i.e., infrastructure savings for water savings, utility insurance savings), low priority (lower transaction costs), or other reasons (i.e., reduced safety from carbon monoxide [CO] monitors). The list of NEBs commonly included in the estimates the utilities develop for the program are listed in Figure 1.1.[9]

Figure 1.1: NEBs and Descriptions from Original NEB 1.0 Model

NEBs	Description
Utility NEBs	
Reduced carrying cost on arrearages (interest)	The utility and its ratepayers have lower revenue requirements because the carrying cost on arrearages is lower when the program achieves (bill) savings and improves bill payment behavior by participants.
Lower bad debt written off	The utility and its ratepayers have lower revenue requirements because the bad debt written off is lower when the program achieves (bill) savings and improves bill payment behavior by participants.
Fewer shutoffs	The utility and its ratepayers have lower revenue requirements because the shutoffs are reduced when the program achieves (bill) savings and improves bill payment behavior by participants.
Fewer reconnects	The utility and its ratepayers have lower revenue requirements because the reconnection costs are lower when the program achieves (bill) savings and improves bill payment behavior by participants.
Fewer notices	The utility and its ratepayers have lower revenue requirements because the cost of issuing notices is lower when the program achieves (bill) savings and improves bill payment behavior by participants.
Fewer customer calls	The utility and its ratepayers have lower revenue requirements because the number and cost of bill-related calls to customers is lower when the program achieves (bill) savings and improves bill payment behavior by participants.
Reduction in emergency gas service calls	The utility and its ratepayers have lower revenue requirements because onsite program activities and older equipment replacement reduce the risk from unexpected gas emergency calls.
Rate subsidy avoided (California Alternate Rates for Energy, or CARE) payments	The utility and its ratepayers have lower revenue requirements because the program achieves energy savings for participants, and fewer funds need to be raised to pay for rate subsidies for these saved kilowatt-hours (kWh) and therms.

[9] *Note that the model included calculations of some societal NEBs, but the utilities did not commonly include these NEBs in model runs. Note also that the categories are phrased as positives, but the net of positive and negative effects underlies the NEB concepts (e.g., reflected specifically in net household benefits).*

NEBs	Description
Participant NEBs	
Water/sewer savings	Measures that are installed under the program save water and energy use. Participants receive direct savings in water and wastewater bills from the lower water use.
Fewer shutoffs	Participants have fewer shutoffs of service because of lower bills and lower arrearages due to the program. This provides household benefits from the cost of fewer shutoffs, and the hardship to residents in getting service restored.
Fewer calls to the utility	Lower energy bills and associated improvements in bill payments lead to fewer calls to and from the utility on billing issues and lower time spent by participants on these calls, valued at participant value of time.
Fewer reconnects	Participants have fewer shutoffs of service because of lower bills and lower arrearages due to the program and, therefore, experience lower costs in time and fees in getting service restored.
Property value benefits	Repairs to the home improve the property value for the household.
Fewer fires	The program's onsite activities and older equipment replacement reduces the risk of fires and associated costs to participants including property damage, injury, and deaths.
Indoor air quality (CO-related)	The installation of CO monitors reduces the potential for sicknesses or deaths from CO poisonings to household members.
Moving costs/mobility	Getting behind on the utility bill is a major factor underlying household moves and evictions. Lower bills and better bill payments due to the program reduces this risk. Fewer moves save households the costs (deposits, etc.) and search time associated with moving houses.
Fewer illnesses and lost days from work	Program measures improve the conditioning of the households and reduce drafts and leaks, which can reduce illnesses of household members. This reduces household costs associated with sick days from work. Cost of sick days from school were not estimated.
Net household benefits from comfort, noise, net of negatives	Program measures improve the conditioning of households and reduce drafts, leaks, and noise from outside. New equipment may also operate more quietly, reducing inside-generated noise. Participant households receive and value benefits from the improved indoor environment from these changes.
Net household benefits from additional hardship benefits	Program measures and lower bills reduce hardship to households, financially and potentially in terms of worry and other quality of life effects.

There are limitations to the above list of utility and participant NEBs. There are uncertainties to the valuation, calculation, and applicability of these NEBs. The consensus from the 2001 NEBs study was to push forward but allow flexibility for each utility to turn on-off certain NEBs and allocations to provide flexibility.

The NEBs included and accepted in NEB 1.0 are listed in Figure 1.2.

Figure 1.2: NEBs Accepted in 2001 NEB 1.0 Model – All Utility NEBs, no Societal or Participant NEBs

Utility NEBs Accepted	Participant NEBs Accepted
• Arrearages • Lower bad debt written off • Shutoffs • Reconnects • Notices • Customer calls • Utility Rate Subsidy • Reduced gas emergency calls • Utility CARE rate subsidy	• Water/Sewer Bills • Calls to Utility • Shutoffs • Reconnects • Property value benefits • Fewer fires • Indoor air quality (CO-related) • Moving costs / mobility • Fewer illnesses and lost days from work/school • Net household benefits from comfort, noise, net of negatives • Net household benefits from additional hardship benefits
Societal NEBs Accepted	
• None	

In the NEB 2.0 project, the consultant team and IOUs set out to re-examine the list of existing NEBs to:

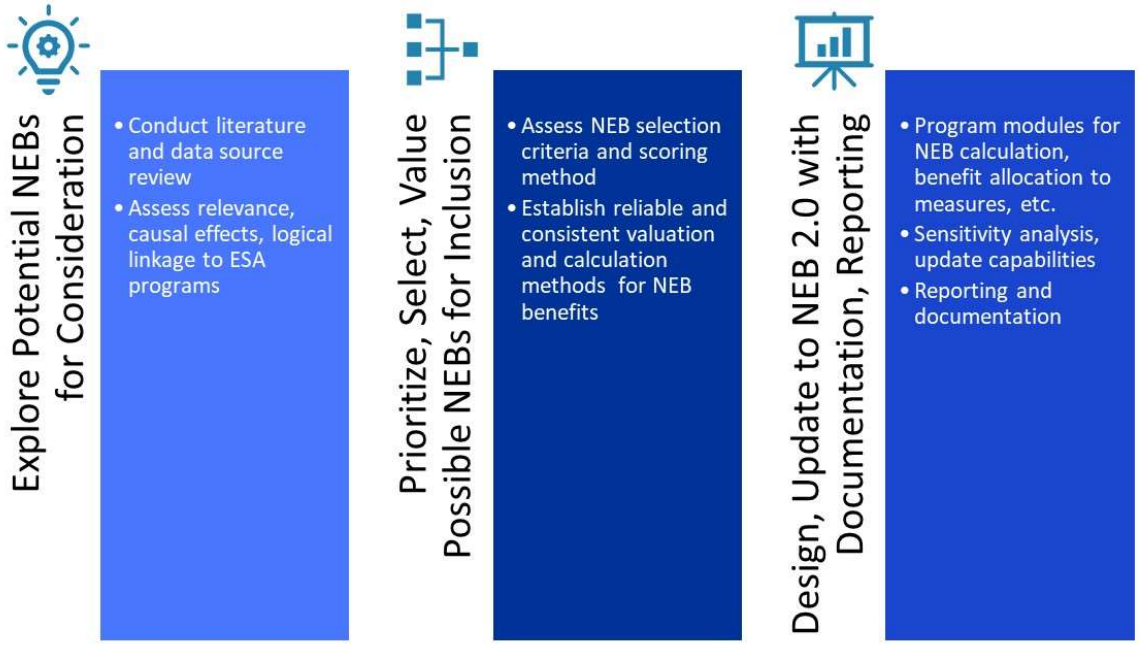
- Strengthen causal/logical linkage and the relevance to ESA/CARE program activities
- Improve the quality and vintage of the literature review inputs
- Ease possible concerns regarding double counting of benefits

The desired result is to improve the rigor, reliability, and confidence of the NEB 2.0 model estimates.

1.2 Project Approach

The project's tasks are illustrated in Figure 1.3. These major tasks included an updated literature review, analysis and assessment of potential NEBs, updated allocation and NEB calculability options, and development of a user-friendly model with enhanced capabilities. No primary data collection or surveys were included in the RFP or project scope.

Figure 1.3: Project Task Outline



- **Literature review update:** The consultant team updated its in-house literature reviews to include the latest literature on NEBs; health-, safety-, and comfort-related work; NEB values; and NEB issues. This involved a web search and review of recent publications from the US and internationally.
- **Assess existing and new NEBs and estimation methods, with a focus on health, safety, and comfort NEBs:** The consultant team identified an inventory of utility, societal, and participant NEBs that have been seriously proposed or estimated in the literature. Working with the IOUs, a list of evaluation criteria was developed that prioritized NEBs with sufficiently strong links to the ESA program, quantitative underpinnings, and consideration/acceptance in the literature. The consultant team reviewed each NEB and the available estimation options and supporting data and identified a short list of NEBs to include in the ESA program's NEB 2.0 model.
- **Assess issues of allocation and transferability:** The literature was reviewed to identify potentially workable options to allocate the program-wide NEBs to individual ESA program measures. In addition, the consultant team researched whether sufficient information existed to support estimation refinements to better account for climate zone, demographic, or other participant/program variations in the NEB computations now or in the future.
- **Develop updated user-friendly model:** Skumatz Economic Research Associates (SERA) developed a self-documented, user-friendly model that estimates the expanded list of selected ESA program NEBs and incorporates a variety of new features. On the user side, the model now operates with fewer user requirements, includes clearer instructions, centralizes and better documents data inputs, and clarifies update frequencies. On the computational side, the model estimates each NEB, allocates the program-wide NEBs to individual measures using defensible allocation rationales, supports more flexible user sensitivity analysis, and allows multiyear NEB analysis.
- **Documentation and training:** The final report, model, and training are the final project deliverables and required support efforts.

1.3 Objectives of this Study

The consultant team conducted research and modeling to upgrade the development, estimation, and modeling of the NEBs. The project had several primary objectives:

- Update the NEB calculations used for cost-effective analysis for the ESA program
- Select a battery of qualified NEBs with justifiable values and calculations for estimation/modeling and identify strengths and weaknesses.
- Provide an updated workbook to calculate the NEBs at both the NEB and measure levels

2.0 NEBs Research and Evaluation Process

This chapter of the report details the activities leading up to the development and inclusion of NEBs in the model. The chapter is organized as follows:

- Exploratory NEBs Research
- Prioritization, Selection, and Valuation of NEBs for Possible Inclusion
- Results of NEBs Scoring and Evaluation
- NEB Calculability and Appropriateness for Inclusion

2.1 Exploratory NEBs Research

2.1.1 Literature Review

The consultant team reviewed extensive in-house libraries of NEB studies and related research papers, augmented with a review of recent publications to construct a comprehensive set of NEBs that could result from ESA program measures. During this phase of the research, the team considered and gathered information on all NEBs that could be attributed to ESA program measures, with the understanding that only a subset would eventually be included in the model. The consultant team recognized that, while certain NEBs may not yet be rigorously quantifiable, those that are attributable to program measures should still be researched and reported on to the extent that they may be considered for inclusion in future models.

Various sources were gathered and reviewed to better understand and update NEBs under consideration. The quality of specific NEBs or inputs was assessed according to the following hierarchy:

1. Primary research on specific NEBs attributable to ESA programs and measures
2. Primary research from low income programs and measures
3. Primary research not specific to low income programs but relevant to ESA measures
4. Secondary research and meta studies collecting or reporting values to be used as inputs to NEB calculations
5. Publicly available reports or data sources providing values to be used as inputs to NEB calculations

Primary NEB research is conducted in many different ways, depending on the intended rigor and feasible methods of estimation for a given NEB. The primary research studies we consulted consisted of a mix of methodologies including more qualitative approaches such as surveys and interviews, along with more quantitative methods incorporating direct measurement and experimental design. Some key considerations in data quality include the recency of studies and data sources, the sample size and overall soundness of a study's methodological approaches, the similarity and relevance of study conditions and data to California's ESA program, specifically similarity to ESA's climate, demographics, measure and program delivery considerations.

2.1.2 Relevance of NEBs to ESA Program Measures

A key consideration in the team's research of NEBs for potential inclusion in the model was their relevance to the ESA program and measures offered through the program. For NEBs to be relevant, they must be logically attributable to program measures through defensible causal mechanisms.

The consultant team categorized the relevance of NEBs according to the following criteria:

- **Not relevant:** NEBs attributable to measures that will never be included in the ESA program (e.g., labor productivity increases due to measures installed in commercial establishments)
- **Relevant:** NEBs that are caused by measures that are:
    - Typically included in the program (e.g., increased comfort attributable to HVAC measures)
    - May only sometimes be included in the program (e.g., reduced carbon monoxide poisonings attributable to CO monitor installations)
- **Potential future relevance:** NEBs that are caused by measures or end uses that are next generation and are not currently included in the ESA program but may be one day

To assign NEBs to the categories outlined above, the team synthesized insights from several different information sources:

- **Literature or studies quantifying NEBs for specific measures:** The most useful quantitative study estimated NEBs for five specific appliances: room air conditioner, refrigerator, dishwasher, CFL bulbs, and CFL fixtures. The results of this study were used to identify defensible causal mechanisms linking ESA program measures and NEBs.[10]
- **Statistical attribution analysis linking NEBs to measures:** Preliminary work in 2006[11] was updated in 2019,[12] using regression analysis to link survey-based NEBs to subsets of measures or whole end use categories of measures installed in the homes. This statistical analysis applied mostly to participant perspective NEBs (including broad illness categories), but participant NEBs tend to be the most complicated to attribute. The other main quantitative residential study identified was an across-the-board, savings-based attribution study conducted for Massachusetts;[13] conceptually this does not address causality or relevance.
- **Interviews with ESA program staff and *Health Comfort and Safety Assessment* (HCSA) authors:** The consult team conducted interviews with ESA program staff from across the IOUs and with the authors of the HCSA. These interviews yielded important insights into NEBs the program staff had witnessed that were directly attributable to program measures, NEBs that could not justifiably be linked to program measures, and NEBs that may be included in future models despite the lack of quantitative evidence in the current literature. For example, from these interviews, the team learned that a decreased likelihood of death due to improvements in thermal stress through ESA program HVAC measures is not justifiable for inclusion in the model because only functional HVAC systems are replaced through the program; as such, the resulting improvement is not likely to have life or death implications.
- **Judgement and logic:** The consultant team assembled insights from the above sources and extended quantitative results from its regression work to whole end use categories in cases

[10] *See Summit Blue, Skumatz Economic Research Associates, and Apex Analytics, 2005*
[11] *See Skumatz and Gardner, 2006*
[12] *See Skumatz, 2019*
[13] *See NMR, 2011*

where studies included measure lists that differed from those offered through the ESA program. Logical assumptions were also made to allow the model to accommodate new and changing measures over time. For instance, if a participant NEB had a societal or utility NEB parallel, a measure link was sometimes assumed for both perspectives when data for only one perspective was available (e.g., participant and societal illness causes).[14] Two steps were modeled: assigning the set of causal measures to an NEB and then sharing out the NEB value among the assigned measures based on data, judgement, and logic.

When using the model and potential measures included in the model, IOUs should omit NEBs from their calculations in cases where NEBs are only attributable to a measure not offered by the program over a given time period. The consultant team recommends the California IOUs undertake primary, survey-based research in the near future to strengthen attribution and establish the relevance of NEBs to given ESA program measures.

2.1.3 NEB Health, Safety, and Comfort Considerations

Significant attention has been paid to health, safety, and comfort (HSC) NEBs over the past 5 years. Progress continues to be made to quantify the variety of benefits related to health and safety in the US and internationally. For example, rather than overall health NEBs, recent studies have estimated NEBs for specific illnesses that can be quantified and are directly related to measures delivered by weatherization programs.

The consultant team identified secondary literature and data sources to serve as key inputs to NEB calculations, in many cases allowing the NEB value to be tailored to California. Examples include information on the incidence of and reductions in various illnesses, citable sources on the costs of associated medical costs, and information on the share of costs paid out of pocket versus by Medicare, Medicaid, or insurance.

The team reviewed the HCSA in its research, paying particular attention to the report's four main HSC NEB considerations:

1. Eliminates combustion-related safety threat
2. Eliminates fire safety threat/improves home security (crime prevention) and building integrity
3. Reduces or eliminates extreme temperatures and temperature variations inside the home/improves customer ability to manage in-home temperature
4. Improves air quality, ventilation or airflow (e.g., reduces drafts and leakage)

In addition to gaining information on NEBs for consideration directly from the HCSA, the team interviewed a subset of HCSA authors and gained their direct input on the rationale behind the four considerations called out in the report, any additions or changes they would suggest for future investigation, any categories of NEBs not included in the HCSA but warranting the team's attention, and any additional context they could provide that might benefit the team's research.

[14] *For measures not yet known or available, the model relies on end use causations. When measures from completely new end uses are included in the program, the program will either have to use miscellaneous as the assigned end-use / measure bundle category or the attribution portion of the model may need updating in the future.*

2.1.4 NEBs Variation by Climate Zone

To date, there are few studies examining NEB-related differences associated with geography or climate. One study on NEBs for the National Weatherization Assistance Program (WAP) [15] found differences in impacts or change factors (inputs to NEB computations) by climate zone. Statistically significant differences were found by climate zone for perceived indoor temperature in the winter and summer, visits to doctors and emergency rooms, and ability to pay energy bills. This study did not link its findings to monetized NEB values; however, some of these factors relate to health and hardship benefits included in the model and would affect the estimate of NEBs for different climate zones, were California to decide to differentiate NEB values by climate zone.

The consultant team notes that measure savings themselves affect the NEBs delivered. For example, payment-related NEBs would be higher if a measure was installed in a climate zone where the measure was likely to save more energy. Survey results for comfort (and several other high value NEBs) are directly related to the savings delivered.[16] To the extent that an HVAC measure, for example, is placed in a city that allows it to delivery higher savings (e.g., in a very hot or very cold climate), the value of (survey-estimated) comfort coming from that measure is directly and measurably higher. The DEER database is a readily available source that identifies variations in savings for different California climate zones. To explore the possible differences, the consultant team examined differences in energy savings for residential furnaces in extreme climate zones, with the results highlighted in Figure 2.1.

DEER values provide a representation of deemed values for savings, and derive from results of multiple impact evaluation and other studies conducted over the years. The variation in DEER savings values between extreme climate zones in California for some vary by multiples of between 10 and 40.

Figure 2.1: High vs. Low Deemed Savings for Comfort-Related Measures for California Climate Zones

Measure	High Savings	Low Savings	Ratio High to Low
Furnace (kWh)	2.38 (CZ14)	0.22 (CZ7)	10.8
Furnace (therms)	0.78 (CZ16)	0.0366 (CZ7)	21.3
Air Conditioning (kWh)	326 (CZ15)	8.12 (CZ1)	40.1
Wall Insulation (kWh)	0.707 (CZ15)	0.0408 (CZ5)	17.3
Ceiling Insulation (kWh)	2.1 (CZ15)	0.113 (CZ5)	18.6

This finding that climate zone may matter for NEBs computations implies that the total value for comfort will be higher in those climate zones with more savings for these measures.[17] Other measures such as water heating and insulation may also vary by climate zone. The program could address this issue by using the DEER savings numbers to adjust the savings per measure entered in to the model by the share of the participants in different climate zones. Beyond DEER as a source, a review of primary sources including additional ESA impact evaluations and ESA and IOU studies can provide further evidence that

[15] *See APPRISE, 2018*

[16] *The basis of the Labeled Magnitude Survey (LMS) survey approach. See Skumatz, et al., 2009.*

[17] *A deeper review of the variations in deemed savings in the DEER database for the ESA measures would identify other NEBs that would be directly affected and result in higher NEB estimates in some climate zones. Given most ESA program HVAC measures do not have savings, it is especially important to examine other measure end uses in this deeper analysis. This is a recommended study in Chapter 4.*

energy use by measures varies by climate zone, and NEBs that use energy savings as a component of the calculation will be affected by these energy use differences.

As a further example of NEBs that may vary with climate zone, research suggests that the immune system does not fight off cold symptoms as effectively in cold weather.[18] As a result, reductions in the experience of colds may translate differently to NEB values based on climate zone. There is also evidence that the transmission and airborne survival of the influenza virus is linked to absolute humidity levels. [19] It is not unreasonable to conclude that the incidence of the flu and colds may be different among different climate zones in the state, resulting in different NEB values.

2.1.5 NEBs Variation by Geography

Most NEB studies are concerned with identifying the impacts for the entire utility territory and not subareas. However, one study drew results from several NEB studies and found that geographic differences, separate from the associated climate zone influences, have a demonstrated effect on the societal, economic, and job impacts from the program.[20] The study found differential effects for the same program and same investment dollars per program budget for three geographic areas, owing to substantial variations in the job and industry mix in each area. These same types of variations are expected in a state as large and diverse as California. As such, the accuracy of NEB results would be improved with different economic multiplier estimates for each of the IOU territories.

For participant benefits, the Apprise 2018 WAP study[21] was revisited, which differentiated results based on whether the respondent lived in an urban, suburban/town, or rural location. The only significant difference identified was town/suburb residents were more likely to have overnight stays only for hospital visits. These results were not, however, translated into measured NEBs.

