DNV

FINAL REPORT

Non-energy Impacts

Avista

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1 INTRODUCTION

DNV's Non-energy Impact (NEI) Database (the "Database") allows DNV to map published NEI values to Avista's Technical Reference Manual (TRM). The values produced are adjusted to account for differences in economic and programmatic conditions. The overall goal of this NEI research is to develop the most comprehensive set of NEI values possible based on published research and to identify gaps where additional research is necessary to quantify the value of occurring NEIs. The results can be used to report, evaluate, and market energy efficiency programs across Avista's Residential and Commercial and Industrial (C&I) sectors.

The overall process for estimating the NEIs is broken down into seven tasks:

Task 1: Map Avista measures to DNV's NEI Database

Task 2: Assign confidence factors

Task 3: Assign plausibility factors

Task 4: Estimate economic adjustment factors

Task 5: Adjust Database values to calculate utility specific NEIs

Task 6: Choose the best value for each NEI/measure combination

Task 7: Gap analysis

This report is constructed from the individual memos provided throughout the duration of this project and provides the necessary documentation to establish the final NEI values as viable impacts results from the installation of energy efficiency measures.

2 OVERVIEW OF APPROACH

The Database approach identifies NEIs from the existing literature and assigns those NEIs to relevant Avista programs and measures. DNV's NEI Database contains 50 separate residential and C&I NEIs from 46 publicly available studies. After assigning the NEI to Avista programs and measures, we adjust the estimates based on plausibility, confidence, and economic adjustment factors. The adjustments improve transferability of the research to Avista territory. They also adjust the NEI values to account for uncertainty stemming from extremely high or low values, the quality of the methods used in the original study, the age of the original study, and differences in economic conditions between the area covered by the original study and Avista service territory.

The NEI Database approach consists of the following 7 tasks:

Task 1. Map Avista measures to DNV's NEI Database - NEI studies can vary considerably in how they aggregate information when reporting a quantified NEI value. The goal in this step is to standardize the Avista measure descriptions into the same taxonomy as we have assigned to the measures from all of the studies in the Database. We then use those standardized descriptions to match the Avista measures to those in the Database.

Task 2. Assign confidence factors - DNV assigns a Confidence Factor (CF) to each study to reflect how well the study follows research best practices. The CF is used to discount the NEI values matched to Avista's measures to provide a conservative estimate of NEI values in our Database. Furthermore, the studies and measures in the Database are sorted from highest confidence to low confidence, so that the matching look-up value select the higher confidence values first.

Task 3. Assign plausibility factors - DNV developed a Plausibility Factor (PF) for each study to further account for nuances in NEI research outside of the actual study methodology. The PF is also used in conjunction with the CF for discounting NEI values and for identifying best-fit values in the event of multiple measure-by-NEI matches.

Task 4. Estimate economic adjustment factors - DNV uses publicly available data to develop factors that adjust NEI's based on the economic activity of the original jurisdictions to Avista's service territory.

Task 5. Adjust Database values to calculate utility-specific NEIs – All NEIs from the Database that match Avista measures are scored according to the combined Confidence and Plausibility scores, creating the "combined score." This combined score, along with the economic adjustment factor, are applied to the study NEI value to make it utility-specific (or more specific, where possible) as well as to discount the value based on how applicable it is. This process is reflected in the following equation:

Equation 1: Discount and geographically adjust NEI value

$$Utility - specific\ NEI = Study\ NEI\ Value * Combined\ Score * Economic\ Adjustment\ Factor$$

Task 6. Choose the best value for each NEI/measure combination – The automated Database process can produce multiple matches between the published NEI values and the Avista TRM. A multi-level ranking approach identifies the best fit for each NEI-by-measure combination. When there are multiple options for a top value, the most conservative estimate is flagged and the DNV NEI team reviews all potential matches to identify the best fit. The results produce a single matched value as the final recommended NEI for each measure-by-NEI combination.

Task 7. Gap analysis – DNV identifies areas in which follow-up research is necessary to confirm or quantify NEIs occurring within Avista territory. This process involves:

a. Conducting a gap analysis to identify Avista measures lacking NEIs; and,

b. Developing and applying a framework to prioritize future research.

3 DETAILED MEASURE MAPPING METHODOLOGY

This section describes how DNV mapped each measure in Avista's data to DNV's Database.

3.1 Conduct Jurisdictional Scan of Existing NEI Studies

The Database contains 46 different NEI studies as part of the NEI database, including studies from literature reviews from Ohio and Ontario and those referenced by the Massachusetts NEI Framework project. We start the process with a jurisdictional scan (JS) to determine the following information from each available NEI study:

- Categories of NEIs
- Quantified NEI values and their units
- Level of aggregation, specifically whether the NEI was identified by sector, program, end-uses, or detailed measures
- Rigor and methodology used to calculate NEIs
- Plausibility of applying the study to other programs
- Economic factors related to the original jurisdiction for each study

Thus, the JS provides the foundation for gathering inputs not only for identifying NEI values, but also the inputs needed to adjust those values based on our various adjustment factors.