Other health and safety values dependent on geographic area include the following:

1. Radon, a chemical element, levels are high in some parts of California and not others.[22]
2. Outdoor air quality (influenced by pollution, agriculture, forest fires, and other factors) will not be consistent across the state. Breysse[23] states that indoor air is "a complex mixture of agents penetrating from ambient (outdoor) air and agents generated by indoor sources." This mixture of air can contain particulate matter, allergens, and secondhand smoke, which are all triggers for asthma.
3. Areas with higher levels of humidity may have higher levels of indoor dampness. Mendell[24] finds sufficient evidence that asthma exacerbation, cough, wheeze, and upper respiratory tract symptoms are associated with indoor dampness or mold.
4. Certain neighborhoods are at a higher risk for lead exposure. One paper stated that replacing windows in single-family homes could have monetary benefits associated with NEB values ranging from $130 to $486 per year depending on the year the house was built. Houses built

[18] *See Foxman, 2015*
[19] *See Shaman, et al., 2010*
[20] *The consultant team recognizes that California has usually turned the estimates of societal NEBs off; however, the policy analysis of factors that affect NEB values naturally include geographic boundaries, and this NEB is affected by local industry mix.*
[21] *See APPRISE, 2018*
[22] *See California Department of Public Health CDPH 2016*
[23] *See Breysse, 2010*
[24] *See Mendell, 2011*

before 1940 had higher values than those built between 1940 and 1959, implying that older neighborhoods have more to gain from lead-safe window replacement than newer neighborhoods. There are many negative health effects on children from lead exposure, including a higher risk for inattention and impulsivity and lower test scores. The ESA program does not include window replacements, but lead-aware repairs conducted prior to weatherization may have similar benefits.

2.1.6 NEBs Variation by Building Type

The literature on NEBs for single family homes (low income and standard) is fairly robust and has been summarized in a number of places;[25] but many ESA participants reside in multifamily units. It might be expected that NEBs in multifamily or other housing types would differ in value or type because of size, age, differences in occupant count or characteristics, or other differences. However, published information on NEBs in the multifamily sector is far less common than single-family studies. Fewer than half a dozen studies were identified, and few had quantified estimates of NEBs overall or by category. The consultant team's analysis focused on four key studies[26] that conducted comparisons and research to draw inferences about the differences between NEBs in single-family and multifamily homes with the same or similar programs (mostly low-income programs). The most directly comparable data showed that single-family households realized a total participant NEB of about 110% of the value of energy savings, and in nearly all cases with similar multifamily households, the NEBs for multifamily varied between 93% and 112% of energy savings[27]. The conclusion is that there is not (yet) evidence of a significant difference for single-family versus multifamily households in participant, survey-based NEBs, presented as a multiple of energy savings.

For health and safety NEBs, multifamily households may have different sensitivity to air sealing measures; unit versus whole building may affect the levels of secondhand smoke in non-smoking units, as shown in Fabian[28] using building simulation models. Additionally, multifamily households may be more sensitive to safety improvements resulting from outdoor and common area lighting.

2.1.7 NEBs Variation by Fuel Type

The consultant team's literature review found only a small number of studies that explicitly identified the NEBs for gas versus electric participants within the same program.[29] Most studies study program-wide savings, perhaps because NEB studies are combined with broader process evaluations that sample for other goals. One study[30] directly compared participant survey-based NEBs for gas versus electric participants in the program, and the single-family results show that the participant NEBs for gas are

[25] *See Skumatz, Maryland, 2014*
[26] *See Skumatz for Xcel, 2010c; NMR Group, 2011; Cluett, 2015; Myers and Skumatz, 2006*
[27] *See Skumatz, 2014*
[28] *See Fabian et al., 2016*
[29] *See Skumatz for Xcel, 2010c*
[30] *See Skumatz for Xcel, 2010c*

110% of energy savings and the NEBs for the electric participants are 116% of savings—an indistinguishable difference.[31]

It is worth noting that gas versus electric measures may result in different NEBs. Some gas-related measures may cause specific safety-related NEBs that are not commonly attributed to their electric counterpart measures (e.g., gas vs. electric water heaters). Hot water scalding incidence may also vary between gas and electric water heaters. In Shields[32] the author finds that gas water heaters are nearly five times more likely to have temperatures set over 120°F relative to electric heaters, increasing the potential for scalding. Similarly, homes using gas combustion for cooking or heating are more vulnerable to CO poisoning relative to electric-only homes.

2.1.8 NEBs Variation by Demographic Variation

The Apprise WAP study[33] explored whether some of the impact calculations were affected by the presence of vulnerable household members—elderly versus children. The study found the following factors varied between these two groups: very hard or hard to pay energy bills, could not afford to see doctor with coverage, and could not afford prescriptions with prescription coverage. The results were not directly related to NEB values but indicate the health NEBs are influenced by the demographics, particularly as it relates to the percentage of participants containing vulnerable populations (specifically those over 65 and children). There is little published work on the role of participant demographics on NEB values, and particularly, whether these factors are influential in NEB values beyond the health and safety categories.

2.1.9 California and ESA Program-Specific Adjustment Summary

The results from the literature and related research on climate zone, demographic differences, and other factors considered in this section indicate the following:

- Participant perspective NEB results are similar in order of magnitude terms for gas and electric programs and for single-family and multifamily occupants.
- Climate zones are a source of considerable potential variation. Although current research only demonstrates the potential effects for one type of HVAC measure,[34] other measures may show similar patterns. Several NEBs are related to energy savings (across all the measures), and research on the DEER database can indicate whether this is substantial enough for utilities to use more refined savings estimates for the array of program measures.[35] The research also indicates that non-savings aspects of climate zones affect health and safety NEBs, which may represent another possible area of refinement between IOUs in the NEBs estimates.
- The limited work on demographic influences indicates that the presence of vulnerable populations may also be a significant factor influencing NEB values, particularly health-related NEBs. However, strong quantitative work on this topic does not exist.

---

[31] Note that the differences for multifamily gas versus electric program participants were 101% electric and 93% gas, with the gas NEBs totaling 212% the NEBs for the electric participants. Source: Skumatz, 2010c.
[32] See Shields, et al., 2013
[33] See Apprise, 2018
[34] Many ESA program HVAC measures do not claim savings.
[35] This research is recommended in Chapter 4.

2.2 Prioritization, Selection, and Valuation of NEBs for Possible Inclusion

2.2.1 NEBs Scoring Criteria and Method

There were three steps of analysis in selecting the NEBs that would be modeled and accepted for use in the NEB 2.0 model.[36]

- The first step included assembling an inventory of potential new NEBs and scoring them according to an organized set of criteria. This determined which NEBs would be potentially included in the model pending development of a defensible source of data and computation method. The consultant team conducted the development and scoring work, according to scoring criteria approved by the utilities.
- The second step involved locating the most defensible input data and computational approaches for the NEBs selected in the first step, and programming them into the NEB 2.0 model. The consultant team conducted this work.
- The third step included reviewing the computations and input data, and determining whether, given the current state of the input information and computation methods available, the computed NEB should be adopted for use in the NEB 2.0 model at this time. This was conducted via a joint decision-making process.

This section of the report discusses the first step.

The consultant team developed an inventory of NEBs to be considered and assessed, and deleted NEBs that were duplicates, had strong overlap with other NEB concepts, were not well-linked to the ESA program or measures, or had murky definitions. The consultant team worked with the study advisory team to develop a set of criteria to assess the quality of the estimated NEBs to inform the decision whether to further investigate the NEB, develop its quantification, and program the NEB into the model. The criteria follow in Figure 2.3.

[36] *Considerable additional work beyond these steps were conducted to develop the NEB 2.0 model and its calculations, but did not involve a scoring methodology. For example, the development of the NEB 2.0 model included addition of a module that would link the NEBs with their specific "causal" measures (called "attribution"). This was not based on a scoring mechanism, but on separate direct research. The link between the attribution work to the scoring in this section is that NEBs that did not pass through the scoring system were not included in the model.*

Figure 2.3: Qualitative Assessment Criteria and Weighting

Criteria	Description	Weights
Causality	Likelihood California ESA measures will result in NEB effects: whether the ESA program includes measures or treatments that are likely to result in the NEB.	25%
Transferability	How easily or not a NEB can be adjusted to California: whether the steps in the derivation of the estimate in the origin study could be modified to adjust to California ESA conditions.	15%
Reliability	Confidence in calculation and value: confidence in the computation method, sources, and resulting value.	15%
Measurability	Feasibility of collecting data and performing calculation: whether the calculation for the ESA program needs, has, or can obtain the inputs needed for the preferred computation for the NEB.	20%
Literature	Quality, quantity, and age of existing literature on specific NEB or associated with the inputs: examining the number of studies estimating the NEB, emphasizing studies with actual research on the underpinnings of the computations, and the level of consistency of logic and computations of the NEBs for other similar programs or measures.	25%
Weighted Score	Quantitative scoring based on computation of the NEB's performance on criteria	
Overall	Consultant team assessment of the NEB's performance, informed by the weighted criteria scoring (above, rounded to an integer). This score also considered the complexity of the likely computation and quality of likely input data[37] and whether the NEB is well-acknowledged or fills a gap.[38] In some cases, the overall score was low to account for the fact that the measurable NEB was elsewhere addressed—for instance, in the avoided cost work.	

The consultant team examined each NEB's underlying logic/causality, inputs, data sources, computation approaches, and the fit within the literature and scored the performance for each NEB on a 1-5 scale. A score of 1 indicated the NEB was very strong on the criteria; a 5 indicated the NEB was very weak on the criteria. The average weighted[39] scores were used to inform the overall score, and these two scores were used to assess whether individual NEBs should be considered for quantification for the ESA program. At least two consultants scored each NEB, based on their knowledge of the literature and assessment of each NEB on each of the criteria.

[37] For example, some inputs may look thin (or old) in a quantitative literature assessment, but the quality of the initial study or studies on the topic were strong enough that little additional research was conducted because little needed to be added to the topic.

[38] In a few cases, the NEB had almost all elements of computation available but lacked one piece of data; addressing that gap would resolve the NEB's quantification. In these cases, some NEBs were upgraded so the attention to that data element would remain and potentially remain on the research radar and be resolved.

[39] Weights were developed to recognize that some criteria were potentially more important, or more "independent" than others. Causality was important; a NEB based on installation of extensive commercial cooking equipment would not be a high scorer, even if there was a perfect computation method. Similarly, if the NEB was not discussed with some frequency in the literature, and had no computations within the literature, the score would be low. Others were accorded a lower weight, because the transferability might depend on the publication of studies from a nearby state or similar program, which might significantly change the assessment of how transferable (and how reliable and measurable) literature values would be when adapted for the ESA program NEB computations.

Based on the consultant team's assessment scores, the NEB was assigned to one of five categories, with 1 and 2 indicating the NEB is expected to be programmed into in the model, and 5 and higher for NEBs generally excluded from the model. The classifications for treatment of NEBs based on their scores is provided in Figure 2.4. The scoring results are discussed in Section 2.3, and the assessment of NEBs for inclusion is discussed in Section 2.4.

Figure 2.4: Assessment of NEBs for Further Study and Quantification

Score	Explanation
1 (Most Credible)	For NEBs included in the previous 2001 NEB 1.0 model or a NEB generally agreed to be included in the NEB 2.0 model.
2	For well-reasoned NEBs, include in model.
3	May or may not include in the model, may warrant further discussion.
4	For controversial but indicative, possibly provide space in the model for future refinement.
5 (Least Credible)	Generally, exclude from the model.

This phase was an important step in refining the list of NEBs from more than 130 candidates to a more abbreviated list with credible links to the program and defensible computation methods. Some NEBs were strong and others were weak, as will be described in the next section.

2.3 Results of NEBs Scoring and Evaluation

After an iterative assessment and review process, the consultant team and IOUs narrowed the list of qualified NEBs for further consideration. These scores were used to prioritize where to focus attention on developing calculation methods and sourcing appropriate inputs. This short list of NEBs was derived from the scoring described above. The detailed list, by NEB, is included in Figure 2.5 (Utility NEBs), Figure 2.6 (Societal NEBs), and Figure 2.7 (Participant NEBs). Early columns in the figures also note whether the NEB was included in the 2001 NEB 1.0 model and whether it was selected for calculation in the new model. Middle columns note the scores on individual criteria discussed in Section 2.2.1. The rationales for the individual criteria scores for each of the NEBs included in the model are included in the discussion of individual NEBs in Appendix B. The last column in the figure is the overall assessment score, which had five categories.

1: Included in the original model and/or include in new model
2: New – include in the model, feasible, calculable, relevant
3: New – likely to include in model for future /discuss
4: Not documented quite well-enough/include as placeholder in model
5 and above: Not included in model

Some NEBs were strong. The literature, causality, calculation methods, and measurability for economic impacts (and their co-calculation elements—labor income and tax effects) are strong. They scored, in order, 1, 2, 2, 1, with a 1.2 weighted score and a 1 overall. The NEB has been estimated by some utilities with dedicated, tailored utility models for many years, and there are multiple well-vetted third-party models that develop local estimates of the multiplier and ripple effects of expenditures on ESA measures in the local economy. They also do not appear to overlap with other NEBs.

The estimates need to be local, not borrowed, and although California estimates have been developed, they were only conducted at a level to provide draft order of magnitude proxies, not conducted as dedicated studies.[40] Therefore, for the immediate term, the utilities may elect not to include this NEB until they engage a project to conduct primary research using the relevant California models (or potentially four IOU subareas) to refine the estimate for this NEB.

Similarly, the EPA's CO-Benefits Risk Assessment (COBRA) model estimates credible, defensible estimates of the value of fewer negative societal health effects due to reduced emissions from reduced electricity generation. These NEBs score highly on the ranking scale (1, 1, 2, 1, 1, 1.2, 1). The model is readily available, embeds the valuations from peer-reviewed journal articles for illnesses, has California electricity generation data embedded, and is user-friendly. Again, however, the utilities may elect to wait for a dedicated study to run this model for the California case, or for subareas of California (if the model can parse the areas) prior to full implementation within the cost-effectiveness test.

Other NEBs that appear reasonable include updated utility-side estimates of payment-related NEBs (reduced carrying costs on arrearages, notices, etc.), sick days from work or school, comfort, fire risk, property value improvements, and others. Each can be calculated with information currently available. However, just as every effective useful life estimate (EUL) for measures would be improved with an updated study, every NEB can be improved with an updated, dedicated study. The priority recommendations are included in Chapter 4 of this report.

Others were weak—in some cases because literature was lacking or because the concepts were addressed in the avoided cost. This included avoided cost of energy, power quality improvements, fuel supply risk, demand reduction induced price effects (DRIPE), avoided cost of renewable portfolio standards, economic competitiveness, and fish/wildlife mitigation, among others.

Finally, Figures 2.5-2.7 show other NEBs with differences between the weighted scores and the overall assessment. An illustrative example includes societal water/wastewater infrastructure. This NEB was historically missing one key input: avoided cost of water for the next water resource. The literature is limited on this variable (hence, a lower quantitative score); however, every other piece of the logic for the computation has been clear, and there happens to be a recent, California-specific study on just this missing piece of information. So, despite the lower quantitative score, the overall score is higher to reflect the relevance of this key piece of literature in completing the NEB computation credibly. Another illustrative example is headaches. Although the data exists to estimate this NEB, the consultant team felt the NEB would overlap with other NEBs that are estimated (allergies or asthma might also lead to headaches), so the overall score was de-rated. Another case in which the NEB may be calculable but was not included were NEBs with literature that was largely international (e.g., New Zealand) or the NEB was not as critical to the California situation generally; an example might be humidity and mold effects.

[40] This study's scope did not include primary data work; some draft analyses were pulled from other Skumatz Economic Research Associates, Inc. (SERA) work to develop order of magnitude proxies to inform this project, including COBRA™, RIMS II™, and IMPLAN™ runs for California.

Figure 2.5: NEB Inventory, Associated Performance Scores, and Inclusion in New Model: Utility NEBs

UTILITY	In NEB 1.0 Model	In NEB 2.0 Model	Accepted in NEB 2.0 Model	Causality	Transferable	Reliable	Measurable	Literature	Wtd Avg	Overall
Customer Service / Collection										
Arrearages *(carrying cost on arrearages)*	1	1	1	1	1	2	1	1	1.1	1
Bad Debt Write-offs	1	1		1	1	2	1	1	1.1	1
Customer Calls and Collections	1			1	1	2	4	1	1.9	1
Customer Calls *(only)*		1		1	1	2	4	1	1.9	2
Collection Costs *(other Collection)*				1	4	4	4	5	3.8	4
Notices	1	1	1	1	1	2	1	1	1.1	1
Terminations *(Shutoffs)*	1	1	1	1	1	2	1	1	1.1	1
Reconnections	1	1	1	1	1	2	1	1	1.1	1
Improved Customer Relations				4	5	5	2	5	4.1	4
Energy Infrastructure / System Security										
Improved Efficiency Program Effectiveness				3	3	5	5	5	4.4	5
Power Quality Improvements				1	3	4	2	2	2.1	6
T & D / Avoided Line Losses *(electric)*	1			2	4	2	2	1	1.9	1
Peak Load Reductions				1	1	1	1	1	1.0	2
Fewer Substations, etc				1	4	4	2	1	1.9	3
Increased Electricity System Reliability				3	3	3	4	2	2.9	3
Energy Efficiency - Fuel-Supply Risk-Reduction Strategy				4	2	2	4	2	2.9	6
Avoided Cost of Ancillary Services				3	3	2	4	2	2.8	6
Avoided Cost of Energy				1	1	1	1	1	1.0	6
Avoided Cost of Generating Capacity				2	2	2	2	1	1.7	6
Avoided Cost of Transmission and Distribution Capacity				2	2	2	2	1	1.7	6
Avoided Line Losses (gas)				2	5	5	3	4	3.6	6
System Reliability *(Power Quality)*				1	3	4	2	2	2.1	6

UTILITY	In NEB 1.0 Model	In NEB 2.0 Model	Accepted in NEB 2.0 Model	Causality	Transferable	Reliable	Measurable	Literature	Wtd Avg	Overall
Environmental										
Avoided Cost of Environmental Compliance				2	4	4	1	5	3.2	6
Reduced Air Emissions				1	1	1	1	1	1	6
Financial										
Rate Discounts / Reduced Subsidy Payments	1	1	1	1	1	2	1	1	1.1	1
Insurance Savings / Utility Risk	1	1		1	4	4	4	3	3.1	1
Energy Efficiency - Fuel-Price Hedging Strategy				4	2	2	2	2	2.4	6
Other Fuels - Reduced fan use, other generation				1	3	4	2	4	2.8	6
Avoided Cost of Renewable Portfolio Standards				1	3	4	2	3	2.5	6
Demand Reduction Induced Price Effects (DRIPE)				2	2	2	2	2	2	6
H&S- Safety / Customer Service										
Safety-Related Emergency Calls	1	1		2	1	4	3	2	2.4	1
Not Elsewhere Classified										
Saved Cost of Inspections and Upgrades by Other Agencies				4	5	5	5	5	4.8	5

Figure 2.6: NEB Inventory, Associated Performance Scores, and Inclusion in New Model: Societal NEBs

SOCIETAL	In NEB 1.0 Model	In NEB 2.0 Model	Accepted in NEB 2.0 Model	Causality	Transferable	Reliable	Measurable	Literature	Wtd Avg	Overall
Economic										
Economic Impact	1	1		1	2	2	1	1	1.2	1
Job Creation	1	1		1	2	2	1	1	1.2	1
Tax Effects		1		1	2	2	1	4	2.3	2
Reduced Short-Term High-Interest Loans				2	2	4	3	4	3.2	4
Economic Competitiveness				4	4	5	4	5	4.5	6
Education										
Improved Educational Outcomes				2	3	4	2	3	2.7	3
Energy Infrastructure / System Security										
Downward Pressure on Wholesale Energy Prices				3	2	4	3	5	3.7	6
Energy Price Stability				1	2	4	2	4	2.7	6
Lower Peak Energy Costs				1	1	3	1	4	2.3	6
Environmental										
Emissions / Environmental Impacts	1			1	1	2	1	1	1.1	1
Emissions / Environmental - Illness		1		1	1	2	1	1	1.1	2
Fish / Wildlife Mitigation				3	5	5	3	5	4.1	4
Coal Ash Ponds and Coal Combustion Residuals				3	4	5	4	5	4.3	6

SOCIETAL	In NEB 1.0 Model	In NEB 2.0 Model	Accepted in NEB 2.0 Model	Causality	Transferable	Reliable	Measurable	Literature	Wtd Avg	Overall
H&S - Health										
Fewer missed days at work		1		2	2	3	2	3	2.5	1
Reduced Asthma Symptoms		1		2	3	3	3	2	2.5	2
Low Birth-Weight Babies / Food Security		1		3	2	3	3	4	3.3	3
Improved Drug Affordability / Adherence		1		3	2	3	3	3	2.9	3
Reduced Cold-Related Thermal Stress				1	2	3	2	2	1.9	6
Reduced Heat-Related Thermal Stress				1	2	3	2	2	1.9	6
H&S - Safety										
Fewer Carbon Monoxide Poisonings	1	1		1	1	2	2	2	1.7	1
Fewer fires				2	2	3	2	2	2.1	2
Higher Safety (or Perception) from Improved Lighting				2	4	3	4	2	2.8	6
National Security										
National Security				3	2	4	2	4	3.1	4
Property Values / Neighborhood										
Improved Housing Stock / Preservation				1	2	4	2	3	2.4	3
Increased Home Productivity				3	4	4	3	4	3.6	4
Resource Benefits										
Avoided Landfill Space				2	2	4	2	4	2.9	3
Incineration of Insulating Foam				2	2	4	2	4	2.9	3
Recycling of Plastics and Glass				2	2	4	2	4	2.9	3
Water Related										
Water / Wastewater Treatment / Supply Plants	1	1	1	2	2	4	3	4	3.2	1
Waste and Wastewater Savings				2	2	3	2	3	2.5	2

Figure 2.7: NEB Inventory, Associated Performance Scores, and Inclusion in New Model: Participant NEBs

PARTICIPANT	In NEB 1.0 Model	In NEB 2.0 Model	Accepted in NEB 2.0 Model	Causality	Transferable	Reliable	Measurable	Literature	Wtd Avg	Overall
Aesthetic Benefits										
More Attractive *(windows, appliances, etc.)*				1	2	4	2	4	2.7	3
Aesthetics -Fluorescent / LEDs *(Measure Specific)*				1	2	3	2	3	2.3	3
Less dusting and vacuuming				1	3	5	4	5	3.8	4.5
Protected Furnishings				1	3	4	3	5	3.4	4.5
Bills / Payment										
Arrearages (Arrearage Reductions)	1	1		1	2	2	1	1	1.2	1
Bill Related Calls to Utility	1	1	1	1	2	2	1	1	1.2	1
Shutoffs	1	1		1	2	2	1	1	1.2	1
Reconnects	1	1		1	2	2	1	1	1.2	1
Reduced Energy Expenses				1	2	1	1	4	2.2	6
Reduced Summer Electric Bill				1	2	1	1	4	2.2	6
Reduced Winter Heat Bill				1	2	1	1	4	2.2	6
Comfort										
Thermal Comfort	1	1	1	1	2	3	2	1	1.6	1
Changes Lighting Generated Heat				2	2	3	3	3	2.7	5
Improved Airflow				2	2	3	2	3	2.5	6
Automatic Thermostat Controls				2	2	3	2	4	2.8	6
Education / control										
"Hassle" Factor Associated with implementing projects				3	3	4	3	2	2.8	3
Control Over Energy Use / Energy Bill				1	3	3	2	3	2.4	3
Reduced Transaction Costs *(Knowledge when purchasing equipment / locating appropriate products)*	1			2	2	4	3	4	3.2	3
Customer O&M savings		1	1	1	1	3	2	2	1.8	2
Product Lifetime *(By Measure)*		1		2	2	3	2	5	3.2	3
Equipment Performance										
Reduced Noise *(Appliance)*	1	1	1	1	2	3	2	2	1.9	1
Product Performance *(By Measure)*		1		1	2	3	2	3	2.3	2
Noise Reduction *(External)*		1	1	1	2	3	2	2	1.9	2
Reduced Drying time *(Clothing)*				3	2	2	2	4	2.9	4
Reduced Wear and Tear *(Clothing)*				2	2	2	4	5	3.6	4
Lighting Turn On / Warm Up Delay *(Measure Specific)*				2	2	3	2	5	3.2	6
Lighting Quality *(Measure Specific)*		1		1	3	3	2	2	2	2
Reduced Detergent Use *(Measure Specific)*		1	1	1	1	4	2	3	2.3	2
Financial										
Reduced use of short-term, high interest loans				2	2	4	3	4	3.2	2
Program Incentives *(rebates, low interest financing, subsidized home assessment)*	1	1		1	2	4	2	4	2.7	1
Operating Costs *(non-energy bills)*				2	2	4	3	5	3.5	3
Economic Development				3	3	4	3	4	3.5	4
Lower Insurance Costs / Deductables / Damage (gas; no electric in lit)				2	2	4	2	4	2.9	4
Buffers Energy Price Increase				3	3	4	2	5	3.6	5
Appearance / Aesthetics / Ease of Selling Home		1	1	1	3	3	2	3	2.4	3
Hardship *(Reduced need to move / costs of moving / homelessness, education)*	1	1	1	2	2	1	2	3	2.3	1

PARTICIPANT	In NEB 1.0 Model	In NEB 2.0 Model	Accepted in NEB 2.0 Model	Causality	Transferable	Reliable	Measurable	Literature	Wtd Avg	Overall
H&S - Health										
Fewer Missed Days Work	1	1		2	2	3	3	2	2.4	1
CO / Improved Indoor Air Quality	1	1		2	2	3	2	3	2.5	1
Reduced Cold-Related Thermal Stress				1	2	3	2	2	1.9	3
Reduced Allergies		1	1	3	4	3	3	2	2.8	3
Reduction Colds and Viruses		1	1	4	3	3	3	3	3.2	3
Reduced Asthma Symptoms		1	1	2	3	2	3	2	2.4	3
Fewer Missed School Days		1		4	3	3	3	2	2.9	3
Increased Home Productivity *(mostly improvements in sleep)*				4	3	3	4	4	3.8	5
Condensation / Moisture / Mold Reduction				4	5	3	2	3	3.2	6
Ease of Maintaining Healthy Humidity				3	4	3	3	5	3.8	6
Hypertension / Cardiovascular Risks				4	4	4	4	2	3.3	6
Improved Mental Health				4	4	3	4	3	3.6	6
Improved Sleep				4	2	4	4	2	3.1	6
Respiratory - Other *(Not Elsewhere)*				3	4	4	4	5	4.2	6
Reduced Radon Exposure				4	3	4	3	5	4.0	6
Reduction Food Poisonings *(food storage)*				3	3	4	4	5	4.1	6
Reduced Headaches				4	3	3	3	3	3.2	6
Reduced Lead Exposure				2	3	3	3	2	2.5	6
Reduced Medical Costs				4	2	3	2	4	3.2	6
Water Damage / Mold				2	3	4	4	3	3.2	6
Sinusitis				4	3	4	4	3	3.6	6
Reduced Heat-Related Thermal Stress				1	2	3	2	2	1.9	2
H&S - Safety										
Reduced Fire Risk	1	1	1	2	2	2	2	2	2.0	1
Reduced Carbon Monoxide Risk		1	1	1	1	2	3	2	2.0	2
Reduced Hot Water Scaldings		1	1	2	2	3	2	3	2.5	2
Improved Household Safety		1		3	2	3	2	2	2.6	3
Improved Lighting - Reduced Accidents				3	3	2	3	4	3.3	3
Negative NEBs										
Negative Impacts (not elsewhere from equipment or program)				1	2	3	2	3	2.3	5
Perceptions & Attitudes										
Enhanced Pride or Prestige				2	3	4	2	4	3.0	4
Doing "Good" for the Environment		1	1	2	3	3	2	3	2.6	2
Perception of Efficiency Improvement & NEIs				3	3	4	2	4	3.2	6
Peace of Mind *(Ease Responsibility for Family Well-Being)*				1	2	4	4	3	2.9	6
Property Value										
Property Value Increase	1	1	1	1	3	2	2	2	1.9	1
Mortgage Risk				2	3	4	4	4	3.5	5
Water										
Water / Wastewater Bill Savings	1	1	1	1	2	2	1	1	1.2	1
Availability of Hot Water				2	2	4	3	5	3.5	4

Figure 2.8 includes a summary count of NEBs that were moved forward to quantification in the NEB 2.0 model. Not all these NEBs were ultimately recommended for inclusion in the immediate computations for ESA program cost-effectiveness. This topic is discussed in the next section.

Figure 2.8: Count of NEBs Modeled in ESA NEB 2.0

	Number of NEBs in Inventory	Included in ESA NEBs 1.0 Model	Included for Modeling in ESA NEB 2.0	Percent Modeled
Utility NEBs	32	11	9	28%
Societal NEBs	32	4	10	31%
Participant NEBs	72	12	27	37%
Total NEBs	**136**	**27**	**46**	**34%**

2.4 NEB Calculability and Appropriateness for Inclusion

In evaluating NEBs for inclusion, the Consulting Team, in a joint decision-making process with the IOUs, considered whether each NEB had a strong rationale and link to the program or its measures and whether review of the literature and available data sources indicated the NEB had been calculated or could be calculated from credible sources.

Many methods are used to estimate NEBs, due to different lines of causation and challenges in quantification. While some NEBs can be measured directly with great certainty, others are less certain. As an example, many of the secondary research-based values that were used as key inputs to our calculation of NEB values were based on the results of studies with large sample sizes and robust experimental designs.[41] An example includes some of the health and safety NEBs related to asthma and other illnesses. In some cases, both the incidence and value were from California data. Water and sewer bill savings are based on key input values from measurement by authoritative third-party sources. In cases such as these, the estimates of NEB effects are highly certain. Similarly, a number of other NEB impacts are calculated through surveys using experimental design. In these cases, participants and non-participants are asked the same questions, and differences are attributable to the NEB with a high degree of certainty. An example includes a few illness-related NEBs based on the Weatherization Assistance Program data. For several of the participant NEBs, a statistically-valid sample of participants were asked about impacts attributable to the program using industry standard design (e.g. comfort, noise, among others). Most primary research findings, however, were adopted from jurisdictions outside the CA IOUs, inherently increasing uncertainty. Examples include the reductions in bill payment / customer-service-related NEBs including arrearages. While the consultant team made adjustments to better tailor these NEBs to the CA ESA program, adjustment procedures also introduce uncertainty.[42] Finally, attribution also contributes uncertainty to the NEB findings. The exact equipment installed, for instance, in one study of NEBs may differ in some way from the equipment installed through the ESA program, leading to another layer of uncertainty.

[41] Examples include a Washington state study with quasi-experimental design with values on asthma incidence used in the estimation (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3910032/) and a health-related NZ study cited in the appendix with quasi-experimental design (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1808149/pdf/bmj-334-7591-res-00460-el.pdf).

[42] Model-based NEBs can be more applicable for California to the extent that their inputs are California-based and the model is vetted for California; however, the model-based NEBs are not currently included because they have not yet been run for California.

In every case, the consultant team chose the most robust, defensible and credible NEB estimates and input values available. However, the Consultant Team acknowledges that there are multiple sources of uncertainty in the calculation of NEBs for this study. While the Consultant Team made all possible efforts to adjust and tailor NEB calculations to mitigate sources of uncertainty, some degree of uncertainty is inherent even in the most robust NEB calculations. As suggested in this report, the consultant team strongly recommends California undertake primary survey-based research in the near future, specific to its ESA program NEBs, to increase certainty moving forward.

All NEBs included in the model have associated methodologies, supporting data, and calculation steps. However, not all NEBs the team researched were determined ready for inclusion in the model. The descriptions below include assessments of whether the current NEB is strongly calculable for California's ESA program and whether the NEB is recommended for immediate inclusion in the cost-effectiveness computation. The consultant team and the utilities discussed the merits of the inclusion of various NEBs in the model, and through a joint decision-making process identified those NEBs that should be accepted for immediate model inclusion versus those requiring additional data, inputs, or research. Those NEBs that can be substantially improved or localized by using data from the additional ESA program and California data collection. NEBs are recommended for inclusion in the near-term cost-effectiveness modeling based on considerations related to inputs, data age, and other factors. The recommendation as to whether a NEB should currently be included in the model is noted at the beginning of each NEB description.

2.4.1 Utility NEBs

Figure 2.9 shows the utility NEBs included in the 2001 NEB 1.0 model, and the NEBs included in the new ESA NEB 2.0 model. A description of the rationale and calculation approach for each of the utility NEBs follows the figure. A discussion of key studies associated with each of the calculated NEBs is included in Appendix B. The data and outline of the computations included in the new NEB 2.0 model are presented in Appendix A. Similar figures (Figure 2.10 and Figure 2.11) as well as descriptions for the societal and participant NEBs follow in sequence.

Figure 2.9: NEBs in 2001 NEB 1.0 Model vs. New ESA NEB 2.0 Model: Utility NEBs

2001 NEB 1.0 – Utility NEBs	2019 ESA NEB 2.0 – Utility NEBs
• Arrearages	• Arrearages
• Bad Debt	• Bad Debt*
• Shutoffs	• Shutoffs
• Reconnects	• Reconnects
• Notices	• Notices
• Customer Calls	• Customer Calls*
• Collection Costs^	• *(EXCL: Collection Costs, excluded)*
• Emergency Gas Service Calls	• *(EXCL: Emergency Gas Service Calls)*
• Utility H&S / Insurance^	• Insurance Savings (Placeholder Only)
• T&D Savings	• *(EXCL: T&D Savings, included in Avoided Cost report)*
• Utility Rate Subsidy	• Utility Rate Subsidy

^Impact Not Fully Calculated in NEB 1.0 Model. *Calculation formulae included in NEB 2.0 Model but have elected not to use at this time.

Utility Arrearages (Utility Customer Service and Payment) – updated from 2001 NEB 1.0 model, adopted for use in NEB 2.0 model: Energy savings from installation of ESA measures reduce the financial burden on households and improve their payment behaviors. This reduces the financial burden on utilities. The value is calculated as the arrearages are updated to 2018 using the consumer price index (CPI) times the program-induced reduction in arrearages. This number was then multiplied by utility data for the interest rate for carrying charges on arrearages. Utility Arrearages is one of the most studied NEBs and has been adopted in many states. The literature includes dozens of different studies from the late 1990s to 2018 containing an overall value or data input for Utility Arrearages. The range of values for Utility Arrearages is about $0.50-$5.00 per household, with a typical value at around $3.00 per household, which is a significant benefit to the utility. The value calculated by test runs of the model for this NEB is comfortably within the range found in the literature.

Utility Bad Debt (Utility Customer Service and Payment) – updated from 2001 NEB 1.0 model, needs additional research, have elected not to use at this time, set to zero: Energy savings from installation of ESA measures reduce the financial burden on households and improve their payment behaviors. This reduces the financial burden on utilities. Calculations from the 2001 NEB 1.0 model have been updated. The value for this NEB is calculated by using the average bad debt value per low income customer from the literature and adjusting that value for inflation. This was multiplied by the estimated program-induced percentage of bad debt written off by utilities. Utility Bad Debt has strong support in the NEBs literature. A review of the literature identified more than a dozen studies on the subject dating back to the 1990s. A standard value for bad debt write-offs is just under $5.00 per household and is, therefore, an important benefit to include. Values for this NEB range from about $0.50 to $6.50per household and the value calculated by test runs of the model is well within that range.

Utility Shutoffs/Reconnects (Utility Customer Service and Payment) – updated from 2001 NEB 1.0 model, adopted for use in NEB 2.0 model: The ESA program's energy savings improves a customer's ability to pay their bills and avoid service disconnects as a result of nonpayment, with resulting savings to the utility and its ratepayers. Most of the literature and values for this NEB have been broken out into Shutoffs and Reconnection elements. The calculations for this study have been run separately for clarity. Terminations or Shutoffs have been calculated using data from the utilities for the average number of terminations per year for low income participants multiplied by the estimated reductions from the program. This is monetized by using the utilities' marginal cost per shutoff and updating it for inflation. The reconnection calculation is the much same, using corresponding inputs but also using the dollar value for the utilities' reconnect fees to adjust for inflation. This NEB is widely recognized by utilities and has been well-supported in the literature with studies dating from the late 1990s to 2018. The literature includes more than a dozen studies that have either estimated or provided data inputs to monetize the impact on the utility. That impact is a non-trivial amount ranging from around $0.00-$7.00 per household and usually less than $1.00 per household, which supports its inclusion in the model. The value calculated from test runs of the model is comfortably within the range from the literature.

Utility Notices (Utility Customer Service and Payment) – updated from 2001 NEB 1.0 model, adopted for use in NEB 2.0 model: The California ESA program's energy savings improves a customer's ability to pay their bills and avoid notices for nonpayment (resulting in savings to the utility and its ratepayers). The calculation for this NEB is much like the others in the Bill Payment / Customer Service and Collection grouping. It uses the average number of notices sent to low income customers multiplied by the reduction realized from the program. It is monetized by using a value for marginal cost per notice for the utility borrowed from the literature and adjusted for inflation. Utility Notices are another well-studied impact, with over a dozen studies from the late 1990s to 2018. The financial impact of this NEB is slightly

lower than other utility NEBs, ranging from roughly $0.00-$5.50, but typically under $1.00 per household. This benefit is still significant enough across most programs to justify its inclusion, and the values calculated by test runs of the model are well within the range from the literature.

Utility Customer Calls (Utility Customer Service and Payment) – updated from 2001 NEB 1.0 model, needs additional research, have elected not to use at this time, set to zero: The California ESA program's energy savings improves a customer's ability to pay their bills and avoid calls related to nonpayment (and resulting savings to the utility and its ratepayers). There are several sources of data for the average number of calls to low income customers, including from California utilities. The reduction in the number of calls for collections is sourced from arrearage studies. There are multiple sources for length of calls, including data from call centers and from multiple utilities. The length of time and number of calls are monetized with the California utilities' average wage and adjusted for inflation to keep current. There is strong evidence for this NEB, with over a dozen studies from the late 1990s to 2018 included in the literature. Like Utility Notices, the typical value for Customer Calls is under $1.00 per household, and values range from about $0.00 to $2.00; however, this value is still significant enough to be included in the total NEB amount. The value for this NEB calculated by test runs of the model is comfortably in the range from the literature.

Utility Health and Safety/Insurance Savings (Utility Health and Safety) – redesigned from 2001 NEB 1.0 model, needs additional research, have elected not to use at this time, set to zero: To the extent that the ESA program installs measures, conducts equipment checks, or undertakes repairs that reduce the risk of catastrophic emergencies in participant homes, the utilities (and their ratepayers) can save the cost of the self-insurance part of the damages. This calculation is somewhat difficult because there is little specific input or strong studies. The calculation uses values from the literature and adjusts it for inflation. The NEB is included only as a placeholder until reliable impact data can be identified. This benefit has less support in the literature than other utility NEBs, with only a few studies conducted between 2011 and 2017. The NEB has been included in the model, but due to lack of reliable data inputs, there is no monetary value for Utility Insurance Savings.

Utility Rate Subsidies (Low Income Rate Subsidies) – updated from 2001 NEB 1.0 model, adopted for use in NEB 2.0 model: The California ESA program's measures reduce energy use by low income households, which pay rates that include a subsidy paid by all other ratepayers. The energy savings reduce the subsidy burden on the utility and other ratepayers. This calculation multiplies the savings by the subsidy level for CARE customers using data specific from the California utilities for program participation, cost of energy, and program-specific discounts for participants. This benefit applies to CARE, and program information for the Family Electric Rate Assistance (FERA) program is excluded. The Utility Rate Subsidies NEB is strongly supported in the literature, with many reports published from the late 1990s to 2018. The values for this benefit range from about $2.50 to $28.00 per household, with a typical value of around $7.00—the largest individual utility NEB value. The NEB value calculated by test runs of the model is comfortably within the range identified by the literature.

Utility NEBs from the 2001 NEB 1.0 model excluded in new ESA NEB 2.0 model:

- Collection Costs (these agency collection activities programs are not generally pursued for low income customers)
- Transmission and Distribution Savings (included in Avoided Cost report)
- Reduction in Emergency Gas Service calls is excluded (some of the numbers are not strong, and the activities may be considered part of due diligence for the utilities and not solely due to the program).

2.4.2 Societal NEBs

Figure 2.10 shows the societal NEBs included in the older 2001 NEB 1.0 model, and the NEBs included in the new ESA NEB 2.0 model. A description of the rationale and calculation approach is provided following the figure.

Figure 2.10: NEBs in 2001 NEB 1.0 Model vs. New ESA NEB 2.0 Model: Societal NEBs

2001 NEB 1.0 – Societal NEBs	2019 ESA NEB 2.0 – Societal NEBs
• Water / Wastewater Infrastructure • Economic Output & Jobs Impacts • Emissions / Environmental Effects • H&S Equipment (CO poisonings)	• Water / Wastewater Infrastructure • Economic Output* Economic Jobs* Economic Tax* • *EXCL: Emissions / Environmental Adder (In Avoided Cost report)* • Emissions / Environmental-related Illness* • H&S CO poisonings* • H&S Sick days from work* • H&S Asthma Symptoms* • H&S Rx adherence* • H&S Low Birthweight Babies Costs*

^Impact Not Calculated *Calculation formulae included in NEB 2.0 Model but elected not to use at this time.

Societal Economic Impacts (Societal Economic) – redesigned from 2001 NEB 1.0 model, needs additional data/research, have elected not to use at this time, set to zero: The installation of measures and the manufacturing of the measures themselves lead to changes in economic activity relative to the baseline. Some of these effects are local; others are regional, national, or international and include direct, indirect, and induced multiplier effects. This type of impact is calculated using an input/output (I/O) model. For California, the RIMS II™ was used, and the resulting value was compared to that from IMPLAN™. Program-specific spending per participant was used for the input. The Economic Impact NEB is widely studied and accepted. Dozens of studies were conducted from the early 1990s to 2018, and most use highly reliable I/O models. Depending on the size of the program, its economic impact can range anywhere from several hundred thousand to tens of millions of dollars. The value calculated by test runs of the model is well within the range identified by the literature.

Societal Job Impacts (Societal Economic) – redesigned from 2001 NEB 1.0 model, needs additional data/research, have elected not to use at this time, set to zero: The installation of measures and the manufacturing of the measures themselves lead to changes in economic activity relative to the baseline. Some of these effects are local; others are regional, national, or international and include direct, indirect, and induced multiplier effects. The impact on job creation is calculated using an I/O model. For California, the RIMS II™ was used, and the resulting value was compared to that from IMPLAN™. Program-specific spending per participant was used for the input. Job Impacts is one of the most studied NEBs, with dozens of reports from the early 2000s to 2016. This benefit is typically estimated with the same I/O modeling systems that are used to determine Economic Impact. Depending on the size of the program and the type of jobs included, job creation can range anywhere from hundreds to thousands of jobs. The NEB value estimated by test runs of the model is comfortably within the range identified by the literature.

Societal Tax Effects (Societal Economic) – newly added to 2.0 model, needs additional data/ research, have elected not to use at this time, set to zero: The installation of measures and the manufacturing of the measures themselves lead to changes in economic activity relative to the baseline. Some of these effects are local; others are regional, national, or international and include direct, indirect, and induced multiplier effects. As with the other NEBs in the Economic grouping, the Tax Effects NEB is calculated using an I/O model. For California, the RIMS II™ (statewide data) was used, and the resulting value was compared to that from IMPLAN™. Program-specific spending per participant was used for the input. The Tax Effects NEB has been estimated less frequently than Economic Impacts or Job Creation (studies mostly from the mid-2000s). Tax Effects are estimated using the same I/O models that are used for Economic Impacts and Job Creation, but they are typically not included in NEBs reports. However, changes in spending and other economic impacts affect the type and quantity of taxes collected at the local, state, and federal level. Reported values for Tax Effects range from about $20.00 to $200.00 per household and are usually under $150.00. The value calculated by test runs of the model is well within the range from the literature.