3.2 Mapping NEI measures in the Database

DNV standardizes the names of NEIs reported by each of the 46 JS studies. For example, many NEIs are similar in nature but were described differently (e.g., "Avoided Operation and Maintenance" vs "O&M avoided"). DNV also created a list of standard NEI names that we assigned to the observed NEIs identified across all the studies in the JS. We create a "crosswalk" that maps the unique NEI names from the original studies to our standardized names.

NEI studies can vary considerably in how they aggregate information when reporting a quantified NEI value. Some studies may report NEI results for specific segment-program-measure level descriptions, such as "C&I-small business retrofit-4-ft linear LED lamp. Other studies may only report NEIs for C&I lighting retrofits, while some may simply report the NEIs that are associated with a prescriptive C&I program.

NEIs can also vary by the fuel-type that was examined as part of the study, such as electricity, natural gas, or kerosene. For example, an NEI study conducted for an electric-only utility might provide different values for insulation measures than one conducted for a gas and electric utility. In addition, the units in which the NEI are reported can be fuel-specific, such as $/kWh or $/therm.

DNV refers to the combination of the following classes of fuel saved, program participant populations, programs, and measure descriptions as the "level of aggregation" (LoA). Below is a list of the seven LoAs we classified for use in this study:

1. **Fuel (Level 0):** Identifies the fuel studied in the JS report (electricity, gas, or both).
2. **Sector (Level 1)**: Identifies the population being served by the program (C&I or Residential).
3. **Program Level (Level 2)**: Designates the class of program within the sector (Low Income, New Construction, Retrofit).
4. **Prescriptive/Custom (Level 3)**: Separates programs into Prescriptive or Custom.
5. **End-use Level (Level 4)**: High-level description of end-use systems modified through a program type.
6. **Broad Measure Level (Level 5)**: High-level description of measure within an end-use (e.g., LED Lighting)
7. **Detailed Measure Level (Level 6)**: Detailed-level description of measure within an end-use (e.g., Linear LED)

We standardized and assign the LoAs to each measure in the 46 studies contained in the Database.

3.3 Mapping Avista measures to the Database

DNV then standardizes and assigns the same LoAs listed above to each of Avista's measures. All the studies in the JS had an original (observed) LoA, but they varied in terminology from study to study. As such, DNV reviewed the Avista TRM to identify the observed LoA in Avista's programs and measures. The result was a list of fuels, sectors, programs, sub-programs, end-uses and measures in TRM, which we refer to as the **Avista TRM.**

DNV reviewed all original LoA across the JS and the Avista TRM to assign a standard set of naming conventions. During the LoA assignment process, DNV analyzed Avista's tracking data to identify the programs in which each measure was installed. In cases where a certain measure in Avista's TRM was installed across different program types (e.g., Custom HVAC measure being installed in a New Construction and Retrofit program), DNV created duplicate rows in the TRM and delineated between the two by adding a program type to column H of the 'NEI Breakout' worksheet in the attached results workbook.

3.3.1 Match JS to Avista TRM

In the subsequent stages of this project, DNV will map the JS measures to the Avista TRM using the standard set of Level 0 through Level 6 match codes. The match codes are assigned to the Avista TRM using the same match code dictionary used in the JS. Table 1 below illustrates how a Linear LED measure in the JS is broken out into the LoA.

Table 1. Example of Standard Level of Aggregation details for one measure in the Avista TRM

Standard Levels of Aggregation	Example of Standard Levels of Aggregation Details
Detailed Measure Level (Level 6)	Linear LED
Broad Measure Level (Level 5)	LED
End-Use Level (Level 4)	Lighting
Prescriptive/Custom (Level 3)	Prescriptive
Program Level (Level 2)	Retrofit
Sector (Level 1)	C&I
Fuel (Level 0)	Electricity
Standard NEI Category Example	O&M-Participant-C&I

Table 2 illustrates how these Standard LoA and the Standard NEI Categories come together to form the matching IDs.

Table 2. Example of Concatenated Matching IDs

Match Level ID	Concatenated Matching ID
6	Electricity_C&I_Retrofit_Prescriptive_Lighting _LED _Linear LED
5	Electricity_C&I_Retrofit_Prescriptive_Lighting _LED
4	Electricity_C&I_Retrofit_Prescriptive_Lighting
3	Electricity_C&I_Retrofit_Prescriptive
2	Electricity_C&I_Retrofit

A match occurs when the concatenated match codes exist in both the Avista TRM and in one or more studies in the JS. All potential matches are created using mutual exclusivity.

First, all matches are identified that happen at a Level 6. Next, all matches are identified that happen at a Level 5, but which did not happen at a Level 6. This process is done all the way through Level 2, and then a match level is assigned, and all potential matches are preserved. Lastly, the top values are chosen by ranking the potential matches from most specific (i.e., Level 6) to least specific (i.e., Level 2).

The following is an outline of how the six levels of matching are used to generate a list of results utilizing the above Avista lighting measure in Tables 1 and 2 as an example. Initially, a lookup of the Level 6 ID in Table 2 is performed in the JS to check for any exact matches. A current look in the JS shows that there are no exact matches at a Level 6, so the code then checks for any matches using the Level 5 ID. The JS does not contain any matches at a Level 5 either, so the next step is to check for any matches using the Level 4 ID. This time the output shows 7 matches spanning 4 different studies at a Level 4. This process continues using the Level 3 and 2 IDs until a list of all potential matches are generated.

4 DETAILED CONFIDENCE FACTOR METHDOLOGY

This section describes how DNV assigns the Confidence Factor to each study in the Database.

4.1 Develop the Confidence Factor

At times, the Avista TRM matched to more than one study in the Database. DNV's Confidence Factor (CF) informs the selection of one study's NEI over another. DNV considers six different questions that relate to best practices in NEI research to develop each CF. Each question has a set of fixed responses, outlined in Table 3.

Each question is also assigned a weight based on significance. These weights can be adjusted and used to reflect whether one or more questions are determined to be more important than others in determining which study to use.

4.1.1 Confidence Factor Scoring Inputs

To assign a CF to each of the studies in the Database, DNV examined each report in the context of the following questions. Table 3 presents the possible responses to each of the confidence factor criteria, and their associated scores in parentheses.

Table 3. Questions used to Calculate Confidence Factor Score, and the Reasons for Each Question

Question	Possible Responses (scores)	Intention of question
1. Is the study measure specific?	a. Measures have specific NEIs associated with them (3) b. Measures are identified by the study, but in aggregate (2) c. Measures are not reported at all (1)	Studies providing values tied to specific measure groups are more robust than those that provide combined NEIs across multiple measures or do not distinguish which measures are included in the sample.
2. Is the study segmented by sector?	a. Study identified NEIs related to sample segments (3) b. Study identifies sample segments used to design sample frame, but NEIs are not specific to segments (2) c. Sample not segmented at all (1)	The impact of measures on participants varies by participant characteristics such as income level and industry. Studies that account for these differences are regarded as providing greater precision in results than those that do not.
3. Was the sample drawn using a statistical method?	a. Study reports statistically significant sample results with precision levels (3) b. Study uses statistical sampling, but results are not always statistically significant (2) c. Does not use statistical sampling (1)	Statistical sampling accounts for key differences in respondents and/or measures that create variance in NEI estimates. NEI studies that use stratified sampling and provide statistically significant results are regarded as superior to those that do not.
4. Does the study incorporate identifiable economic factors?	a. Approach clearly isolates/identifies relevant economic factors (3)	NEIs result from changes to either consumer or producer surplus. As such, they should relate to some aspect of the household or firm decision-making

	b. They used some economic factors based on theory, although not clearly identified in study (e.g., property values) (2) c. Economic factors are not identified, and cannot be inferred (1)	process such as improved costs, revenues, living conditions, etc. Studies that isolate NEIs that tie to identifiable economic factors provide greater confidence than those that are less specific about the factors that justify NEIs.
5. Does the study consider any of the following when appropriate: Open-ended questions, Additivity, Double Counting	a. Accounts for Open-ended questions, Additivity, and Double Counting (3) b. Accounts for two out of the three factors (2) c. Accounts for only one of the factors (1) d. No evidence to suggest any of the factors were accounted for (0)	Best practices in NEI research document the need for studies to tie NEI estimates to known factors (such as utility bills) or derive estimates from factors that are known, such as hours to do a task and wages. Research also clearly documents the need to account for non-additivity of multiple NEIs. Finally, more rigorous studies take steps to ensure that NEIs are distinct across NEI categories.

4.1.2 Confidence Factor Scoring

DNV applied the rating system presented in Table 3 to construct the confidence factor for each study as follows:

- DNV recorded the numeric score (0-3) for each of the five questions for each study.
- A weighted score was calculated by multiplying the numeric score for each question by the question's weight. In the calculation, each of the five questions was given an equal weight; however, the weights can be adjusted in the final Database.