Societal Emissions-Induced Illness Effects (Societal Environmental and Water) – newly added to 2.0 model, needs additional data/research, have elected not to use at this time, set to zero: The energy savings reduce the electricity generation and its associated emissions. This reduces negative health effects in the airshed. To compute the impact, the NEB 2.0 model uses the program measure data to estimate the reduction in emissions in kilowatt-hours. This is multiplied times the dollar per kilowatt-hour factor derived from the US EPA's COBRA model run for the state of California. This provides health effects in 2017 dollars, which are inflated to the relevant program year using the CPI. While many NEB studies estimate emissions impacts, only a few from the early 2000s calculate the effect of those emissions on public health. The literature includes several that monetize public health impacts. When quantified, the benefits are significant, typically tens of thousands of dollars. However, the available model is highly reliable, well-vetted, and based on well-documented studies by the EPA and the health community. Test runs of the model developed estimates in the range of $40.00 per household.

Societal Water/Wastewater Effects (Societal Environmental and Water) – updated from 2001 NEB 1.0 model, adopted for use in NEB 2.0 model: The ESA program installs measures designed to reduce hot water use and, hence, the energy used to heat that water (for example, low flow showerheads, efficient clothes washers). Consequently, many of these measures save demand on the water and wastewater infrastructure and defers investment in equipment like dams, and in the future, desalination plants. The NEB computation sums up the water savings associated with each of the water savings measure installed (relative to the baseline equipment) and multiplies them by the societal marginal element of the water and wastewater rates, represented by the avoided cost of the next source of water supply and wastewater treatment plants. These avoided cost figures were developed from published sources. Participant-level water savings are widely studied, but fewer attempts have been made to quantify the benefit of saving water on the water infrastructure level. The values reported for this NEB range from $0.00 to $15.00 per household and are usually about $10.00; this is a significant benefit to be included in the model. The value calculated by the model is slightly below the range identified by the literature because of the relatively low number of water-saving measures installed by the program. The new NEB estimate is improved compared to the 2001 NEB 1.0 model because the incremental water savings are updated to a more suitable baseline, more measures are included (e.g. DHW, tub diverter, clothes washers), and the avoided water infrastructure costs are better grounded in the literature.

Societal Reduction in Sick Days Lost from Work (Societal Health and Safety) – newly added to 2.0 model, needs additional data/research, have elected not to use at this time, set to zero: The ESA

program may improve safety and health in the home, leading to fewer missed days at work. This NEB is calculated by quantifying the expected reduction in missed earnings due to the program and multiplying it by the percentage of households with a primary wage earner. Participant costs are the reduction in earnings for individuals without sick leave, whereas societal costs are those paid by the employer for a day of missed productivity for employees with sick leave. At the participant level, this benefit is monetized through individuals who are the primary earner for their household but do not have sick leave. This NEB is lower than previous estimates due to a smaller value for reduction in missed days at work and a more conservative estimate for the number of households with an employed primary wage earner. The Societal Reduction in Sick Days Lost from Work has been studied less than other societal NEBs but has been well-examined from the participant perspective (mostly in the mid-2010s). The value of this NEB ranges from $5.00 to $35.00 per household and is typically around $20.00; this is significant enough to be included in the total NEB value. The value calculated for this NEB by the model is below the range found in the literature.

Societal Reduction in Carbon Monoxide Poisonings/Deaths (Societal Health and Safety) – redesigned from 2001 NEB 1.0 model, needs additional data/research, have elected not to use at this time, set to zero: CO monitors reduce incidences of illnesses and deaths in program homes. The NEB is calculated as the sum of multiple contributing elements. The first is the reduction in number of hospitalizations—and the hospitalization costs—from CO poisonings, calculated to cover only the share paid by the households out of pocket. The second element values the reduction in emergency room visits, and the out of pocket costs the households would pay. The literature includes over a dozen studies from 2011 to 2018. Typical values from the literature for this NEB range from $0.00 to $90.00 per household and are typically under $2.00per household per year. The quantification methodology is similar for the societal NEB; however, avoided deaths are quantified as a societal benefit and the medical costs are those associated with Medicare, Medicaid, or insurance payments.

Societal Reduction in Asthma Symptoms (Societal Health and Safety) – newly added to 2.0 model, needs additional data/research, have elected not to use at this time, set to zero: The ESA program installs measures that can improve indoor air quality by controlling the flow of outdoor allergens and particulate matter into the home. The NEB is calculated as the product of three parts.

- The first is the expected number of children with environmentally attributable asthma in a home (the average number of children per home times childhood asthma incidence in California times the percentage of asthma that can be environmentally attributable).
- The second portion is the cost of asthma per child. For the societal NEB, this is the expected portion of payment covered by Medicare or Medicaid. For participants, this is the expected out of pocket payment.
- The third part of the calculation is the reduction in asthma occurrence due to the program. These values are lower than expected due to lower medical cost estimates in California and more conservative estimates of the percentage of the population at risk.

The literature examining Societal Asthma impacts is less robust than that from the participant perspective with under a dozen studies identified, mostly from the mid to late 2010s. When quantified, this NEB ranges from $5.00 to $300.00 per household and is typically around $200.00 per household, representing a significant program benefit. The NEB value calculated by test runs of the model is slightly below the range identified by the literature.

Societal Improvements in Prescription Drug Adherence (Societal Health and Safety) – newly added to 2.0 model, needs additional data/research, have elected not to use at this time, set to zero:
Weatherization programs can reduce energy bills and allow participants to spend that money on other necessities (for example, prescriptions). The NEB is calculated as the reduction in medical costs associated with not taking prescribed medicines. The increase in households being able to afford prescription medications is multiplied by the cost to the nation of patients not taking prescription medicines, which is then multiplied by the compliance rate of prescription medicine in the US. This is lower than previous estimates due to a lower percentage increase in households being able to afford prescription medicines. The Societal Prescription Drug Adherence benefit has been given less attention than most other societal NEBs, consisting of several studies from the late 2010s that attempted to quantify this impact. However, when monetized, the NEB ranges from $350.00 to $2,000.00 per household and is usually around $1,000.00 per household, which is enough to justify its inclusion in the model. The NEB value quantified by test runs of the model are slightly below the range from the literature.

Societal Reductions in Low Birthweight Babies (Societal Health and Safety) – newly added to 2.0 model, needs additional data/research, have elected not to use at this time, set to zero:
Weatherization programs can reduce energy bills and allow participants to spend that money on other necessities (for example, food). The NEB is calculated as the reduction in medical costs associated with low birthweight babies. The estimate is derived from the individuals per household times the fertility rate in California times the expected percentage of births being low weight, resulting in the expected low birthweight births per home. This is then multiplied by the decrease in homes trading off heat for food and the reduction in low birthweight babies associated with that to get to the avoided low birthweight babies per household. Finally, this is multiplied by the excess first-year hospitalization costs for babies born underweight. The final value for this NEB is $0.00 due to a 0% value for decrease in houses trading off heat for food in hot climate regions. Reductions in Low Birthweight Babies is another NEB that has not been well-studied from the societal perspective. The literature includes several reports from the mid-2010s on this topic; however, the logic of the impact is reliable, and it should be included in the model. The typical monetized value for this NEB is around $20.00 per household (no range).

Societal NEBs from the 2001 NEB 1.0 model excluded in new ESA NEB 2.0 model:

- Environmental Emissions Costs (included in Avoided Cost report)

2.4.3 Participant NEBs

Figure 2.11 shows the participant NEBs included in the 2001 NEB 1.0 model, and the NEBs included in the new ESA NEB 2.0 model. A description of the rationale and calculation approach is provided following the figure.

Figure: 2.11: NEBs in 2001 NEB 1.0 Model vs. New ESA NEB 2.0 Model: Participant NEBs

2001 NEB 1.0 – Participant NEBs	2019 ESA NEB 2.0 – Participant NEBs
• Program Rebate	• *(EXCL: Program Rebate – Not used/relevant)*
• Water / Sewer Bills	• Water / Sewer Bills
	• Arrearages*
• Shutoffs	• Shutoffs*
• Reconnects	• Reconnects*
• Calls to Utility	• Calls to Utility

2001 NEB 1.0 – Participant NEBs	2019 ESA NEB 2.0 – Participant NEBs
• H&S Fewer Fires • H&S CO / Indoor Air Quality • H&S Illness / Missed Days Work • Property Value • Transaction Costs • Frequent Moves & Costs • Combo Comfort, Noise • Hardship	• H&S Fewer Fires • Replaced with H&S CO Poisonings • H&S Missed Days Work* • H&S Missed Days from School* • H&S Asthma Symptoms • H&S Allergy Symptoms • H&S Cold Symptoms • H&S Hot Water Scaldings • H&S Household Safety (Placeholder Calculation) • Property Value • *(EXCL: Transaction Costs – No Interest)* • Frequent Moves & Costs* • Thermal Comfort • Noise Internal • Noise External • Lighting Quality / Quantity* • Customer O&M • Equipment Lifetime / Deferred replacement purchase* • Equipment Performance / Features* • Aesthetics / Appearance / Ability to Sell Home • Reduced Detergent Use • Contributing to Environmental Good / Doing Good for Environment* • Hardship*

*Calculation formulae included in NEB 2.0 Model, elected not to use at this time.

Participant Reductions in Service Shutoffs/Reconnects (Participant Bills/Payment) – updated from 2001 NEB 1.0 model, needs additional data/research, have elected not to use at this time, set to zero: The California ESA program's energy savings improves a customer's ability to pay their bills and avoid service disconnects as a result of nonpayment, with resulting benefits to the household in terms of value of service, cost to restart, and lost rental value during termination. Most of the literature and values for this NEB have been broken out into Shutoffs and Reconnection elements. The calculations for this study have been run separately to avoid duplication. Terminations or Shutoffs have been calculated using data from the utilities for the average number of terminations per year for low income participants multiplied by the estimated reductions from the program. This is monetized using estimates of utility marginal cost per shutoff and updating it for inflation. The reconnection calculation is the much same, using corresponding inputs but also using the dollar value for the utility reconnect fee, adjusted for inflation. The participant perspective Shutoffs and Reconnections NEB has been studied less than its utility perspective counterpart, but it still has strong support in the literature. The literature on the topic includes about a dozen reports, conducted from the late 1990s to 2011. The values for this NEB range from about $0.00 to $5.00, with an average value around $0.50 per household. The value calculated by test runs of the model is slightly below the range identified by the literature because of the low customer value per shutoff.

Participant Reduction in Time on Bill Payment Calls (Participant Bills/Payment) – updated from 2001 NEB 1.0 model, adopted for use in NEB 2.0 model: The California ESA program's energy savings improves a customer's ability to pay their bills, and avoids the occupants having to spend time on the

phone with the utility related to payment issues. There are several sources of data for the average number of calls to low income customers, including from California utilities (or a proxy utility source). The reduction in the number of calls for collections is sourced from arrearage studies. There are multiple sources for length of calls including data from call centers and from multiple utilities. The length of time and number of calls are monetized, preferably with the California utilities' average wage and adjusted for inflation to keep current. Like Shutoffs and Reconnects, the bill-related call NEB has been given less attention from the participant perspective than the utility perspective. The literature includes fewer than a dozen studies from the mid-2000s to 2018 that had monetized this benefit, with values ranging from about $3.00 to $6.00 per household—typically around $5.00 per household. The value calculated by test runs of the model is slightly below the range identified typically in the literature.

Participant Reduction in Arrearages (Participant Bills/Payment) – newly added to 2.0 model, needs additional data/research, have elected not to use at this time, set to zero: Energy savings from the ESA program reduce energy bills. The reduced bills allow households to reduce the bill backlog or arrearages. Arrearage studies have not been conducted over multiple years, following participants, so to be conservative, this savings is estimated as a one-time effect, not an annual impact. As a result, the consultant team spread the value over the lifetime of the measures. The computation is the average arrearage times the estimated impact of the program on reducing arrearages, divided by the weighted average lifetime of the measures installed by the program. The literature on participant perspective arrearages is less robust than its utility perspective counterpart. Just under a dozen studies from the mid-1990s to 2010 were identified. Values ranged from about $25.00 to $400.00 per household and averaged around $45.00 per household. The value estimated by test runs of the model is comfortably within the range found in the literature.

Participant Ability to Control Energy Bills (Participant Hardship) – newly added to 2.0 model, needs additional data/research, have elected not to use at this time, set to zero: The installation of new energy efficient measures and their operating manuals and features as well as the (ancillary or intended) information and discussions provided by the program staff lead to households having an improved sense of ability to control their energy bills. These effects are perceived by households as a benefit from the program and are separate from the actual bill savings delivered by the program, calculated as the deemed measure savings times measures installed. Because this effect is based on a perception of these effects, most bill control estimates have derived from surveys of the household occupants, using a survey report of changes or improvements. Because households have difficulty associating numeric factors (like willingness to pay for more control) to program effects, most of the surveys use an approach that asks households to value the benefit relative to another factor for which a number is available—usually the value of the energy savings. One of these surveys was used to estimate savings from this program. The calculation in the model is expressed as the energy savings value times the comfort multiplier from another similar NEB program to develop the value of the comfort benefits to the household. When monetized, the per household benefit ranges from about $7.00 to $40.00 and is typically close to $35.00. The value calculated by test runs of the model is within the range identified in the literature.

Participant Water/Wastewater Bill Savings (Participant Water Savings) – updated from 2001 NEB 1.0 model, adopted for use in NEB 2.0 model: The ESA program installs measures designed to reduce hot water use and, hence, the energy used to heat that water (for example, low flow showerheads, efficient clothes washers). Consequently, many of these measures save water that households must pay for in water bills and wastewater bills. The NEB computation sums up the water savings associated with each of the water savings measure installed (relative to the baseline equipment) and multiplies them times

the residential marginal element of the water and wastewater rates. Water savings is a much-studied and vetted NEB. There are dozens of reports on this topic, mostly from the early 2000s to 2018, with a range of values from around $5.00 to $25.00; the average value is about $15.00 per household. The value estimated by test runs of the model is below the range identified by the literature due to the relatively low amount of water-saving measures installed by the program.

Participant Thermal Comfort (Participant Comfort, Health, and Safety) – redesigned from 2001 NEB 1.0 model, adopted for use in NEB 2.0 model: Many of the measures installed by the ESA program (HVAC and shell measures, most notably) improve the thermal comfort of occupants. These benefits are perceived by households as a strong benefit from the program, and the improvement is highly valued by participants. Because comfort is based not only on actual presence of more comfortable temperatures and fewer drafts, but also on perception of these effects, most comfort estimates have derived from surveys of the household occupants, using a survey report of comfort improvements. Because households have difficulty associating numeric factors (like willingness to pay for more comfort) to program effects, most of the surveys use an approach that asks households to value the comfort benefit relative to another factor for which a number is available—usually the value of the energy savings. One of these surveys was used to estimate savings from this program. The calculation in the model is expressed as the energy savings value times the comfort multiplier from another similar NEB program to develop the value of the comfort benefits to the household. Thermal Comfort is a well-studied and impactful participant NEBs. The literature includes dozens of reports from the early 2000s to the mid-2010s, with values ranging from around $10.00 to $250.00 and a typical value of about $100.00 per household. While typically survey-based, this NEB has been repeatedly addressed in the literature. The NEB value calculated by test runs of the model is slightly below the range identified in the literature due to the relatively low program-induced energy savings.

Participant Fewer Fires (Participant Comfort, Health, and Safety) – updated from 2001 NEB 1.0 model, adopted for use in NEB 2.0 model: To the extent that the ESA program installs new, safer measures, performs checks, and addresses safety issues, the program reduces risks of fire. The NEB is calculated by finding the product of the average property loss from fires per incident per household, the percentage of incidents caused by equipment that might be fixed by the program, the percentage of households receiving heating-related measures, and the assumed percentage of fires eliminated by program efforts. The resulting value is added to the product of the average number of injuries and lives lost per household, the percentage of incidents caused by equipment that might be fixed by the program, the value of each loss of human life, the percentage of households receiving health and safety measures, and the assumed percentage of fires eliminated by the program's efforts. The NEB calculation also takes into account factors insurance coverage and out-of-pocket cost assumptions. This NEB has been researched less than other participant benefits, but it still has strong literary and logical support. More than a dozen studies have been conducted on the topic from the early 2000s to 2018. The benefit to the participant is significant, with a range of about $0.00 to $85.00 and an average monetized value around $50.00 per household. The value estimated by test runs of the model is below the range found by the literature because of the low percent reduction in fires caused by the program.

Participant Fewer Missed Days from Work (Participant Comfort, Health, and Safety) – redesigned from 2001 NEB 1.0 model, needs additional data/research, have elected not to use at this time, set to zero: The ESA program may improve safety and health in the home, leading to fewer missed days at work. This NEB is calculated by quantifying the expected reduction in missed earnings due to the program and multiplying it by the percentage of households with a primary wage earner. Participant costs are the reduction in earnings for individuals without sick leave, whereas societal costs are those paid by the

employer for a day of missed productivity for employees with sick leave. At the participant level, this benefit is monetized through individuals who are the primary earner for their household but do not have sick leave. This NEB is lower than previous estimates due to a smaller value for reduction in missed days at work and a more conservative estimate for the number of households with an employed primary wage earner. Fewer Missed Days from Work is a well-studied participant benefit. The literature includes dozens of reports from the early 2000s to 2018 that discuss this NEB. Many reliable attempts to monetize the value have been made with significant findings that range from several dollars to around $200.00, with an average benefit at about $150.00 per household. The value calculated by test runs of the model is slightly below the range identified in the literature.

Participant Fewer Missed Days from School (Participant Comfort, Health, and Safety) – newly added to 2.0 model, needs additional data/research, have elected not to use at this time, set to zero: The ESA program may improve safety and health in the home, leading to fewer missed days at school. This NEB is quantified as the reduction in missed days in school multiplied by the hourly cost of childcare in California, accounting for the percent of families that must rely on some form of childcare. Additional savings from the NEB may result from higher earning potential due to higher graduation rates from more consistent school attendance. The calculation includes space for effects from the change in graduation rates (drop-outs) associated with chronic absences and the consequent decreases in lifetime or annual earnings, but this sub-calculation does not yet have strong impact values available. Fewer Missed Days from School has been given less attention than Fewer Missed Days from Work, although it is still a fairly well-studied NEB (reports concentrated in the early 2000s). The typical value is not large, ranging around $10.00 per household. The NEB value estimated by test runs of the model is below the average value from the literature.

Participant Carbon Monoxide Poisonings (Participant Comfort, Health, and Safety) – updated from 2001 NEB 1.0 model, adopted for use in NEB 2.0 model: CO monitors reduce incidences of illnesses and deaths in program homes. The NEB is calculated as the sum of multiple elements (see Appendix A). The first is the reduction in number of hospitalizations—and the hospitalization costs—from CO poisonings, calculated to cover only the share paid by the households out of pocket. The second element values the reduction in emergency room visits and the out of pocket costs the households would pay. The literature includes dozens of studies, from the early 2000s to 2018. Typical values from the literature for this NEB average about $5.00 per household per year. The quantification methodology is similar for the societal NEB; however, avoided deaths are quantified as a societal benefit and the medical costs are those associated with Medicare, Medicaid, and insurance payments. The values for this NEB identified by the literature range from $0.00 to around $150.00 per household.

Participant Reduced Asthma Symptoms (Participant Comfort, Health, and Safety) – newly added to model, adopted for use in NEB 2.0 model: The ESA program installs measures that can improve indoor air quality by controlling the flow of outdoor allergens and particulate matter into the home. The NEB is calculated as the product of three parts.

- The first is the expected number of children with environmentally attributable asthma in a home (the average number of children per home times childhood asthma incidence in California times the percentage of asthma that can be environmentally attributable).
- The second portion is the direct medical cost for a child with asthma. For the societal NEB, this is the expected portion of payment covered by Medicare or Medicaid. For participants, this is the expected out of pocket payment.

- The third part of the calculation is the reduction in asthma occurrence due to the program. These values are lower than expected due to lower medical cost estimates in California and more conservative estimates of the percentage of the population at risk.

Reduced Participant Asthma Symptoms are a well-studied NEB, with over a dozen reports included in the literature from the mid to late 2010s. When monetized, the benefit is fairly significant, with a range of values from about $7.00 to $300.00 but typically around $15.00 per household. The NEB value calculated by test runs of the model is below the range identified in the literature.

Participant Reduction in Allergy Symptoms (Participant Comfort, Health, and Safety) – newly added to model, adopted for use in NEB 2.0 model: The ESA program installs measures including duct sealing and improved temperature/humidity controls during in-home assessments. These energy efficiency measures improve indoor air quality by reducing infiltration of outdoor air, improving indoor air temperature and relative humidity, reducing the likelihood of mold, mildew, pollens, pests, and dust which can be triggers for allergic rhinitis. The NEB is calculated as follows:

- The expected percent reduction in allergic rhinitis is multiplied by the following to arrive at the per-household benefit:
    - typical cost of environmental allergies
    - portion of that cost that is "out of pocket"
    - percent of the population affected by environmental allergies
    - average number of persons per household

Reduced Allergy Symptoms has been studied less than other health and safety NEBs. Several reports on the topic have been conducted between the mid-2000s and the late 2010s. Results for this NEB are presented as a percent reduction of participants experiencing allergy symptoms, and values are typically just over 10%. Dollar values are typically under $1.00.

Participant Reduction in Cold and Virus Symptoms (Participant Comfort, Health, and Safety) – newly added to model, adopted for use in NEB 2.0 model: Temperatures, irritants, and low humidity can affect the severity or duration of colds. The ESA program has measures in place to prevent these conditions. The NEB is calculated as the reduction in medical costs associated with colds. The three portions of medical costs are over-the-counter cold medicine, cold symptom-related prescriptions, and visits to doctor's offices discuss cold symptoms. The built-in assumption for this NEB is that one individual in a household per year gets a cold severe enough to warrant a trip to the doctor's office. This NEB has not been fully quantified previously. Like Allergy Symptoms, Cold and Virus Symptoms has been given less attention than other health and safety NEBs. The literature includes about five reports on the subject. Monetized results are usually less than $10.00 per household.

Participant Reduced Scalding (Participant Comfort, Health, and Safety) – newly added to model, adopted for use in NEB 2.0 model: The ESA program offers thermostatic shower valves and water heater temperature checks, which can prevent hot water scalding. The NEB is calculated as the reduction in medical costs associated with avoided accidental tap water scalding, split by children and elderly individuals (those over age 65). For children, tab water scalding incidence is calculated as the incidence in burns in children in the US times the percentage of burns caused by hot tap water. For elderly individuals, the incidence of tap water scalding is available directly. Those incidence estimates are then multiplied by expected out of pocket costs and the number of children/elderly individuals per home. This NEB has not been quantified previously, although it is closely related to the HCSA's safety

goals and has been observed by PMs. While not monetized in the NEBs literature Reduced Participant Scalding has been discussed in just under a dozen reports from the review.

Participant Improved Household Safety (Participant Comfort, Health, and Safety) – newly added to model, needs additional data/research, have elected not to use at this time, set to zero: The computation of this effect is set as zero, and the estimate remains a placeholder in the model. The effects related to safety from CO monitors are estimated in another NEB, and health effects are also identified in other NEBs. The overall safety from measures in the program have previously included survey-reported improvements in safety from better lighting in the home. However, there are no studies related to LED lights and improved safety or safety from improvements related to replaced gas equipment. When studies on these topics become available, these computations may be included in the model. Improved Household Safety has not been studied as much as other participant perspective health and safety NEBs. Several reports, from the mid-2000s to 2018, were identified with values ranging from about $20.00 to $30.00 per household and averaging around $25.00 per household. The value calculated by test runs of the model is below the value identified in the literature due to the relatively low program-induced energy savings.

Participant Property Value Increase (Participant Equipment Performance) – updated from 2001 NEB 1.0 model, adopted for use in NEB 2.0 model: Measures provided by low income weatherization programs often include simple structural repairs (to doors, windows, porches, etc.). When included, these repairs improve the value of the property, presumably represented by the cost of the repair the homeowners or other purchasers would have to incur to correct these defects. To value these impacts, the best estimate is the cost of the repair (from program records) divided by the lifetime of the improvements made (usually estimated in the 10-year range, but it would depend on the measure). There are no measures of this type included in the ESA program, but this computation automatically pulls over the value should the measure be added in the future. The literature discussing Participant Property Value Increase is strong with dozens of reports (published from the early 2000s to 2017) on the NEB. Values range from several dollars to about $2,000.00 per household, and average values are generally around $20.00 per household. The value calculated by test runs of the model is below the range identified in the literature because of the low cost of housing improvements induced by the program.

Participant Reduction in External Noise (Participant Equipment Performance) – redesigned from 2001 NEB 1.0 model, adopted for use in NEB 2.0 model: The installation of shell/enclosure measures can reduce street noise, improving the household's indoor environment. These benefits are perceived by households as a strong benefit from the program, and the improvement is highly valued by participants. Because indoor noise is based not only on the actual presence of noise, but also on the perception of these effects, most indoor noise estimates have been derived from surveys of the household occupants using a survey report of noise-related improvements. Because households have difficulty associating numeric factors (like willingness to pay for less noise) to program effects, most of the surveys use an approach that asks households to value the noise benefit relative to another factor for which a number is available—usually the value of the energy savings. One of these surveys was used to estimate savings from this program. The calculation in the model is expressed as the energy savings value times the noise multiplier from another similar NEB program to develop the value of the noise benefits to the household. External Noise Reduction is a fairly well-studied participant NEB with about a dozen reports published from the early 2000s to 2018. The impact typically ranges from about $3.00 to $30.00 per

household and averages around $20.00 per household. The NEB value estimated by test runs of the model is comfortably within the range identified by the literature.

Participant Reduction in Internal Noise (Participant Equipment Performance) – redesigned from 2001 NEB 1.0 model, adopted for use in NEB 2.0 model: The installation of new appliances can reduce interior noise, improving the household's indoor environment. These benefits are perceived by households as a strong benefit from the program, and the improvement is highly valued by participants. Because noise is based not only on the actual presence of noise, but also on the perception of these effects, most noise estimates have been derived from surveys of the household occupants using a survey report of noise-related improvements. Because households have difficulty associating numeric factors (like willingness to pay for less noise) to program effects, most of the surveys use an approach that asks households to value the noise benefit relative to another factor for which a number is available—usually the value of the energy savings. One of these surveys was used to estimate savings from this program. The calculation in the model is expressed as the energy savings value times the noise multiplier from another similar NEB program.[43] Participant Reduction in Internal Noise or Appliance Noise has been studied less than External Noise; a few studies conducted from the mid-2000s to 2012 were identified that measured this NEB independently without combining it with External Noise. When monetized, the values range from around $15.00 to $30.00 per household and average about $20.00 per household. The value calculated by test runs of the model is below the range identified in the literature due to the relatively low program-induced energy savings.

Participant Improved Lighting Quality/Quantity (Participant Equipment Performance) – newly added to model, needs additional data/research, have elected not to use at this time, set to zero: The installation of new light bulbs and fixtures can improve the quality and quantity of light produced for residents, improving the indoor environment. These effects are perceived by households as a benefit from the program. Because lighting quality and quantity is based not only on the actual presence of light and lumens, but also on the perception of these effects, most light-related estimates have been derived from surveys of the household occupants using a survey report of light-related improvements. Because households have difficulty associating numeric factors (like willingness to pay for less noise) to program effects, most of the surveys use an approach that asks households to value the light benefit relative to another factor for which a number is available—usually the value of the energy savings. One of these surveys was used to estimate savings from this program. The calculation in the model is expressed as the program's energy savings value times the light multiplier from another similar NEB program to develop the value of the light benefits to the household. This factor should be updated because the factor was estimated for CFLs, not LEDs. Therefore, this estimate should be conservative; it would be expected that household perceptions of lighting quality would be higher for LEDs than CFLs. Lighting Quality is a fairly well-studied NEB, although is it often combined with bulb lifetime. At least a dozen studies on this topic were conducted in the mid-2000s. Lighting quality represents a substantial NEB value for participants, with values ranging from about $10.00 to $30.00 per household and typically around $28.00 per household. The value estimated by test runs of the model is below the range identified by the literature because of the relatively low program-induced energy savings.

Participant Reduction in Equipment O&M Costs (Participant Equipment Performance) – newly added to model, adopted for use in NEB 2.0 model: New appliances and household equipment should have

[43] Some surveys refine the noise multiplier, asking about the simple or pre-/post- percentage that could hear noise from next room times a willingness to pay (WTP) factor, but the WTP is a difficult concept to gather accurately from households. See Skumatz and Gardner, ACEEE, 2002a.

fewer repairs and, therefore, lower repair costs than older equipment. This NEB is calculated by determining the product of the average number of appliances (a limited view of the potential measures that could experience O&M reductions) installed per home, the appliance repair rate for equipment, and the reduction in repairs for new equipment. The values were gathered from websites related to appliance repair. The consultant team was unable to find literature-based values for these factors; this should be a focus of future data collection. The resulting value is multiplied by the average cost of appliance repair in California. The consultant team estimated the value from longer equipment lifetimes in another NEB. The Equipment O&M NEB has strong support, with dozens of studies conducted mostly from the early 2000s to 2011. This NEB values range from about $20.00 to $80.00 and tend to be just under $40.00 per household. The NEB value calculated by test runs of the model is slightly below the range identified by the literature because of the relatively few appliances installed per home by the program.

Participant Benefits from Equipment Lifetime/Purchase Deferral (Participant Equipment Performance) – newly added to model, needs additional data/research, have elected not to use at this time, set to zero: Installing new equipment saves participants money because they have a longer time to save up money for the next replacement of the equipment.[44] The benefit is a direct function of the cost of the equipment times the change in years until next replacement, now deferred from some short time (remaining useful life, or RUL) to the full lifetime of the replaced equipment. This NEB is calculated using Microsoft Excel™'s payment calculation function for the replacement cost at an interest rate for RUL times the measure life minus the replacement cost at an interest rate for the full measure life. The resulting value is multiplied by the average number of that measure per household. In this model, the computation occurs per measure on the program measure page, and the sum of the computation is brought over to the individual NEB page. The computation is modified by one additional effect: the likelihood the occupant will be responsible for replacing the equipment. While single-family owners would be nearly 100% likely to be responsible for replacing household equipment, this may or may not be true for participants in the ESA program. Some are renters (which affects perhaps furnaces, but not light bulbs). The consultant team made assumptions about these likely responsibilities, but the model could be improved with estimates of the percentage of renters and studies on whether owners versus renters are usually responsible for specific equipment replacement. Finally, the data on RUL suggests that 33% is the accepted figure for generic studies (i.e., it is the accepted CPUC figure).[45] Equipment Lifetime is generally discussed with Equipment O&M, so the two NEBs have similar values. Dozens of reports from the early 2000s to 2011 were identified for this NEB, with values ranging from about $20.00 to $80.00 and typically just under $40.00 per household.

Participant Improvement in Product Performance (Participant Equipment Performance) – newly added to model, needs additional data/research, have elected not to use at this time, set to zero: The installation of new equipment provides benefits in product service (new features, etc.) for occupants. These are perceived by households as a benefit from the program. These services are mostly perception-based, so most estimates have been derived from surveys of the household occupants, using a survey report of performance-related improvements. Because households have difficulty associating numeric factors (like willingness to pay for performance improvements) to program effects, most of the surveys use an approach that asks households to value the benefit relative to another factor for which a number

[44] This NEB has not been calculated in most NEB studies before or not in this form, but the change was recommended in the Skumatz et al. 2010b study.

[45] However, this RUL figure may vary by equipment and may vary for low income versus other households. This literature should be monitored. Better yet, the next round of the ESA may collect information on the age of removed equipment so program-specific estimates may be developed.

is available—usually the value of the energy savings. One of these surveys was used to estimate savings from this program. The calculation in the model is expressed as the program's energy savings value times the relative multiplier from another similar NEB program to develop the value of the benefits to the household. This benefit has the possibility of overlapping with other feature or performance factors from the equipment, which might be measured through other NEBs in the study (e.g., noise and others). Surveys that ask about this factor should clearly ask about whether the effect overlapped with any other NEBs to ensure no overlap. This question was asked and accounted for in the survey used. The NEB should also be asked by measure and associated specifically with installed measures. Because no other information was available, this NEB remains program-wide; new research would be beneficial. This NEB is calculated by finding the product of the average program-attributable energy bill savings and the multiplier value of the NEB from a specialized LMS participant survey. The literature on Product Performance is less robust than on Equipment O&M and Lifetime. Several studies from the early 2000s were reviewed for this NEB. When monetized, the impact on participants is significant, ranging from around $15.00 to $20.00 per household, with an average value of about $20.00 per household. The value estimated by test runs of the model is slightly below the range of values identified from the literature due to the relatively low program-induced energy savings.

Participant Aesthetics/Appearance of the Home (Participant Equipment Performance) – newly added to model, adopted for use in NEB 2.0 model: The installation of new equipment provides benefits in equipment and the home looking cleaner, newer, and more fashionable. These are perceived by households as a benefit from the program. These services are mostly perception-based, so most estimates have been derived from surveys of the household occupants using a survey report of aesthetic-related improvements. Because households have difficulty associating numeric factors (like willingness to pay for aesthetic improvements) to program effects, most of the surveys use an approach that asks households to value the benefit relative to another factor for which a number is available—usually the value of the energy savings. One of these surveys was used to estimate savings from this program. The calculation in the model is expressed as the program's energy savings value times the relative multiplier from another similar NEB program to develop the value of the benefits to the household. This NEB is calculated by finding the product of the average program-attributable energy bill savings and the multiplier value of the NEB from a specialized LMS participant survey. There might be concern that this is related to property value improvements, but this effect relates specifically to installed and improved equipment; property value is separately calculated as the cost of household repairs. Home Aesthetics has been given less attention than other participant NEBs, with several studies conducted from the early to mid-2000s. When quantified, the resulting values range from about $15.00 to $25.00 per household and are typically around $20.00 per household. The NEB value estimated by test runs of the model is comfortably within the range identified in the literature.

Participant Reduced Detergent Use from Efficient Washers (Participant Equipment Performance) – newly added to model, adopted for use in NEB 2.0 model: The California ESA program installs new washers which, in addition to using less water (measured in another NEB), require less detergent per load. This NEB is calculated by using a vetted published study from 2001 on the difference in the value of reduced detergent use annually per washer (including a factor related to average number of loads per household) multiplied by the average number of washers installed in the home. The value calculated by test runs of the model is significantly below the value from the literature, a result that is affected by the relative share of washers installed by the program.

Participant Reduction in Hardship (Participant Hardship) – redesigned from 2001 NEB 1.0 model, needs additional data/research, have elected not to use at this time, set to zero: The energy-saving

measures installed by the ESA program lead to bill savings, which reduces household financial stress. Hardship is commonly a goal of low-income programs and can be interpreted to go beyond financial stress to quality of life assessments. The definition of what should be included in hardship metrics has been a source of discussion. However, the bulk of the literature focused on financial stress. Although discussion on the topic has been common, reliable quantitative estimates are few, and the consultant team was unable to identify a strong value. This NEB is calculated by finding the product of the average program-attributable energy bill savings and the multiplier value of the NEB from a specialized LMS participant survey. A strong source for this value has yet to be identified, so the calculation is a placeholder. The Hardship NEB has been fairly well-studied, with over a dozen reports completed from the early 2000s to 2018. The benefit to participants ranges from about $2.00 to $65.00 per household and values are usually around $60.00 per household. The NEB value calculated by test runs of the model is below the range identified in the literature due to the relatively low program-induced energy savings

Participant Reduction in Need to Move (Participant Hardship) – updated from 2001 NEB 1.0 model, have elected not to use at this time, set to zero: The program's energy savings reduce the financial burden on low income households. Energy bills are one of the top reasons for forced moves for low income households. This NEB conducts a financial-based calculation accounting for program-related reductions in moving costs (from a published study, supported by web research) and an estimate of the impact that frequent moves have on lower educational achievement by children in the home (from a published study). It does not include the costs of temporary or permanent homelessness, which should be included in enhanced estimates of this NEB in the future. This NEB is calculated by multiplying the number of avoided moves per participant by the sum of average moving costs and the reduced earning power and education from household moving. The Reduction in Need to Move NEB has been given less attention than the general Hardship benefit, with studies conducted between the early 2000s to 2018. The average value to participants is less than that of the Hardship NEB—values range from about $0.50 to $80.00 per household, but typically only around a couple dollars per household. The value estimated by test runs of the model is comfortably within the range identified in the literature.

Participant Ability to Contribute to Environmental Efforts (Participant Hardship) – newly added to model, have elected not to use at this time, set to zero: The California ESA program brings energy efficiency opportunities to low income households, which often do not have the financial luxury of undertaking actions that positively impact the environment.[46] These are perceived by households as a benefit from the program. These services are mostly perception-based, so most estimates have been derived from surveys of the household occupants using a survey report of environmental ethic-related improvements. Because households have difficulty associated numeric factors (like willingness to pay for environmental ethic improvements) to program effects, most of the surveys use an approach that asks households to value the benefit relative to another factor for which a number is available—usually the value of the energy savings. One of these specialized (LMS) surveys was used to estimate savings from this program. The calculation in the model is expressed as the program's energy savings value times the relative multiplier from another similar NEB program to develop the value of the benefits to the household. The literature examining Participant Ability to Contribute to Environmental Efforts is not as strong as that of other participant perspective benefits (several studies conducted in the mid-2010s). While few have quantified this benefit, its monetized value ranges from about $10.00 to $45.00 per household and usually around $30.00 per household. The NEB value calculated by test runs of the model

[46] An example might be they are perhaps more likely to be using an older car that has more emissions and cannot purchase a higher priced, newer hybrid vehicle.

is below the range identified in the literature because of the relatively low program-induced energy savings.

Participant NEBs from 2001 NEB 1.0 model excluded in the new ESA NEB 2.0 model:

- Program Rebate (program does not supply a rebate)
- Transaction Costs (the NEB has limited literature, weak underpinnings, and is not very relevant to program).

2.4.4 All NEBs Accepted for Inclusion in Near-Term NEBs Computations

Figure 2.12 shows the list of NEBs accepted into the computation of ESA NEBs in the near term. The decision-making was based on the logic and ability to model the NEB; it also included an assessment of the quality of immediately available data, conformance with estimates from the past and from the literature, and other factors. Figure 2.13 includes the NEBs accepted for immediate computation.

Figure 2.12: Count of NEBs Accepted for Inclusion/Computation for Cost-Effectiveness (C/E) Calculations

	Number of NEBs in Inventory	Included in ESA 2001 NEB 1.0 Model	Accepted for Inclusion in C/E 2001 NEB 1.0 Calculations	Included for Modeling in ESA NEB 2.0	Accepted for Inclusion in NEB 2.0
Utility NEBs	32	11	8	9	5
Societal NEBs	32	4	0	10	1
Participant NEBs	72	12	11	27	15
Total NEBs	**136**	**27**	**19**	**46**	**21**

The 19 NEBs accepted in the 2001 NEB 1.0 model were listed in Figure 1.2. The number of NEBs accepted in ESA NEB 2.0 is 21. Figure 2.13 lists the NEBs accepted in NEB 2.0, and Figure 2.14 provides a brief description of each of these NEBs, parallel to the descriptions of accepted NEBs in the NEB 1.0 model included in Figure 1.1.

Figure 2.13: List of NEBs Accepted for Inclusion/Computation in NEB 2.0 for Cost-Effectiveness Calculations

Utility NEBs Accepted

- Arrearages
- Shutoffs
- Reconnects
- Notices
- Utility Rate Subsidy

Societal NEBs Accepted

- Water/Wastewater Infrastructure

Participant NEBs Accepted

- Water/Sewer Bills
- Calls to Utility
- H&S Fewer Fires
- H&S CO Poisonings
- H&S Asthma Symptoms
- H&S Allergy Symptoms
- H&S Cold Symptoms
- H&S Hot Water Scaldings
- Property Value
- Thermal Comfort
- Noise Internal
- Noise External

Utility NEBs Accepted	Participant NEBs Accepted
	• Customer O&M • Aesthetics/Appearance/Ability to Sell • Reduced Detergent Use

Figure 2.14: NEBs and Descriptions of Accepted NEBs for NEB 2.0 Model

NEBs	Description
Utility NEBs	
Reduced carrying cost on arrearages (interest)	The utility and its ratepayers have lower revenue requirements because the carrying cost on arrearages is lower when the program achieves (bill) savings and improves bill payment behavior by participants.
Fewer shutoffs	The utility and its ratepayers have lower revenue requirements because the shutoffs are reduced when the program achieves (bill) savings and improves bill payment behavior by participants.
Fewer reconnects	The utility and its ratepayers have lower revenue requirements because the reconnection costs are lower when the program achieves (bill) savings and improves bill payment behavior by participants.
Fewer notices	The utility and its ratepayers have lower revenue requirements because the cost of issuing notices is lower when the program achieves (bill) savings and improves bill payment behavior by participants.
Rate subsidy avoided (California Alternate Rates for Energy, or CARE) payments	The utility and its ratepayers have lower revenue requirements because the program achieves energy savings for participants, and fewer funds need to be raised to pay for rate subsidies for these saved kilowatt-hours (kWh) and therms.
Societal NEBs	
Water/sewer savings	Measures that are installed under the program save water and energy use. Society receives benefits from deferral of investment in water infrastructure.
Participant NEBs	
Water/sewer savings	Measures that are installed under the program save water and energy use. Participants receive direct savings in water and wastewater bills from the lower water use.
Fewer calls to the utility	Lower energy bills and associated improvements in bill payments lead to fewer calls to and from the utility on billing issues and lower time spent by participants on these calls, valued at participant value of time.
Property value benefits	Repairs to the home improve the property value for the household.
Fewer fires	The program's onsite activities and older equipment replacement reduces the risk of fires and associated costs to participants including property damage, injury, and deaths.
Indoor air quality (CO-related)	The installation of CO monitors reduces the potential for sicknesses or deaths from CO poisonings to household members.
H&S asthma symptoms	The ESA program installs measures that can improve indoor air quality by controlling the flow of outdoor allergens and particulate matter into the home, resulting in reduced incidences and occurrences of asthma symptoms and resulting out-of-pocket costs for households.
H&S allergy symptoms	The ESA program installs measures that can improve indoor air quality by controlling the flow of outdoor allergens and particulate matter into the home, resulting in reduced incidences and occurrences of allergy symptoms and resulting out-of-pocket costs for households.

NEBs	Description
H&S cold symptoms	The ESA program puts measures in place that helps reduce temperature, irritant and low humidity conditions that can increase cold and virus symptoms. Households experience fewer out-of-pocket costs from over-the-counter cold medications, prescriptions, and doctor visits related to colds.
H&S hot water scaldings	The thermostatic shower valves and water heater temperature checks provided by the program can prevent hot water scalding and reduce out-of-pocket medical costs to households from accidental tap water scaldings by children and elderly residents.
Thermal comfort	Program measures improve the conditioning of households and reduce drafts and leaks, and improve resident thermal comfort. Residents receive and value benefits from the improved indoor environment from these changes.
Noise internal	New equipment installed by the program may operate more quietly, reducing inside-generated noise. Residents receive and value benefits from the improved indoor environment from these changes.
Noise external	Installation of shell / enclosure measures may reduce street noise experienced by residents. Residents receive and value benefits from the improved indoor environment from these changes.
Customer O&M	The program installs new measures that presumably have fewer repairs and residents have savings from lower out-of-pocket repair costs than they experienced with the replaced equipment.
Aesthetics / appearance / ability to sell	The installation of new equipment provides benefits in equipment and the home looking cleaner, newer, and more fashionable. Residents receive and value benefits from the improved indoor environment from these changes.
Reduced detergent use	The program installs new high efficiency washers which, in addition to using less water (measured in another NEB), require less detergent per load. These are out-of-pocket savings for the household.