Equation 2: Confidence Factor Score Calculation Using Weights

$$Confidence\ Factor\ Score = \frac{(Q1\ Score * Q1\ Weight) + (Q2\ Score * Q2\ Weight) + (Q3\ Score * Q3\ Weight) + (Q4\ Score * Q4\ Weight) + (Q5\ Score * Q5\ Weight)}{Max\ Total\ Score}$$

- An example of how the weights are applied for two of the studies is shown in Table 4. If the question weights ("Q Weight") are adjusted, then the max score will also adjust:

Table 4. Example Confidence Factor Calculation

Study_ID	Q1 Score	Q2 Score	Q3 Score	Q4 Score	Q5 Score	Weighted Total Score	CF (Percent of Max)
Q Weight (0-1)	**1**	**1**	**1**	**1**	**1**	**Max = 15 Min = 5**	**CF Max = 100% CF Min = 50%***
Study0001	3	3	3	3	3	15	100%
Study0002	2	3	3	3	3	14	93%

*DNV sets of CF floor of 50%

- The weighted scores were summed to create an aggregate score for each study. The maximum possible weighted score was 15, while the lowest score was five.
- The weighted CF was calculated by dividing the aggregate score by the maximum possible score of 15. Studies with higher CFs typically contain more granular measure details and have more identifiable economic factors.

- The DNV method includes a CF “floor” of 50%, meaning no CF will drop below 50%, regardless of the answers to the five scoring questions. The DNV NEI team believes that NEIs should not be discounted to zero, but some discounting is appropriate. DNV reasoned that reducing NEIs from studies with a low confidence factor by 50% allows some value of NEI to be recognized, while still reducing the value to reflect our lack of confidence in the estimate.

Table 25 and Appendix B: Confidence Factor Scoring contain a table that shows the CF scores and adjusted CF for each study in the Database.

5 DETAILED PLAUSIBILITY FACTOR METHODOLOGY

DNV developed a Plausibility Factor (PF) to further account for nuances in NEI research outside of the actual study methodology. The Plausibility Factor (PF) considers three variables:

1. Level of matching (Level 6, Level 5, etc.) represents how specifically the measures in the study match to Avista's measures
2. Age of the study
3. Changes in energy consumption within an end-use category over time

These inputs account for factors that impact NEI values that are not included in the CF, since the factors depend on data outside of the study. Similar to the CF inputs, each of these three inputs can receive a different weight to reflect greater or lesser relative importance. By default, DNV set all weights to 1 to represent equal importance for each factor. DNV calculated a PF score from 0% to 100%, with the higher the score representing a higher level of plausibility.

5.1.1 Plausibility Factor Scoring Inputs

5.1.1.1 Level of Matching

We used the level of matching discussed in Section 3.2 to provide the first input to the PF. Higher level matches indicated that the study from the Database closely represented the measure in the Avista TRM, and therefore received a higher score. Table 5 shows how the matching level translated into a PF input for matching. DNV's calculation does not typically result in the use of a prior studies with a level of match of 3 or lower. The level of match is typically 4 or greater for all NEI estimates used in the final calculations.

Table 5. Level of Matching Scoring Table

Match Level	Match Level Description	Example	Score
Level 6 Match	Detailed Measure	Air Source Heat Pump	6
Level 5 Match	Broad Measure	Heat Pump	5
Level 4 Match	End-Use	HVAC	4
Level 3 Match	Prescriptive/Custom	Prescriptive	3
Level 2 Match	Program	Retrofit	2

5.1.1.2 Age of the Study

Existing studies are affected by the economic, programmatic, demographic, and other factors relevant at the time those studies took place. As the studies age, these factors can shift, which decrease the relevance of the study to current programs and measures. For example, the Great Recession affected programs running in the 2009-2015 time period. Also, NEI research has evolved substantially over the last several years (Skumatz, 2016). This adjustment factor is designed to represent this potential decrease in relevance and discount NEI values based on it. DNV grouped the studies into the categories shown in Table 6, assigning higher scores for more recently published studies.

Table 6. Age of Study Scoring Table

Age of Study	Score
Five years or less	4

Six to ten years	3
11-15 years	2
Greater than 15	1

5.1.2 Change in End-Use Unit Energy Consumption

The third aspect of the PF calculation accounts for technological change in measure energy consumption over time. DNV assumed that if a study from the Database analyzed an end-use that has had a large change in energy consumption over the last several years, then the age of the study, in combination with the end-use category, provides important insight into whether the study's NEI results should be further discounted. For example, a study published prior to 2013 (with energy efficiency data from 2012 or older) that analyzed lighting NEIs would almost certainly have little coverage of LEDs in the measure-mix of the study. Therefore, the NEIs in that study related to lighting measures should be discounted to account for the large change in lighting energy consumption.

To calculate this value, DNV reviewed historical end-use energy consumption from the 2003 and 2012 Commercial Building End-Use Survey (CBECS) and the 2009 and 2015 Residential End-Use Consumption Survey (RECS) published by the Energy Information Administration.[1] CBECS and RECS provide tables reporting the unit energy consumption (UEC) of end-use technologies over time. DNV used the UEC/sq ft and UEC/household reported in CBECs and RECS, respectively, to measure change in energy consumption in each end use category over time. By calculating the Compound Annual Growth Rate (CAGR) between the earlier study and later study, DNV assumed that constant energy consumption over time for a specific end-use (indicated by a low CAGR %) showed that a study of that end-use would still be reliable today.