3.0 Updating 2001 NEB 1.0 Model to NEB 2.0

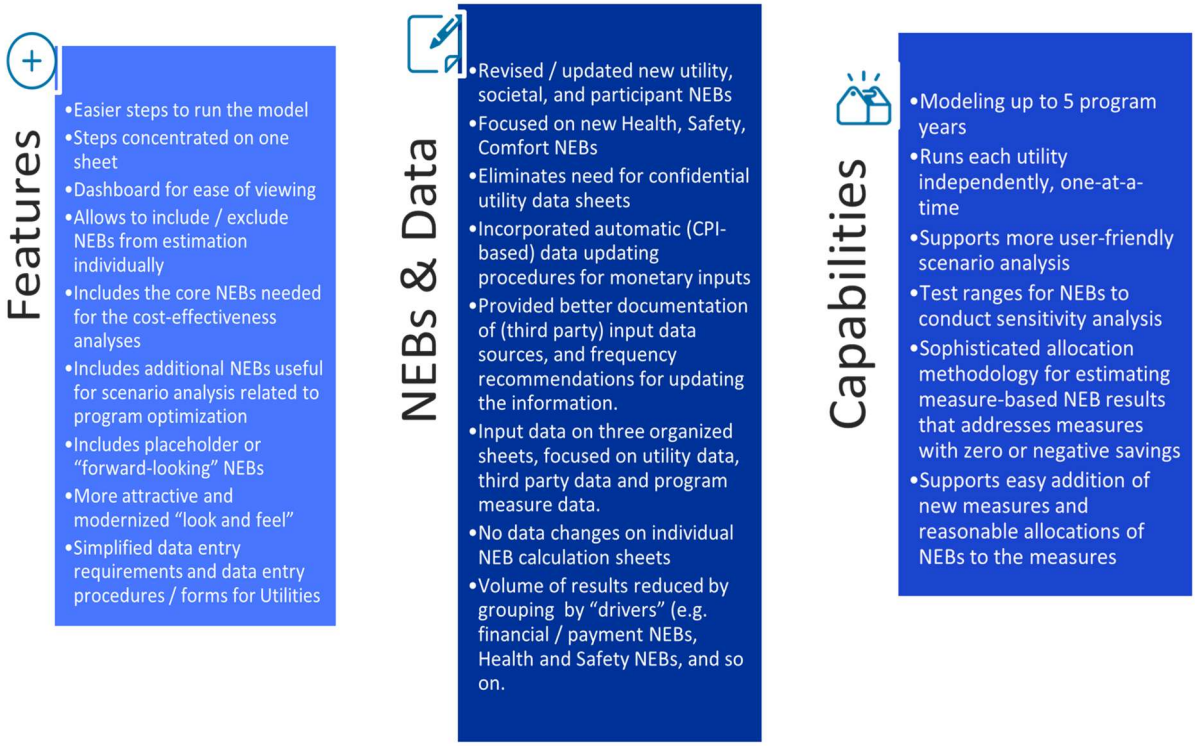
The consultant team had the following project objectives when developing the 2019 NEB 2.0 model:

- The model should be user-friendly.
- The model should accommodate both existing and new NEBs.
- The model should support defensible allocation of NEBs to the measure level.
- The model should support estimation of NEBs for a single year or up to 5 years in single model run.
- The model should support sensitivity analysis.

3.1 NEB 2.0 Model Structure and Organization

The updated ESA program NEB 2.0 model has been rebuilt to incorporate a variety of new features and capabilities (outlined in Figure 3.1) described in the paragraphs below.

Figure 3.1: Features and Capabilities of the Updated NEB 2.0 Model



New values have been developed for NEBs in the ESA model: This includes updated values for several societal effects including water infrastructure NEBs, regional economic impacts, updated health effects from emissions reductions, and a variety of societal health and safety NEBs. On the participant side, substantial improvements and additions were made, including better baselines for estimates for water measure savings; improved estimates of comfort, noise, avoided moves, and other household NEBs; and the health and safety NEBs noted above. The consultant team also included the transparency and logic associated with the NEB for O&M and measure life-related NEBs associated with the program measures.

Some NEB calculations were removed from the new model because they have been accounted for in the Avoided Cost computations: Several NEB estimates that were included in the 2001 model have been deleted because the effects are embedded in the latest Avoided Cost analysis, including transmission and distribution system line loss savings and the (market) value of emissions. The remaining emissions factor relates specifically to the effects on health and safety, which are not included in the Avoided Cost report. The estimation of some of these NEBs omitted in California remain relevant in other jurisdictions depending on their cost-effectiveness tests and Avoided Cost approaches.

Reduces utility data entry and data updating requirements: The model and computations have been restructured to reduce the data request burden on the utilities. Some of the data were considered confidential, and other data are scattered across multiple departments. Using a combination of focused utility data requests, automatic updating for inflation, industry data, and other sources, the model has been made easier for the utilities to populate and operate.

More NEBs were estimated than used for cost-effectiveness test applications: The study develops estimates for more NEBs than the utilities will include immediately for the cost-effectiveness testing. These extra NEBs remain included for several reasons:

- The model has historically been used for a long time between updates, and if California changes its test or undertakes a National Standard Practice Manual exercise and expands the NEBs included, the additional NEBs are available for use. Given the potential extended time between updates, the model is forward looking and these are placeholder computations. In the meantime, the values can be set to zero.
- The model and NEB computations are meant to serve four utilities. The utilities can elect to include or exclude specific NEB values from the computation depending on the specific application of the model run.
- The NEB model is meant to serve two main purposes: to calculate NEBs for cost-effectiveness tests and to run sensitivity analyses. One of the sensitivity analysis options that can be run is to design the program to maximize the overall benefits (including potentially all NEBs or all participant NEBs, or other choices), subject to a program budget maximum. This allows the utilities to optimize the program and its attractiveness to potential participants.[47]

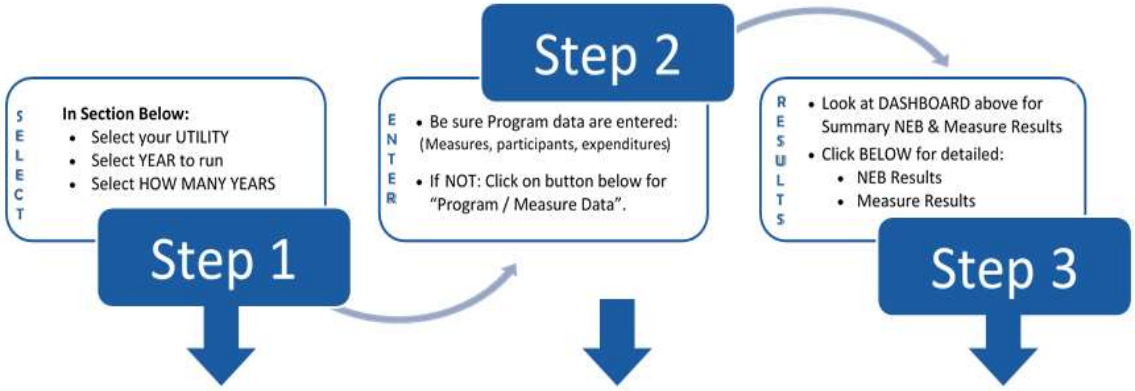
[47] *Including the broader range of NEBs may be useful for marketing or other applications.*

Structure of the NEB 2.0 Model

The new ESA NEB 2.0 Model calculates the NEBs for 47 categories, and the value for each NEB is then allocated among each of the individual measures included in the ESA program for the program year modeled. To accomplish that result takes a number of modeling steps, and a model structure that is outlined below.

Figure 3.2: Excerpt of the Model's Introduction Pages

Figure 3.3: Model Steps – Excerpt from Model's Introductory Pages



The model's Excel workbook includes 81 active sheets, divided into six groups:

- **Key user sheets (four sheets):**
  - ***Opening/Table of Contents:*** This sheet includes a description of the model background, model color, and cell conventions; provides a table of contents explaining each sheet and its purpose; and provides a quick link to each sheet.
  - ***User/Opening:*** This sheet includes all the settings and choices for basic model operations: selection of utility, program years, confirmation of program data entry status, and location of results. The sheet also includes a dashboard of key results and provides instructions for how to accomplish more advanced steps like sensitivity analyses/benchmarking and changing other inputs and settings, with quick links to the appropriate pages.
  - ***Results by NEB Categories:*** Lists the annual NEB results in decreasingly aggregated form (totals for three perspectives, then 12 NEB groups, then 47 individual NEBs) for each of up to 5 program years, by household and program-wide. This sheet also allows the user to include or exclude the computations for individual NEBs.
  - ***Results by ESA Measure and End Use:*** Lists the annual NEB results in decreasingly aggregated form (totals for end uses, then by measure). Data is presented for up to 5

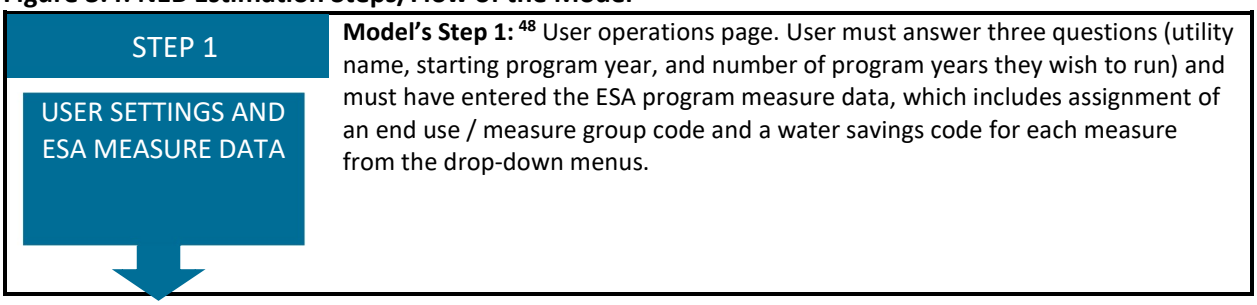
years, for household and program-wide, and the user may include or exclude results for individual measures.

- **Data sheets (three sheets):** These three sheets (Utility measures, Utility data, and NEBs & reference studies) include the data needed to run the model. The utility measures sheet assembles the data related to program participation, measures, and data about the measures (lifetime, cost, number installed). Utility data includes rates and a few other utility-specific data elements. The other important data sheet is the reference studies sheet. This includes the data used to calculate all 47 NEBs and identifies the value, source, and year; discussion/rationale for the data selection; and recommended data update frequency. The data from this last sheet carries over to each individual NEB computation sheet.
- **Sensitivity analysis sheet:** Most users will not need this sheet, and it is not needed to run the model. However, users that wish to conduct a sensitivity analysis or benchmark the calculated NEB values against the literature can use the sensitivity analysis sheet.
- **Measure allocation sheets (two sheets):** These sheets do not generally need to be referenced by users to run the model. These sheets pull the NEB values for each individual NEB and perform the computations for allocating NEB values to the individual measures, using look-up tables of selected allocation methodologies.
- **Interim calculations and look-up tables (three sheets):** Not referenced by user. These sheets contain look-up tables (consumer price index, water savings by measure), and one sheet includes an array of ESA measure-based calculations (number installed, share of savings, spend, and other items).
- **Individual NEB calculation sheets (46 sheets with content, 22 placeholders for future NEBs):** The utility perspective has eight active NEBs and six extra sheets, societal has 10 calculated NEBs and space for six future NEBs, and the participant perspective has 28 calculated NEBs and 10 sheets for future NEBs. Each sheet lays out each step of the computation of the NEB with an explanation and the detailed data source (pulling from the data sheet). Each step is carried out for up to 5 program years, and the results are transferred to the results pages discussed above.

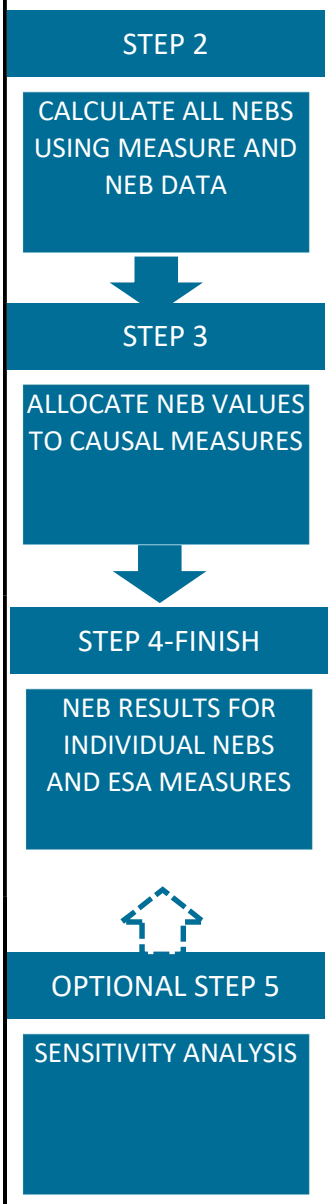
Estimation Steps/Flow of the Model

Figure 3.4 outlines the main steps the model uses to compute the individual NEBs and the NEBs for the ESA measures.

Figure 3.4: NEB Estimation Steps/Flow of the Model



[48] *Note these are the model's steps, not the user's steps.*



Model's Step 2: Most of the data needed to compute the NEBs is already populated in the model's data sheets. Based on the user entry of program year ESA measure data, the model calculates many variables that are used actively in the computations of the NEBs on the data sheet, transferring the information to the data sheet and to the individual NEB pages. These include the number of measures of various types installed, savings and spending shares, and many other results. If zero measures of certain types are installed, a warning goes to the user on the NEB results page that they should turn off the associated NEB(s) because causal measures are not present.[49]

Model's Step 3: The model pulls the NEB results from each individual NEB sheet onto a measure allocation page.[50] The model includes a set of allocation tables with preselected assignments associated with each specific NEB.[51] One part of the table identifies each causal measure each of the NEBs is influenced by.[52] The second part of the allocation table identifies which factor should be used to share out the NEB to the measures. Options include (but are not limited to) percentage of savings, percentage of expenditures (spend), percentage of water savings, and others.

Model's Step 4: Basic results are transferred to NEB and measure results sheets. The user may select in or out for various NEBs on the NEB results sheet, and the NEB computation results display on two sheets and the dashboard.

Model's Optional Step 5:[53] USER OPTION: Sensitivity analysis. The results from Step 2 are transferred to the scenario analysis sheet. The user can compare calculated results with the ranges for the value from other studies and the reliability scores assigned elsewhere in this project. The user can turn on a reliability discounting factor for any NEB if desired, adjust individual NEB results in other ways, or may elect to return the NEBs to full value after running sensitivity analyses. These final NEBs are the ones transferred to Step 3. In addition, the user may elect to test the sensitivity to the presence/absence or number of individual ESA measures delivered by the program. These are adjusted on the measure results sheet. The final settings affect the calculation of results presented.

[49] Again, it was decided not to automate this so the user would be aware and those running the model for design purposes could reconsider whether to add measures to the program. The NEB will calculate a zero value in either case.

[50] Actually, it goes through the sensitivity analysis sheet first, but since this sheet is optional, it is described later in this step list.

[51] NEBs stay relatively constant, but measures can change every year, and the names may not stay consistent. Therefore, much of the allocation is related to drop-down menu measure groups/end uses for allocation that are identified as causing the NEB effect in question. Some are individually assigned (CO monitors, if they appear, property repairs, etc.).

[52] One extra step happens in this section; the initial assignment may not sum to 100%, depending on the allocation method used. The first round of results is reproportioned to assure exactly 100% of each NEB's value is allocated among the relevant measures.

[53] Additional model adjustments available to users include: allocation table settings, selection of specification of savings share (with/without zeros or negatives), data updating, revising likelihood to purchase" by measure for measure life NEB, and adding new NEB categories. The model also accommodates more complicated changes like adding measure groups and end uses.

PERIODIC STEP 6

DATA UPDATES

Periodic Step 6: Program measure data (measures/type, number of measures, number of participants) are updated by the user each program year. Utility data are updated every year or two (rates, CPI, fees). On the NEB and published data sheet, the general data update schedule is:

- NEB studies (dollar values and other input values): as new studies are available, at least review in 5-year intervals
- Reference data (damage values from fires, statistical death value): every 3-5 years

The model also highlights old data via color coding and recommends updating ASAP. Reminders that appear in future years to remind about data update schedules are embedded in the model.

3.2 Modified Method for Allocating NEBs to Measures

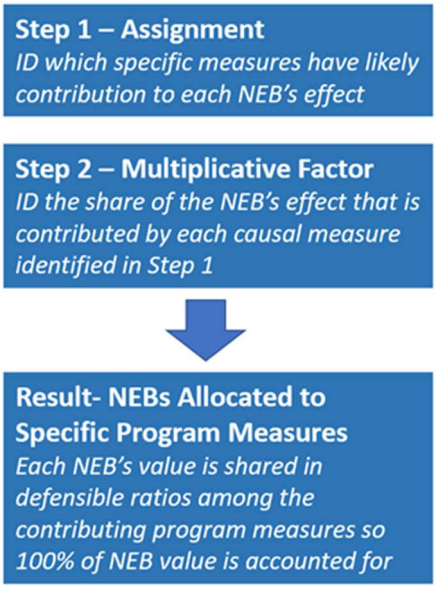
An important requirement of the ESA NEBs estimation work and model is the ability to estimate the degree to which individual measures provided by the ESA program are responsible for contributing to the NEB value. Delivering this capability is complicated because there is very sparse literature directly linking measures to NEBs; most NEBs for programs like ESA are measured "program-wide", not "measure-by-measure".

Historically, the NEB 1.0 model used a straightforward two-step method for allocating NEBs to measures (See Figure 3.5).[54]

In Step 1, for each individual program measure (33 in the most recent NEB 1.0 model vintage), the IOUs determined whether the measure had a "causal link" to, or contributed to the value for each of the NEBs, in turn. A total of 23 NEBs[55] were allocated this way in the NEB 1.0 model.[56]

For each NEB, Step 2 the assigns a factor that reflects that some measures contribute more value to the NEB than other measures. For the NEB 1.0 model, that factor was the share of the program's energy savings (net present value of total lifecycle dollar savings) that the measure delivered. The result is a dollar NEB value for each of the measures identified as "causing" at least some value for at least one of the NEBs. Summing across all NEBs results in the total NEB value assigned to each measure.

Figure 3.5: Two Main Steps for Allocation of NEB Value to Measures



[54] *For more detail on the allocation of NEB value to contributing measures, consult Appendix E.*
[55] *The questions were "hidden" for an additional four societal NEBs.*
[56] *Although a few had some settings turned to zero, like water savings.*

Findings regarding the existing Allocation Methodology: Although the same general approach is used by a few other jurisdictions (for example, Massachusetts), there are weaknesses with this methodology of assigning NEB values to individual measures.

- Negative or zero NEBs for measures: Several measures that would be expected to contribute NEB value to participating households have zero or negative energy savings (e.g. furnace repairs). Because savings is used as a factor in the calculation, the NEB value would be zero or negative for these measures, and the overall value of these measures would tend to be understated.
- Importance of measures reflected by savings only: Energy savings is the only option available for sharing out the importance of a measure in causing NEBs in Model 1.0. However, other factors than savings might better communicate the importance of individual measures in delivering a NEB value. For example, it would be expected that NEBs related to economic impacts (if included in the model) would be more suitably allocated based on the dollars spent on individual measures installed.[57]
- One-by-one assignment of measures: NEB 1.0 required making decisions about assignment of each individual measures to each NEB based on the perception of its causal relationship, and reflecting that choice in the model. The data available to inform these choices was relatively thin and relied on user judgement, and the data entry could be tedious and possibly lead to errors because there are multiple NEBs and measures. If consistency between utilities in settings about measure causality is desired, this method is somewhat complicated to verify.

NEB 2.0 Allocation Approach: The measure allocation process was changed to address these findings. The NEB 2.0 model uses the following steps for allocating NEB value to ESA program measures.

- **Step 1, Basic**. Model 2.0 allows direct choices in selection of whether each measure is assumed to have a direct causal effect on each NEB. The resulting matrix of choices forms the basis for the model's computation of which measures are included for which NEBs (or similarly, which NEBs are caused by which measure).
    - However, the report and the model also include a research-based table of information[1] from the literature and from research that can be used to inform those causality choices.

- **Step 2**. Model 1.0 always selected "energy savings" as the multiplicative or importance factor that determined how important any of the causal measures were relative to each other. NEB 2.0 allows a selection from among several multiplicative factors. The most important factors that are available include: energy savings (abbreviated as "sav" in the model), the project dollars spent on the various measures (abbreviated as "spend"), and water savings delivered by different measures (abbreviated as "H2O"). These additional factors can better reflect the relative importance of individual measures for some NEBs. Then, to address the problem that some of the measures that have zero or negative energy savings, two substitute options are provided for NEBs in which it would be expected that even measures with negative savings would be delivering positive NEB values to the participants. One simple option uses the

[57] *Participant water allocation was "turned off", but when turned on, it also allocated the savings according to energy savings.*

absolute value of the savings, called "abssav". This factor still allows zero values for the importance factor for a measure and may not suit all uses. Therefore, the model includes another new option, included as a *pilot* option, called "SavSpend". This value replaces negative and zero values in savings with a "fitted"[58] value calculated from a statistical regression,[1] and its derivation assures the "SavSpend" multiplicative importance values are never zero or negative. This factor can be used when some of the causal measures would be expected to deliver positive NEB value from the service to the household that is provided by that measure, but the energy savings from that measure happens not to be positive. *Therefore, in Model 2.0, the multiplicative factor for each NEB is selected from among several options, based on which factor is expected to best represent the importance of the NEB's selected causal measures.* This multiplicative importance factor is then applied to the causal measures selected in exactly the same way as in Model 1.0.