Appendix C: Plausibility Scoring Metrics contains tables that show the scoring inputs by the different CAGR categories and UEC numbers by end-use categories in CBECS and RECS.

5.1.3 Plausibility Factor Scoring

DNV constructed the plausibility factor for each study, end-use, and matching level combination as follows:

- DNV recorded the numeric score for each of the three factors.
- DNV assigned a weight to each score. By default, the weights are all set to 1.
- The weighted scores were summed to create an aggregate score for each study, end-use, and matching level combination.

Equation 3: Plausibility Factor Score Calculation Using Weights

$$Plausibility\ Factor\ Score = \frac{\begin{array}{c}(Age\ of\ Study\ Score * Age\ of\ Study\ Weight)\\ +(UEC\ Change\ Score * UEC\ Change\ Weight)\\ +(Match\ Level\ Score * Match\ Level\ Weight)\end{array}}{Max\ Total\ Score}$$

- A PF was calculated by dividing the aggregate score by the maximum possible score of 13. Studies with higher PFs are typically more recent.

[1] For further details on RECS, see: https://www.eia.gov/consumption/residential/data/2009/index.php?view=consumption
https://www.eia.gov/consumption/residential/data/2015/index.php?view=consumption

For further details on CBECS, see: https://www.eia.gov/consumption/commercial/archive/cbecs/cbecs2003/detailed_tables_2003/2003set19/2003html/e06a.html
https://www.eia.gov/consumption/commercial/data/2012/c&e/cfm/e6.cfm

- The DNV method includes an PF “floor” of 50%, meaning no PF will drop below 50%, regardless of the scores attached to the three factors.

The PF scores apply to a measure within a study. Table 7 shows examples of PF scores for different combinations of study age, UEC change score, and match level. Table 29 in Appendix D: Plausibility Combinations show all possible combinations of PF factors and the resulting adjusted PF score.

Table 7. Example of Plausibility Factor Scoring

Age of Study Score (A)	Unit Energy Consumption Change Score (B)	Matching Level Score (C)	Total Score (A+B+C)	% of Max Score (A+B+C)/13	Adjusted Plausibility Factor (No PF below Min PF)
4	3	6	13	100%	100%
3	3	6	12	92%	92%
4	3	4	11	85%	85%

6 DETAILED EXAMPLE OF COMBINED SCORE CALCULATION

Equation 4 below shows an example calculation of the CF score for NEI Framework Study Report (Study 04). This example uses Equation 2 referenced above and utilizes the CF question scoring for that Study 04 further detailed in Table 8. The calculation also assumes an equal weight of 1 for Q1-Q5.

Equation 4: Confidence Factor Calculation Example

$$Confidence\ Factor\ Score\ (Study0004) = \frac{(3*1)+(3*1)+(2*1)+(2*1)+(1*1)}{15} = \frac{11}{15} = 0.73$$

Table 8. Confidence Factor Scoring Examples – Study0004

Confidence Factor Question	Score	Rational
Q1 - Is the study measure specific?	3	The study reports NEI values for specific measures such as boilers, thermostats, and heat pumps.
Q2 - Is the study segmented by sector?	3	The sample design is segmented by sector (Residential, Low-income, and C&I) and initiatives (e.g. multifamily retrofit, home energy services, lighting, new construction). NEI results were linked to all sector initiatives.
Q3 - Was the sample drawn using statistical method?	2	The study used statistical sampling, but some results regarding electric hot water measures were not statistically significant.
Q4 - Does the study incorporate identifiable economic factors?	2	The study identified several property value NEIs based on the Hedonic Price theory.
Q5 - Does the study not consider any of the following when appropriate: Open-ended questions, Additivity, Double Counting	1	This study cites coordination across its approach in order to avoid double counting across both residential and C&I sectors. This study aimed to eliminate possible double counting by recommending that Program Administrators do not count existing property value NEIs for measures with property value and other NEIs. The report did a review of TecMarket Works (2007) study which included open-ended questions, but there was no evidence in the report to suggest they accounted for this or additivity.

Equation 5 below shows an example calculation of the PF score for Study0004. It is based on Equation 3 referenced above. The study was published in 2018 and therefore gets an Age of Study Score of 4. The UEC and Match level scores depend on the measure being matches to the measures in the original study. For the purposes of this example, the calculation will assume a Level 5 match to an HVAC measure. Because the measure falls under HVAC end-use, the UEC score is 3. The Match Level score is 5 due to it being a level 5 match. An equal weight of 1 is used for each factor. The Max Total Score possible for the PF is 13.

Equation 5: Plausibility Factor Calculation Example

$$Plausibility\ Factor\ Score\ (Study0004) = \frac{(4*1)+(3*1)+(5*1)}{13} = \frac{12}{13} = 0.92$$

If either the CF or the PF were less than 0.5, we would adjust them to 0.5 at this point before multiplying them together. As both are above 0.5, no minimum adjustment is needed.

The Combined Score is the product of the CF and PF and is the factor by which the Study NEI value is discounted prior to any economic adjustments.

Equation 6: Combined Score Calculation Example

$$Combined\ Score\ (Study0004) = CF * PF = 0.73 * 0.92 = 0.67$$

Therefore, the Study NEI value retains 67% of its original value prior to economic adjustments.

If both the CF and PF were set to the 0.5 individual value minimum, then the combined score would be 25%. Therefore, the maximum adjustment taken in the study is to discount an NEI to 25% of its original value.

7 ECONOMIC ADJUSTMENT METHDOLOGY

This section describes how DNV developed economic factors that adjust the Database NEIs to account for differences in economic activity between a study's original jurisdiction and Avista's service territory. DNV's Database already contains economic adjustment factors at the state level (e.g., Massachusetts versus Washington), so for Avista's analysis the focus was on developing intrastate economic adjustment factors that can be applied at the service-territory level.

7.1 Construct the Economic Adjustment Factors

During the NEI jurisdictional scan (JS) to develop the Database, DNV identified various economic factors on which NEIs from each study are based, either explicitly (stated in the study) or implicitly (assumed based on economic theory). DNV used publicly available data to develop factors that adjust the NEI based on the economic activity in the original jurisdiction to the intended jurisdiction.

DNV identified eight economic factors that can be used to adjust the NEIs. The factors are broken into Residential and C&I categories and include the following.

Residential economic adjustment factors:

- **Property Value –** Noise, visual, and air/temperature NEIs that are reflected in the differences in home values.
- **Income & Health Impacts (loss of income) –** Economic development NEIs related to income, as well as health NEIs related to longer life or missed days at work can be adjusted using differences in income.
- **Health Impacts (avoided costs) –** Health and safety NEIs related to avoided medical costs in hospitals. These NEIs are adjusted using the differential in medical costs between jurisdictions.
- **Age of Home –** Fire related NEIs using the differential in the age of homes between jurisdictions.
- **Utility Cost - Residential –** NEIs that result from changes to utility costs such as bad debt, arrearages, and hedging. These NEIs can be adjusted using the ratio of the average utility cost per MMBtu by sector (commercial, industrial, residential).

Commercial and Industrial economic adjustment factors:

- **Labor Costs (wage-based) –** Operations and maintenance (O&M) NEIs are largely a function of the time spent to maintain, repair, or replace equipment. These NEIs are adjusted using wage differentials in C&I settings.
- **Revenue & Productivity –** NEIs that change the profitability or operating costs for C&I customers other than what can directly be attributed to O&M. Comfort changes in C&I applications result in productivity NEIs. Changes may also affect the durability of a product or the amount of sales revenue. These NEIs can be adjusted using differentials in output or GDP.
- **Utility Cost - C&I –** NEIs that result from changes to utility costs such as bad debt, arrearages, and hedging. These NEIs can be adjusted using the ratio of the average utility cost per MMBtu by sector (commercial, industrial, residential).

The following sections discuss the economic adjustment factors:

- Section 7.1.2 discusses the values already contained in the Database and how to use them with newly developed, Avista values
- Section 7.1.3 presents the economic variables used for the adjustment factors
- Section 7.1.4 discusses economic adjustment factors for NEIs applicable to residential programs
- Section 7.1.5 discusses economic adjustment factors for NEIs applicable to C&I programs
- Section 7.1.6 discusses how these economic adjustments are applied to create NEI values representative of Avista's service territory
- Section 7.1.7 provides an example of economic adjustment for a residential NEI

7.1.2 Between State and Within State Adjustments

DNV developed adjustments to account for economic differences within the state of Washington. The JS already contains factors used for state-to-state comparison, so the updated factors address how Avista's service territory differs from that of Washington as a whole. The study uses the state-level adjustments to modify NEI values from their original jurisdiction, but it will now also include these service territory-level adjustments.

Most data used for the Avista adjustments are identified by county or area and not by specific utility service territory. Avista provided a geographic distribution of customers that DNV used to weight county-level economic data to a utility-level adjustment that could be compared with the state as a whole. These customer distributions were identified for each sector (Residential and C&I). With both the state and Avista adjustment factor representing relational qualities, the two can be multiplied together to form a single ratio for comparing Avista's service territory to that of the original study jurisdiction (See example in Section 7.1.7).

Equation 7: Relating Avista service territory to original state

$$\frac{Economic\ Adjustment_{WA}}{Economic\ Adjustment_{study\ state}} * \frac{Economic\ Adjustment_{Avista}}{Economic\ Adjustment_{WA}} = \frac{Economic\ Adjustment_{Avista}}{Economic\ Adjustment_{study\ state}}$$

7.1.3 Variables Used for Adjustment

Table 9 shows the variables, along with their description, year, and source, used to create the economic adjustment factors. These variables will be used in the formulas described in the subsequent sections. A more extensive bibliography can be found in Section 12.