This basic approach addresses the first two issues related to the operation of Model 1.0. A second *pilot* process was also incorporated into Model 2.0, called Step 1, Enhanced, which can be selected as an option, with a switch in the model. Note that whether Step 1 Basic or Step 1 Enhanced is used, Step 2 remains as described above.

Step 1, Enhanced. The information from the research-based information matrix referenced in Step 1 Basic was also integrated into Model 2.0 in an automatic way, with default settings included in the model. The outline of this process follows.

- The research-based information matrix shows the pattern of which measures affect which NEBs, based on information from a combination of sources.[59] Unfortunately, the sources in the literature do not match either the measure list or the NEB list included in the ESA program exactly. Therefore, judgement was needed to translate the measures in the literature and research to measure groupings or categories that could be more suitable to the array of measures installed in ESA – current and potential future measures. These are called "measure groups".

- The utilities are required to assign a measure group to each measure installed in the ESA program. This is accomplished using a drop-down menu included as part of the data sheet with information on all the measures installed in the program. These choices should be made based on the functional and household service similarities of the individual measures to the measure

[58] *This "fitted value" was derived from an OLS (ordinary least squares) model regressing energy savings against measure cost for the ESA measures. The details of the model's fit are provided in Appendix E. However, note that the regression used all the data available from all the program measures supplied by the utilities for the development of the NEB 2.0 model, but the total number of measures was about 30, so sample sizes were small. For this reason, and because this approach is exploratory work and not widely discussed in the literature yet, this approach of filling in the negative and zero values with "fitted values" estimated from a regression is considered a "pilot" approach.*

[59] *The sources include a study specifically addressing NEBs associated with individual appliances (Smith-McClain et. al. 2006), the table of results from the IOU Health and Safety research memo, and results from a regression analyzing the statistical evidence for causal relationships between measures and NEBs (Skumatz et. al. 2019). These sources were reviewed by the consultant team to develop default values for the set of causal measures for the NEBs. Note that this causal relationship is deemed to be "pilot" for the purposes of this model, partly because the regression work is based on proprietary data on a weatherization program in another state and the equations cannot be fully vetted, and partly because the translation of the research to the ESA program required consultant team judgement.*

group (furnaces all together, or caulking and weather-stripping measures that might be separated into individual measures are grouped, etc.). In this way, each measure (current and future) is mapped to a measure group.

- This can reduce the effective number of measure / NEB relationships that must be assigned as "causal" within the model.[60] All furnace options, regardless of efficiency level, are expected to cause the same NEBs (comfort, etc.). That yes/no causal relationship is the crux of Step 1. However, the granularity that furnaces of different efficiencies or in different climate zones may cause more or less comfort than others is still computed at the measure level (in Step 2), and is not affected by this enhanced option for Step 1. Step 2 still assigns the selected multiplicative importance factor for each measure (*not* measure *group*) to calculate the NEB associated with each measure.

- In the Enhanced Step 1 option, the utilities select which measure *groups* cause which NEBs. This makes sure all furnaces, regardless of efficiency, are selected to cause the same NEBs. This is accomplished in a matrix, and the switch can tell the model to select this set of utility choices based on measure groups (Enhanced) OR the choices made separately measure-by-measure in Option 1 basic.
  - The use of the Enhanced Step 1 option leads to fewer choices or causal assignments that need to be made, and helps keep consistency in NEB causal logic for similar types of measures.
  - This use of "measure groups" allows the model's causal relationships to function properly, even if the utilities change the order of the NEBs included in the model in the future. As long as the utilities are satisfied with the assignments between measure groups and NEBs causation, the look-up tables in the model make sure that the individual measure is included in the proper NEB causation. This is true as long as each measure, current or future, is assigned to a NEB measure group by the utility. The causation does not need to be reassigned by measure every time the order of measures changes, or new measures are added to the program. The model includes space for 29 measure groups.
  - One additional enhancement is supported by the model – "named" causal measure groups. Because research is not yet available to definitely identify the measures or measure groups associated with each NEB individually (e.g. the difference in measures that cause allergy vs. cold symptoms), and because there are logical repetitions in causation, some measure groups will likely be assigned over and over again, but to different NEBs. For instance, all the NEBs that are caused directly or indirectly by financial effects from the measures (e.g. NEBs including arrearages, calls, shutoffs from each perspective) will be caused by the same measures (actually measure groups), over and over. In that case, the causal measure or measure groups included would be all except perhaps property repairs. Economic and job creation effects will be based on all measures and activities including property repairs, and the model allows for at least three economic -related NEBs. The model allows these groups to be "named" so that logically-consistent measure groups are assigned to NEBs with similar causations. The first group here is called "Sav" group (for energy savings) in the model, and the second is

[60] *Without direct one-by-one matching and / or survey sampling and research for each measure's effect on each NEB, for each current and future measure, some judgement will always be needed to assign measures to NEBs. Measure groups are a practical way to address this issue.*

called the "spend" group in the model. Logically, the "sav" group is assigned to all the financial NEBs (arrearages, etc. for the utility and participant perspectives). However, these measures also directly cause the emission-related impacts of the program, so it makes sense to assign that same named causal measure group to NEBs like the societal emission-related health NEBs (not currently accepted for inclusion). Some named causal measure groups are used for just one clear NEB[61]; in other cases, the same named causal measure group should logically be assigned to multiple NEBs.[62] The model allows a total of 25 named "named" causal measure groups, and the default settings use the same named set for multiple NEBs. *However, for convenience, there is space for enough causal measure groups to have each one assigned individually to each of the 20 NEBs accepted for inclusion in the model, so each can be named and assigned individually.* Default values are included in the model, based on the consultant team's review of causal relationships and repeats in measure groups and their causal relationships.

The NEB 2.0 model supports operation manually as in Model 1.0, or by the use of measure group assignments, as in Step 1 Enhanced, the model automatically updates for changes in measures and additions of new measures, or changes in the order in which measures are included in the program measure list. Step 1 Enhanced also makes it easier to maintain consistency in the causation relationships between NEBs and between utilities. More detail on these processes are included in Appendix E.

Step 3: Then the model uses the information from causal Step 1 (basic or enhanced) and importance-related Step 2 to allocate the total dollar value of each NEB among the program's measures first, by whether the measure is included as a "causal" measure for that NEB or not, and second, *among* the causal measures using the selected sharing factor. This is the same process used in NEB 1.0 for calculating the NEB value assigned to each measure for each NEB. The total (allocated) NEB value for any measure is the total of these contributions across all NEBs included in the model.

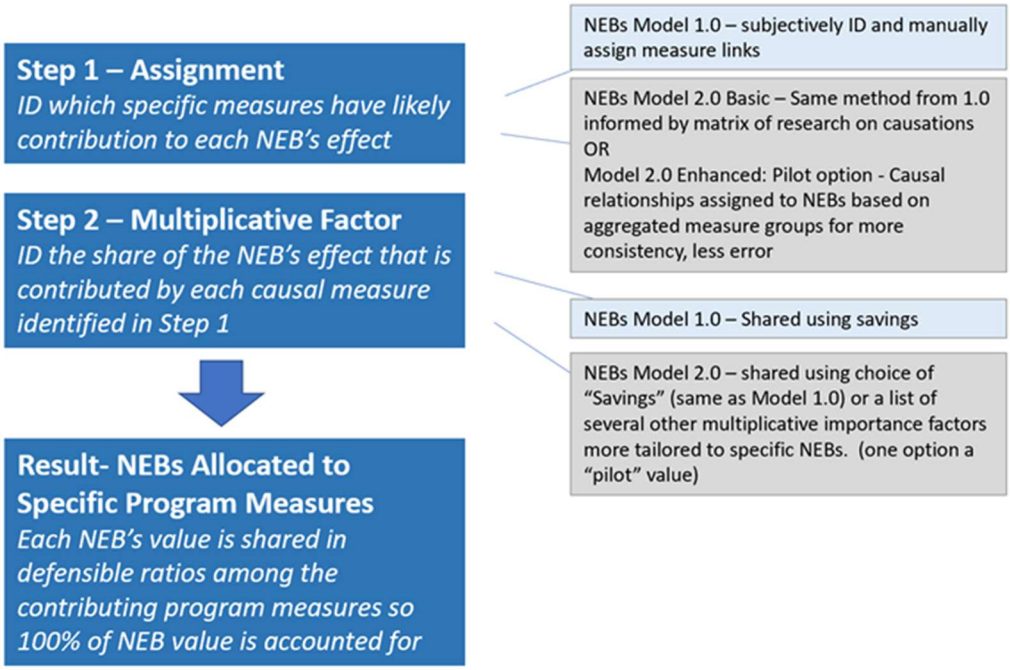
---

[61] *In the default settings, many of the named causal measure groups are assigned to just one specific NEB. This includes "safe" for measures related to safety in the home and assigned to the NEB on household safety (not currently accepted for inclusion); "CO" for carbon monoxide monitors, should they be added to the program and assigned to CO poisonings (participant and societal); "H2O" for water-related measures for the societal and participant water savings NEBs; "scald" for measures that contribute to fewer scaldings; "ff" for fire-related measures for the fewer fires NEB; "PV" for property value / property repair measures for that NEB; "Nout" for measures affecting perception of noise from outside the home; "Nin" for measures affecting perception of noise from equipment inside the home; "lite" relating to lighting-related measures; "O&M" for measures contributing to O&M costs; "ML" measure life, relating to measures with a lifetime (all measures); "DU" for detergent use (washers); "Perf" for performance-related measures; "Aesth" for measures assumed to cause improvements or reductions in aesthetics or ability to sell the home; "control" for measures related to improvements in knowledge or capabilities of better controlling the household bill; and "DoGood", identifying measures that households perceive as helping them help the environment assigned to the "doing environmental good" NEB. Space for an additional five blank named measure groups is provided. These groups can be renamed or reassigned by users on the measure allocation page of the model.*

[62] *In the default settings, several causal groups are repeated for multiple NEBs. The named causal measure group "sav" includes all measures contributing to savings or negative savings, and assigned to all the financial NEBs from both utility and participant perspectives (arrearages, calls, shutoffs) and to the NEBs related to changes in emissions caused by energy savings (societal illnesses). The named factor "spend" includes all measures that have a cost to include in the program, and are assigned to the three societal economic NEBs. Because granularity on individual measure causes for many illnesses is not available, a set of measure groups is defined and called "sick", and includes measures that contribute to fewer generalized illness incidents. This named causal measure group is assigned to allergies, cold symptoms, asthma, etc.*

The operation of the measure allocation function in NEB 1.0 and NEB 2.0 is illustrated in Figure 3.6.

Figure 3.6: Allocation of NEBs to Measures, Model 1.0 and Model 2.0



3.3 Sensitivity Analysis and Updating the Data

Sensitivity Analysis

The model incorporates a sheet allowing users to conduct sensitivity analyses on the estimated NEBs. Sensitivity analyses related to both the individual NEBs and the measure-allocated NEBs are incorporated into the model. These capabilities allow the user to modify the NEB computations and results based on considerations of policy, reliability, input data age, allocation assumptions and other analyses that may be useful to the user to provide a fuller understanding of the NEB results.

Several individual NEB sensitivity analyses can be accommodated:

- **Sensitivity to NEB value changes:** The model incorporates logic to conduct detailed analysis of the impact of changes in individual NEBs. Specifically, the updated model facilitates comparison of the calculated NEB value against the range or typical values from other studies in Skumatz Economic Research Associates, Inc. (SERA)'s NEBs database. Users can scale up or scale down the NEB based on the reliability score for the NEB or the user's comfort with inputs or comparisons to literature values. Users can also check the influence of individual NEB values on the overall NEB results; they carry through to the results for NEB results by end use that are displayed live on the same page.
- **Sensitivity to inclusion/exclusion of NEBs:** The NEB 2.0 model allows the user to include or exclude specific NEBs in the computation (in conjunction with another sheet) based on confidence, appropriateness for the cost-effectiveness tests, or other reasons, and shows the impact on subtotal and total NEBs for the program.
- **Linkage to underlying causal measures:** Alerts users to whether particular NEBs for particular years lack causal measures to cue the user to turn off that NEB, or to provide a prompt that if the measure is important or reflects a program goal, the program may wish to consider introducing additional measures.
- **Sensitivity to CPI updates or selection of other factors:** The NEB 2.0 model allows the user to turn on or off the CPI update function in the model, which can indicate problems with aging data.

Several measure allocation sensitivity analyses can also be accommodated:

- **Impacts of changes in specification allocation assumptions:** The NEB 2.0 model allows users to examine the impact on end use measure-allocated NEBs from changing assumptions about the specification of certain allocation assumptions, including whether unadjusted savings or adjusted savings (replacement of zeros and negatives with proxy data) have on the total NEBs and NEBs by end use.
- **Inclusion/exclusion of specific measures:** The NEB 2.0 model also shows how the program-wide NEB, measure-based NEB, and end use NEB results change as specific measures are included or excluded from the program measures.

Process for Updating the Model

The model still requires users to update key data for it to produce defensible NEB estimates. However, several key changes reduce the data and updating burden.

- **The values that must be updated are fewer:** This is largely because the model incorporates an automatic updating mechanism for all inputs that are dollar-based (using the CPI). This forestalls the data aging problems from the previous model, to some degree.
- **The amount of required utility data is less:** Beyond the program measures, measure counts, number of participants, and the residential rates/tariffs, the utilities do not have to enter additional data regularly. The utilities may allow measure lifetimes, savings, measure-based water savings, water rates, and even costs over several years if they are still reasonably applicable. Most of the utility-sensitive data now uses data from third-party sources; this data can easily be replaced with utility data at any time.
- **Measure data sheet can be distributed for easier data entry:** The data entry for ESA program measure and participation is included on one sheet that can be copied, distributed, and then recopied into the model. This makes it easier to circulate the data request sheet to the various staff that may be involved in updating the program values.
- **The data entry needed to support the measure allocation procedures is less:** The earlier model required utilities to identify each NEB that each measure affected when the measure data was entered into the model. The new model includes 47 NEBs and can handle more than 90 measures; therefore, this process would be onerous.[63] The data entry associated with the new model requires the user to select items from two drop-down boxes to assign both the enhanced measure group/end use code and a water measures code to each measure. This is substantially less labor intensive, helps avoid errors, and makes it easier for utilities to run models consistently among utilities and over time. The embedded default allocations are also linked to research and do not require judgement on a repeated basis by those entering and updating measures.[64]
- **Non-measure data entry is centralized, and some items are included in look-up tables, simplifying model updating:** Rather than updating numbers on multiple sheets, the data is centralized onto one main sheet. Look-up tables for some key data (e.g., CPI) simplify data updating for some information from published sources.
- **The data that needs to be updated is color- and number-coded with a recommended replacement schedule:** Rather than updating numbers on multiple sheets, the data is centralized onto one main sheet. Data ages are attached, so aged data can be found and updated easily. Data is color-coded and number-coded so the user can link the data with the recommended updating schedule for each data element. Some is recommended for replacement every 3-5 years (the CPI adjustments can handle changes in between); for NEB study values, an updated NEB literature review is recommended every 5 years (minimum) to update those values.[65] Most importantly, URLs and page numbers are associated with all the data and reports that were possible; clear citations are included for others.

[63] *It was also inflexible for allocation rationales, not transparent, and made it difficult to be consistent between the utilities.*
[64] *Although, as mentioned earlier, users may override the default allocations and enter their own ad hoc allocation settings.*
[65] *They can be updated as staff become aware of new studies.*

3.4 Importance of Data-Related Updates Going Forward

NEB computations and data inputs benefit from regular review and updating. Dollar value input data, such as value of a statistical life and other health-related indicators, need to be updated as new information and calculations become available to accurately characterize NEBs. Several methods are suggested to keep the data more easily updated in the ESA NEB 2.0 model.

- **Utility data updates:** To optimize the results of the model, updated utility data will be useful prior to running the model. These include the following:
    - ***Required:*** Years that are covered, list of measures included in the program, answers to two drop-down menus for each measure, quantities of each measure to be installed, and number of participants
    - ***Helpful:*** Updated measure costs and any program administration costs, measure savings, measure lifetimes, updates to billing rates and CARE discounts, and, if possible, latest CPI inflation rate values

  Other more current data may be culled from the published utility data or other sources, including public sources and new research.
- **Automatic updates:** For some dollar values used in the model, automatic updates are embedded based on the CPI index. This minimizes the amount of data to be updated every year and assures calculations are based on common, current-year financial inputs.
  Summary data from well-documented sources: The model includes a summary page of data and sources for key secondary/non-utility resources rather than including data on discrete individual pages for each NEB. Live links are identified where available. In other cases, the specific citations and pages are provided. Some of these NEBs may use time-sensitive values in their calculation. The consultant team provided instructions about recommended frequencies for updating in the model, using a color-coded and number-coded data tagging system. In addition, the dates for all data sources are marked, making it easy for users to scan data periodically for aged entries; data that is especially aged now are color-coded for priority update.
- **Priority NEB data:** Some priority NEBs (i.e., NEBs scored as highly credible) could not be estimated and might be desired, are not strictly (yet) included in the benefit-cost equation, or are not yet acceptable to one or more of the utilities. However, the NEBs are included in the model for several reasons. These NEBs may be useful for sensitivity analysis or to test which program design could increase overall benefits subject to a budget maximum. Keeping them in the model reminds the users that these NEBs are close and keeps the data gap that needs addressing on the radar as opposed to forgotten. This data is likely to become relevant as California revisits its cost-effectiveness tests in the future. The model also includes space for new NEBs yet to be developed.

4.0 Findings and Recommendations

4.1 Strengths, Weaknesses, and Limitations of NEBs

The figures (Figure 4.1 – Figure 4.3) below identify key modifications provided by this effort and potential next steps to continue to improve understanding of the magnitude and role of NEBs associated with measures provided via California's ESA program.

Figure 4.1: Overall Study Informed ESA NEB Revisions

NEB and Model Modifications	NEB and Model Limitations
• On a qualitative basis, these NEBs are updated on the most suitable available information and data sources, and input values are borrowed from the most similar and recent programs and publications. • NEBs estimates that are within the ranges of NEB estimates developed for other similar programs. • NEBs are linked to logical and analytical connections to underlying measures	• Many NEBs use time-sensitive information and benefit from periodic updates. • NEBs would benefit from more utility-specific information to improve estimates (starting values on levels for arrearages, debt, calls, notices, and other data). • NEBs would benefit from more California-specific information, rather than data borrowed from other programs or states. • Participant NEBs, in particular, would benefit from more defensible connections to the program and measures – potentially via current surveys & analysis for the ESA program • NEBs would be stronger if the publicly available literature included more recent analyses of some concepts and inputs (i.e., some source data date back to 2001/2005). • NEBs would be stronger as more literature also tackles the logical relationships, input concepts, and computations for these NEBs.

Figure 4.2: NEB Allocation Revisions

Allocation Modifications	Allocation Limitations
• Allocation incorporates available information on measure-based NEBs. • Allocation incorporates recent work statistically linking NEBs and measures for residential participant NEBs, providing additional justification. • Allocation incorporates flexibility and logical relationships between NEBs and measures.	• Allocation would benefit from current measure-based surveys with ESA participants and nonparticipants. • Allocation would benefit from additional quantitative information on magnitude and linkage of the measure-stratified NEBs. • Allocations would benefit from additional research / treatment / understanding of NEBs for measures with zero or negative savings.

Allocation Modifications	Allocation Limitations
• Allocation addresses the limitations of the current NEB allocation method that assigns NEBs using savings-based methodology. • Allocation provides opportunity for low/non-savings measures to provide NEBs.	• Allocations would benefit from differentiating strength of measure-based vs program-based allocations to accommodate measure changes within the program and across years. • Allocation would be stronger as more literature becomes available that addresses the issue and mechanism alternatives for allocation, and as the concepts developed and used in this study are reviewed and enhanced by the research community.

Figure 4.3: 2001 NEB 1.0 Model Revisions to ESA NEB 2.0

Model Revisions	Model Potential Limitations and Next Steps
• Includes modified list of NEBs to support cost-effectiveness tests associated with the ESA program, and provides space for future changes. • Increases attention to health and safety NEBs, which are important to the ESA program. • Excludes NEBs addressed by revisions to the avoided costs. • Simplifies data entry and updating, and assembles the data into one main sheet. • Includes detailed documentation of sources. • Minimizes need for regular, utility data updates. • Provides color- and number- coding for updating data. • Reduces steps to run the model. • Includes more user-friendly documentation, and improved navigation between model sheets. • Includes sensitivity analysis capabilities related to including / excluding NEBs or measures, benchmarking or modifying the NEB values. • Model automatically update dollar values to program year. • Allows users to easily modify the measures included in the NEB estimate and scales the associated NEB estimates. • Incorporates steps to allocate program-wide NEBs to ESA program measures based on best research available, rather than *ad hoc* user assignments. • Allows users to select measure groupings / end use and water measure codes from drop-down menus. • Supports modeling for up to 5 program years. • Avoids concerns related to confidential data sharing. • Includes dashboards and updated look and feel.	• Basic model operations are much easier than the earlier model, but the underlying model capabilities and relationships are necessarily more complex, so full understanding of the model requires more knowledge and training. • Model based on available allocation information that may/may not apply to California ESA program benefits. • Model includes imprecise allocations to simplify process or where supporting data are lacking. Additional research and data to support allocation methodology refinements would be helpful. • Model includes NEBs that are both expansive and conservative. The model will benefit as more literature becomes available, and advancements are made in understanding and calculating additional NEBs. • Calculations and inputs for all steps of the modeling may not be clear to new or casual users of the model.