Table 9. Variables with descriptions, years, and sources use to calibrate NEIs to a different state or region

Variable Name	Description	Year	Source
Median Home Value/Rent per Square Foot	The variable is equal to the median home value ($) divided by the square footage of the home. The value is the sum of the value per square foot of single-family attached houses, single-family detached houses, and mobile homes.	2018	Zillow, 2018
Square Foot	Total square footage of residency. These values are only available by the census regions[2] of (1) New England, (2) Middle Atlantic, (3) East North Central, (4) West North Central, (5) South Atlantic, (6) East South Central, (7) West South Central, (8) Mountain North, (9) Mountain South, and (10) Pacific. Individual states are imputed with the values from their region. Home types included in data: single-family attached houses, single-family detached houses, apartments in a building with 2 to 4 units, apartments in a building with 5 or more units, and mobile homes.	2015	EIA, 2018

[2] For more information about how states are divided into census regions, please visit https://www.eia.gov/consumption/residential/terminology.php

County Median Rental Price per Square Foot	This variable is equal to the median Zillow Rent Index over the course of a 12-month period. It includes all homes (own/rent/multifamily).	2017	Data World, 2020
Median Age of Structure	This variable is the median age of the structure from the ACS data. It is available at the state level and county level. State level adjustments use 2017 data, county level adjustments use the 2020 5-year detailed table.	2017/2019	US Census Bureau, 2018
Average Health Care Spending – State	Health care spending ($) in a state divided by the population of the state. This amount includes both public and private health care spending for goods and services. The health care spending does not include operation and maintenance costs, construction, or research and development.	2014	KFF, 2014
Average Health Care Spending - County	Standardized per capita medical costs using the Medicare fee-for-service population.	2018	Centers for Medicare & Medicaid Services, 2020
Median (household) Income by Age Group of Head of household	Median (household) income ($) from ACS data. These data are broken out by the householder age group or by education and are used to make the state adjustment.	2017	US Census Bureau, 2018
Median household income estimates	Income estimates for the counties of Washington based on census data.	2017	Washington Office of Financial Management, 2017
Age Bracket	Householder age groups: under 25 years old, 25 to 44 years, 45 to 64 years, and 65 years and over.	2017	US Census Bureau, 2018
Total Energy Price per Million Btu	The cost of total energy per million Btu in (USD). This accounts for primary energy (coal, natural gas, petroleum, biomass) and retail electricity.	2017	EIA, 2018
Retail Sales of Electricity to Ultimate Customers	Total revenue from sales of electricity broken out by sector (residential, commercial, industrial, transportation).	2019	EIA, 2020
Median Wage Dollar	Median hourly wage ($) by state.	2017	BLS, 2018
Add updated wage	Median hourly wage ($) by statistical area.	2019	BLS, 2020

GDP	Gross domestic product (GDP) is an economic measure for the value of output in a given area. The data are measured by 2-digit NAICS and by state.	2016	BEA, 2018
GDP - County	Updated GDP values for Washington counties segmented by 2-digit NAICS.	2019	BEA, 2020
Home Type	The classification of residential location: single-family attached house, single-family detached house, apartment in a building with 2 to 4 units, apartment in a building with 5 or more units, or mobile home.	2015	EIA, 2018

7.1.4 Residential Economic Adjustment Factor

This section covers the state and Avista economic factors used to adjust NEIs for residential programs. Residential adjustment factors are based on the economic principle of household utility maximization. These factors consider how the new technologies associated with energy programs affect a participant's economic wellbeing aside from the direct changes in energy consumption. Further detail explaining the economic theory behind residential economic factors can be found in Appendix E: Non-energy Impact Theory. Each factor discussed in Section 7.1.4.1 generates a single value for a geographic region. Section 7.1.6 describes how these geographic values are used in relation to one another.

7.1.4.1 Types of Residential Economic Adjustment Factors

Each adjustment factor will result in a single monomial represented by X_{Avista}, where "X" represents the specific economic adjustment being discussed. This holds for both the residential adjustment factors and the C&I adjustment factors in Section 7.1.5. Use of these monomials and interpretation will follow in Section 7.1.6 with an example in Section 7.1.7.

DNV created five general adjustment factors for NEIs associated with residential programs:

- Property value related adjustments
- Income and health impacts (loss of income) related adjustments
- Health impacts (avoided costs) related adjustments
- Age of home related adjustments
- Utility costs related adjustments

Property Value

State-to-State Adjustment

Most Residential NEIs impact a home's value; therefore, differences in property value serve as the key variable for adjusting most residential NEIs. These NEIs will include, but are not limited to: comfort, aesthetics, noise, and home durability and improvements.