4.2 Findings and Recommendations

This report summarizes the results of the project, including progress to improve the NEBs for the ESA program, and the development of the California ESA NEB 2.0 model. Key findings and resulting recommendations for additional work (ordered by priority) are listed below.

Finding 1: The consultant team research found the literature on NEBs includes a substantial amount of aging data, but in many cases these older data are the best input sources currently available. Replacement and updating of input data are important elements in estimating defensible NEBs. The NEB 1.0 model documented the data sources in an inconvenient and de-centralized fashion, which complicated identification of aging data. The model's results were negatively impacted by infrequent and incomplete updates. The NEB 2.0 model centralizes data, provides complete sources, and identifies a recommended update schedule. More regular updating will improve the resulting NEB valuation. Recommendation 1 reinforces this finding.

- **Recommendation 1 - Support ongoing data needs to update NEB 2.0 as needed:** Review the data update schedule, periodically review the literature for new reports, and focus on NEBs with high values or those based on older data.

Finding 2: The consultant team research found NEBs research has continued over the years, adding some new NEBs into the literature. Where they are reliable, introducing new NEBs can better represent the program's impacts. Reflecting progress in the literature and available data, the NEB 2.0 model introduced new NEBs. It also introduced new measure allocation methods reflecting the limited quantitative information available. Continued review from researchers and review by the IOUs as new studies become available will improve the NEB results. Recommendation 2 reinforces this point.

- **Recommendation 2 - Conduct additional review and verification of the proposed NEBs and valuation to vet the benefits and acceptance of the NEBs:** NEBs are complex and difficult to isolate and estimate. However, NEBs work is becoming more important as the traditional cost-effectiveness models are increasingly viewed as not sufficiently comprehensive. Many NEBs will benefit from continued discussion and testing to improve reliability and confidence.

Finding 3: Over the past decade participant NEBs have received increased research attention, and their varied effects have been measured using more than a dozen variations of direct, statistical, or survey-based approaches. There are several independent quantitative estimates of some of the survey-based NEBs such as comfort. However, the confidence and transferability of these NEBs would be improved if there were participant NEB surveys stratified to support linking these NEBs to the ESA program's specific measures and end uses. Moreover, most studies have sampled program-wide, rather than sampling on measures to allow attribution, which is a vital element if the NEB values are to be allocated to program measures. For participant NEBs, more data is needed to support valuation. Reviews of prior work are only marginally useful; measure-stratified participant NEB surveys should be a priority for near-term research. For the NEB 2.0 model, greater granularity in survey-based NEBs were incorporated than

existed to support the NEB 1.0 model. nonetheless, it is still negatively impacted by the lack of measure-based estimates. These suggested surveys are a priority, as reflected in Recommendation 3.

- **Recommendation 3 - Conduct a well-designed, California ESA-specific survey with both treatment and control groups**: Current, California-specific information is needed to support estimates of a variety of participant NEBs. The survey should be designed to address an array of supporting research needs. The sampling for the survey should allow estimation of measure-based NEBs; include health and safety NEBs; include subsampling for demographic, climate zone, and housing type subsets; and include a focus on developing an estimate of hardship NEBs. Significant findings from the survey should be incorporated into the 2019 California ESA NEBs 2.0 model as they become available.

Finding 4: The literature search found relatively limited primary quantitative research on new values for existing NEBs, and noted that a number of recent studies continue to use or adapt the final NEB values estimated for other programs, with little review of the underlying computations or inputs. Bill payment / customer service NEBs are high among those that have used old data[66]. The ESA NEB 2.0 model examined the underlying logical derivations of the NEBs and incorporated the most appropriate or defensible data sources available in the new NEB computations. However, some of these data were older or from programs or states that will not provide as defensible numbers as could be obtained from a local ESA-based study. This is reflected in Recommendation 4.

- **Recommendation 4 - Conduct a new arrearage study to provide updated and local data for outdated data in the model:** This pre-/post- control group study is inexpensive and quick to complete. The study should use data from one to four of the utilities to develop statistically reliable estimates of the starting value for payment-related data, and the program's effects on arrearages, phone calls, notices, shutoff and reconnects, and other utility bill payment-related impacts attributable to the program.

Finding 5: Many of the NEB studies estimated the same NEBs repeatedly from 2001 to 2015,[67] but starting in about 2015 quantitative work focusing health and safety became available (Hawkins 2016, as well as international work). Historically, most NEB progress seems to pioneer in low income programs, where energy savings are not the driver for the program. In the US and internationally, part of the rationale for many of these programs has to do with hardship/easing burdens and concern over making

[66] For a number of NEBs (for example, payment-related values like arrearages), studies applied the 2001 NEB 1.0 model value or the average of that and two or three other studies and used the value regardless of whether the program: 1) was a similar size in terms of savings and might, therefore, be expected to have a similar size of reduction effect and might be in a different climate zone, which can have a large effect on savings; 2) had similar starting values for arrearages; 3) targeted the same types of households and demographics, among other issues. Many of the studies reviewed were literature reviews, recounting and reusing or slightly adapting the same values without substantial work to identify the relationship or comparability to the specific program. Until recently, the last arrearage studies for low income programs had been conducted in 2002 or 2005, despite arrearage studies being conducted frequently in the 1990s. In general, it seemed once a number was available, even if from a program that may not be similar to the new program, the value was often reused. In addition, little real progress was made on a number of NEBs that have increasing potential value, including system security, and a number of other utility NEBs that are not fully incorporated into avoided cost studies.

[67] For a review of the literature and progress, see Skumatz et al. 2009, NMR 2011 and 2014, Skumatz Maryland 2014, and other sources.

homes healthier. Health and safety NEBs were also a key focus of some of the workshops on NEBs (or as International Energy Agency calls them, multiple benefits) assembled by the International Energy Agency (IEA) from about 2013 to 2017.[68] The progress in understanding health benefits are drawn largely from the following:

- Surveys and data on hospitalization and medical costs associated with specific illnesses, and the share of costs paid by individuals out of pocket, through insurance or through social sources like Medicare/Medicaid.
- Detailed surveys of baseline occurrences of health issues in the population and, in some cases, in program homes, as well as new research on some of the program-attributable reductions in incidences pre-/post- in program homes.
- The availability of this data increases the reliability of estimates of health-related NEBs, and the ESA NEB 2.0 model includes the best health and safety information available. It moves forward the understanding of NEBs, extending specific NEBs to portions of medical costs paid by society versus the participant. However, additional information on medical costs, California-based estimates, and a few other refinements would improve the NEB 2.0 estimates. These needs are reflected in the Recommendation 5.

- **Recommendation 5 - Research true medical costs to get more defensible information on quantifying health and safety values:** Health and safety NEB estimates have historically relied on somewhat imprecise estimates of illness-related medical costs and often did not address concepts related to who pays (private insurance, government insurance, out of pocket). Continual improvements and additional data on medical-related topics would improve ESA program NEB estimates.

Finding 6: Considerable progress has also been made since 2001 in the important and high value areas for utilities of health effects from emissions[69] and job creation impacts. Work on economic impacts using third-party models (usually IMPLAN™ or RIMS II™) has demonstrated that job creation impacts vary widely based on program type and local economic/business type mix;[70] this work also addressed the concerns of some of the early literature that occasionally reported gross rather than net economic impacts in their reports. RIMS II™ and IMPLAN™ estimates developed for another effort were incorporated as draft/proxy values in this ESA NEB 2.0 model for illustrative purposes. Full-scale projects to develop economic NEBs at the state or utility level are recommended as improvements to the NEB 2.0 placeholder values. This finding results in Recommendation 6.

[68] See IEA, 2014, 2018

[69] Emissions impacts have been measured three main ways using simple (using system average emissions), complex (load dispatch), or using intermediate approaches (variations of peak versus off-peak generation fuel mixes), with strong results. The US EPA recently developed the COBRA model to routinize these estimates of emissions from generation fuel mix for each area of the country and takes the next step: applying health damage factors from well-vetted literature to provide a user-friendly source for death and illnesses associated with emissions reductions from program kilowatt-hour savings. Full-scale projects to develop emissions NEBs at the state or utility level would also be helpful in improving the NEB 2.0 placeholder values

[70] For example, net job creation from weatherization programs is much higher than from appliance replacement programs and figures are higher in areas that make insulation, etc.

- **Recommendation 6 - Estimate California economic multipliers by subarea to improve the model and better reflect differences in NEBs between utilities**: California IOU territories are large and differ substantially in industry mix. Although statewide economic effects were estimated for this project,[71] regional modeling would better reflect the program's effects for each IOU.

Finding 7: Limited information exists on the influence that climate zone, demographics, housing type, geography, fuel type, and other factors have on NEB values; this literature was discussed elsewhere in the report. However, the indicative research available identifies climate zone, demographics, geography, and fuel type as potentially having significant influence on NEB values. Ignoring the role of influencing factors and using average NEBs may bias the estimates. Additional research is needed, and a recommendation to address these omitted factors is included as Recommendation 7.

- **Recommendation 7 - Research climate zone measure variations to support model improvements**: Conduct a detailed review of the Database of Energy Efficiency Resources (DEER) to examine the high and low values for energy savings for program measures based on climate zone and incorporate differential savings for the four IOUs.

Finding 8: The NEB 2.0 model uses an end-use / measure grouping system to help organize the changing list of measures into categories that allow NEBs to be allocated to measures. That list is reasonably well-suited to the categories of measures included in programs now, and the near future. However, the measures included in weatherization programs continually evolves, and the IOUs will also enhance the program's offering to meet goals. For the model to be able to keep up with new measures, research is needed on measure directions and their end-use categories, as well as the allocation linkages for NEBs to these new measures. This leads to Recommendation 8.

- **Recommendation 8 - Research potential new end uses to support the model and update measure attribution methodology:** Conduct a market study to identify likely new measures, but especially new end uses that may be considered for the ESA program in the future. The project may involve expert interviews, Delphi approaches, or other market intelligence work. Use the results to refine the model's drop-down menus used for new measures and to allocate the NEBs to those measures.

Finding 9: The study inventoried and reviewed a wide variety of NEBs and assessed them on topics related to relationship to measures in the program, calculability, and quality of the literature. It did not assess or prioritize the NEBs based on the basis of specific dockets, policy documents, or goals for the ESA program. NEBs like hardship, which is often mentioned in association with low income programs, may be a very high priority for ESA. If true, that would indicate focused research would be needed on

[71] Skumatz Economic Research Associates, Inc. (SERA) used the Regional Input-Output Modeling System (RIMS II™) using 2016 data to conduct this statewide analysis.

hardship and other (so-far-omitted) NEBs.[72] Clarifying the goals for the ESA program and conducting follow-up work to move forward on priority NEBs is addressed in Recommendation 9.

- **Recommendation 9 - Review policy and dockets to inform which NEBs are priorities:** Conduct a review of California filings and dockets to identify and confirm policy goals that can be reflected by NEBs and develop NEB calculations for any new NEBs identified.

[72] *For instance, research in the dockets may help inform the appropriate definition (and therefore, derivation) of hardship. There are two interpretations of hardship included in the literature: purely financial hardship and hardship that also incorporates quality of life concepts.*

5.0 Bibliography

Apprise, (2018), *Connecticut Non-Energy Impacts Literature Review: R1709*, prepared for the Connecticut Energy Efficiency Board, December.

Apprise, (2018), *Non-Energy Benefits of WAP Estimated with the Client Longitudinal Survey*, Final Report. National Weatherization Assistance Program Evaluation. Results Report January 2018.

Breysse, PN. et al. (2010), "Indoor Air Pollution and Asthma in Children." Proceedings of the American Thoracic Society, May 2010.

CDPH, (2016), *Radon in California.* Special Report by County from the CA Department of Public Health at https://www.cdph.ca.gov/Programs/CEH/DRSEM/Pages/EMB/Radon/Radon-in-California.aspx

Cluett, Rachel, and Jennifer Amann, (2015), *Multiple Benefits of Multifamily Energy Efficiency for Cost-Effectiveness Screening*, ACEEE Report A1502.

Colton, Rodger D., (1996). "The Road Oft Taken: Unaffordable Home Energy Bills, Forced Mobility And Childhood Education in Missouri." *Journal on Children and Poverty*. September 1996.

Drehobl & Ross, (2016), "Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low Income and Underserved Communities," 2016, ACEEE, Energy Efficiency For All.

ESA (2017), "Energy Savings Assistance Program Health Comfort Safety Evaluation," December 2017. https://pda.energydataweb.com/#!/?q=esa%20health%20comfort%20safety%20evaluation

Fabien, et al., (2016), "Modeling Environmental Tobacco Smoke (ETS) Infiltration in Low-Income Multifamily Housing before and after Building Energy Retrofits." *International Journal of Environmental Research and Public Health,* 13 (3): 327. doi:10.3390/ijerph13030327. http://dx.doi.org/10.3390/ijerph13030327.

Foxman, et al., (2015), "Respiratory and Allergic Health Effects of Dampness, Mold, and Dampness-Related Agents: A Review of the Epidemiologic Evidence" Proceedings of the National Academy of Sciences of the United States of America

Fuchs, Leah, Lisa Skumatz and Jennifer Ellefsen, (2004), "Non-Energy Benefits (NEBs) from Energy Star™: Comprehensive Analysis of Appliances, Outreach, and Homes Programs", Proceedings of the ACEEE Summer Study in Buildings, Asilomar, CA.

Hawkins, Beth et al., (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., 2016

Horii, Brian, Eric Cutter, and Zach Ming, (2018), "Avoided Costs 2018 Update," Energy and Environmental Economics, Inc., May 24, 2018.

International Energy Agency (IEA), (2014), "Capturing the Multiple Benefits of Energy Efficiency," International Energy Agency (IEA), 2014;

International Energy Agency (IEA), (2018), "IEA workshop emphasizes the "multiple benefits" of energy efficiency," 2018, https://www.iea.org/newsroom/news/2018/march/iea-workshop-emphasizes-the-multiple-benefits-of-energy-efficiency.html

Itron, (2014), "Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs," for the State of Maryland, Aug 2014

Magouirk, Jeffrey K., (1995), "Evaluation of Non-Energy Benefits from the Energy Savings Partners Program," Proceedings of the 1995 Energy Evaluation Conference, Chicago, IL, 1995.

McKernana, et al., (2016), "Thriving Residents, Thriving Cities: Family Financial Security Matters for Cities", Urban Institute, April/

Mendell, et al., (2011), "Respiratory and Allergic Health Effects of Dampness, Mold, and Dampness-Related Agents: A Review of the Epidemiologic Evidence." June 2011

Myers, Jody, and Skumatz, Lisa. (2006), "Evaluating Attribution, Causality, NEBs, and Cost Effectiveness in Multifamily Programs: Enhanced Techniques." Proceeding from 2006 ACEEE Summer Study on Energy Efficiency in Buildings. https://aceee.org/files/proceedings/2006/data/papers/SS06_Panel2_Paper19.pdf

National Energy Assistance Directors' Association (NEADA), (2018), *2018 National Energy Assistance Survey Final Report*, December

National Efficiency Screening Project (NESP), (2017), "National Standard Practice Manual: For Assessing Cost-Effectiveness of Energy Efficiency Resources," Spring 2017.

Navigant (2014), "Water/Energy Cost-Effectiveness Analysis", Revised Final Report Prepared for: California Public Utilities Commission. *www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5356*

Northeast Energy Efficiency Partnership (NEEP), (2017), "Non-Energy Impacts Approaches and Values: An Examination of the Northeast and Mid-Atlantic," June.

NMR Group, (2011), *Massachusetts Special and Cross-Sector Studies Area, Residential, and Low Income Non-Energy Impacts (NEI) Evaluation*, http://www.rieermc.ri.gov/documents/evaluationstudies/2011/Tetra_Tech_and_NMR_2011_MA_Res_and_LI_NEI_Evaluation%2876%29.pdf

Oppenheim, Jerrold, and MacGregor, Theo, (2002), *The Economics of Low-Income Electricity Efficiency Investment in Arkansas*, Prepared for Entergy Corp. February 2002.

ORNL, Tonn et al., (2014), "Weatherization Works - Summary of Findings from the Retrospective Evaluation of the U.S. Department of Energy's Weatherization Assistance Program," Reference ORNL/TM-2014/338

SDG&E (2018), "San Diego Gas & Electric Company Request For Proposal For Non-Energy Study," SDG&E Sempra Energy Utility, March 23.

Shaman, et al., (2010), "Absolute Humidity and the Seasonal Onset of Influenza in the Continental United States." PLOS Biology

Shields, Wendy C., et al., (2013), "Still Too Hot: Examination of Water Temperature and Water Heater Characteristics 24 Years After Manufacturers Adopt Voluntary Temperature Setting." *Journal of Burn Care & Research*, Volume 34, Issue 2, March-April 2013, Pages 281–287,

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

Skumatz, Lisa A., PhD and Chris Ann Dickerson. (1997), "Recognizing All Program Benefits: Estimating the Non-Energy Benefits of PG&E's Venture Partner Pilot Program (VPP)," 1997 Energy Evaluation Conference Proceedings, Chicago, Ill.,

Skumatz, Lisa A., PhD, and Chris Ann Dickerson, (1999), "What Do Customers Value? What Benefits Utilities? Designing to Maximize Non-Energy Benefits from Efficiency Programs in the Residential Sector," 1999 Energy Evaluation Conference, Denver, August

Skumatz, Lisa. and John Gardner, (2002a). "Comparing Participant Valuation Results using Three Advanced Survey Measurement Techniques: New Non-Energy Benefits Computations of Participant Value," Proceedings of the ACEEE Summer Study on Building Conference, Asilomar, CA.

Skumatz, L., and Nordeen, T., (2002b), *Connecticut WRAP Program Non-Energy Benefits, Revised Report,* Northeast Utilities Service Company

Skumatz, Lisa, and Nordeen, Trevor, (2002c), *Massachusetts ESP Program Non-Energy Benefits*, Revised Report. Submitted to Northeast Utilities Service Company. March 2002.

Skumatz, L., Gardner, J., Schauer, L., and Rathbun, P. (2005), *Low-Income Public Benefits Evaluation: The Non-Energy Benefits of Wisconsin's Low-Income Weatherization Assistance Program: Revised Report*, State of Wisconsin Department of Administration Division of Energy

Skumatz, Lisa, and Gardner, John (2006), "Differences in the Valuation of NEBs According to Measurement Methodology: Causes and Consequences," Proceedings of the 2006 AESP Conference, Clearwater Beach FL.

Skumatz, Lisa and Khawaja, Sami (2009), "Lessons Learned and Next Steps in Energy Efficiency Measurement and Attribution: Energy Savings, Net to Gross, Non-Energy Benefits, and Persistence of Energy Efficiency Behavior." For the California Institute for Energy and Environment Behavior and Energy Program. https://uc-ciee.org/downloads/EEM_A.pdf

Skumatz, L., Khawaja, M.S., and Krop, R., (2010a), *Non-Energy Benefits: Status, Findings, Next Steps, and Implications for Low Income Program Analyses in California*, Prepared for Sempra Utilities. Revised Report May 2010.

Skumatz, Lisa A., Sami Khawaja, (2010b), (SERA), *Non-Energy Benefits: Status, Findings, Next Steps, and Implications for Low Income Program Analyses in California*, Prepared for SDG&E, Skumatz Economic Research Associates, May 2010. Available at: http://liob.cpuc.ca.gov/docs/Non%20Energy%20Benefits%20Study%20-%20SERA%20Inc%20%202010.pdf

Skumatz, Lisa A., Ph.D., (2010c), *Non-Energy Benefits Analysis for Xcel Energy's Low-Income Energy Efficiency Programs*, May.

Skumatz, Lisa, (2014). *Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and Their Role & Values in Cost-Effectiveness Tests: State of Maryland*. Prepared for NRDC. http://www.energyefficiencyforall.org/sites/default/files/2014_%20NEBs%20report%20for%20Maryland.pdf

Skumatz, Lisa. (2015), "Considering the Inclusion of NEBs in IL TRM for Single and Multi-family Whole Building Retrofit Programs: The Issue of Measure-Based NEBs," Working Paper for NRDC, Illinois. http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Sources/IL_NEBs_estimates_measures_Skumatz_for_NRDC_2015-08-03_Final.pdf

Skumatz, L., M. Santulli, and D. D'Souza. (2019), "Meta Results in NEBs / NEIs – Progress in NEB Values, Attribution to Measures, and State Adoption into Cost-Effectiveness Tests", Proceedings from 2019 ECEEE Conference, France.

Smith-McClain, Lisa, Lisa Skumatz, and John Gardner, (2006), "Attributing NEB Values to Specific Measures: Decomposition Results from Programs with Multiple Measures," Proceedings of the ACEEE Summer Study on Building Conference, Asilomar, CA.

Summit Blue, Skumatz Economic Research Associates, Apex, (2005), *New York Energy $mart^{SM} Program Evaluation and Status Report*. Final Report Prepared for NYSERDA, Systems Benefits Charge Advisory Group, May 2005.

Summit Blue Consulting and Quantec. (2006), *Non-Energy Impacts (NEI) and Evaluation*. Prepared for New York State Energy Research and Development Authority, Project Number 7721

TechMarketWorks, Skumatz Economic Research Associates, and Lori Megdal, (2001), *Low Income Public Purpose Test (LIPPT) Report*, Prepared for RRM Working Group Cost Effectiveness Committee, San Francisco, CA

US EPA, (2011), *Assessing the Multiple Benefits of Clean Energy: A Resource for the States*, US Environmental Protection Agency, Washington, DC.