DNV created a property value adjustment factor based on single family attached houses, detached houses, and mobile homes. The general formula consists of a factor that relates the home value to the building stock in the state, calculated for each state in the U.S.[3]

[3] Note to the reader: This equation takes a similar form for many of these NEI category calibrations. The values within the summation will end up as the sum of monomials by home type (and later by NAICS code or industry). The final output for X_{State} will be a single monomial specific to that state.

$$Property\ Value_{State} = \left[\sum \begin{pmatrix} Median\ Home \\ Value\ per \\ Square\ Foot \end{pmatrix} \times \begin{pmatrix} \%\ of\ Square\ Footage \\ within\ Each\ Home\ Type \end{pmatrix}_{\substack{Non-Apartment \\ Home\ Type}} \right]_{State}$$

Intrastate Adjustment

DNV then used median county rental price per square foot (Zillow Rent Index (ZRI) Summary, 2017) to develop the Avista property value adjustment. DNV used count of residential customers to weight the county level rental prices. Note that while the state-level adjustment used only non-apartment home types, the Avista adjustment used all home types, due to the data available.

$$Property\ Value_{Avista} = \left[\sum (Median\ Rental\ Price\ per\ ft^2 \times \%\ Customers)_{WA\ County} \right]_{Avista}$$

Income and Health Impacts (loss of income)

State-to-State Adjustment

This adjustment factor considers two different categories of NEIs, both adjustable by income: 1) NEIs associated with the income adjustment relate to economic development benefits, both direct and indirect, and 2) monetization of health impacts, or lost income experienced by participants due to the illness or death. Consequently, the economic adjustment factor for both categories is determined using a formula that relates the income in Avista to the income in the corresponding state from the JS. The general formula consists of a factor that accounts for the distribution of median household income by age of the head of household, calculated for each state in the U.S.

$$Income\ and\ Health\ Impacts_{State} = \left[\sum \begin{pmatrix} Median\ HH\ Income & \%\ of\ Head\ of \\ by\ Age\ Group\ of & \times\ HH\ Within\ Each \\ Head\ of\ HH & Age\ Bracket \end{pmatrix}_{\substack{Age \\ Bracket}} \right]_{State}$$

Intrastate Adjustment

The 2017 county household median income (Washington Office of Financial Management, 2017) was used for developing the Avista income and health impacts factor. DNV used count of residential customers to weight the county level income to a single Avista median income.

$$Income\ and\ Health\ Impacts_{Avista} = \left[\sum (Median\ Household\ Income \times \%\ Customers)_{\substack{WA \\ County}} \right]_{Avista}$$

Health Impacts (avoided costs)

State-to-State Adjustment

Other healthcare impacts are derived from the value associated with avoided healthcare costs. The monetization of these impacts is measured by the avoided costs associated with medical treatment. The formula consists of one factor that represents the average health care spending per resident. This factor is determined for both WA and the state from which the respective study in the JS was completed.

$$Health\ Impacts\ (avoided\ costs)_{State} = \ [Average\ Health\ Care\ Spending]_{State}$$

Intrastate Adjustment

Data used for state adjustments did not have information at the county level, so new data was identified for developing county-level factors for Washington health impacts (Medicare Geographic Variation, Public Use Files, 2018). DNV then used count of residential customers to weight the county level health costs to a single Avista health cost.

$$Health\ Impacts\ (avoided\ costs)_{Avista} = \left[\sum (Per\ Capita\ Health\ Spending \times \%\ Customers)_{WA\ County}\right]_{Avista}$$

Age of Home

State-to-State Adjustment

For NEIs related to fire damage, DNV investigated factors that are considered indicative of home fires. Of the available economic data, age of home (ACS 1 Year Detailed Tables State, 2017) was identified as the best variable corresponding with incidence of fires. Therefore, this economic adjustment factor will be used to relate the distribution of the age of a home in WA to the corresponding state from the JS. The formula consists of one factor that represents the median age of residential homes.

$$Age\ of\ Home_{State} = [Median\ Age\ of\ Home]_{State}$$

Intrastate Adjustment

To get Washington county median age of home, DNV used an updated census dataset segmented by county (ACS 5 Year Detailed Tables County, 2020). DNV then used count of residential customers to weight the county level health costs to a single Avista health cost.

$$Age\ of\ Home_{Avista} = \left[\sum (Median\ Age\ of\ Home \times \%\ Customers)_{WA\ County}\right]_{Avista}$$

Utility Cost – Residential

State-to-State Adjustment

The final residential NEI adjustment factor applies to utility NEIs, or NEIs that result from changes to utility costs. This adjustment factor can be applied to NEIs that include but are not limited to transmission and distribution savings, arrearages, and bad debt write-offs. These NEIs can be adjusted using the average utility cost per MMBtu in each state.

$$Residential\ Utility\ Costs_{State} = \frac{Total\ Residential\ Energy\ Revenue_{State}}{Total\ Residential\ Energy\ Usage\ MMBtu_{State}}$$

Intrastate Adjustment

For Avista, DNV used updated EIA information containing residential utility costs segmented by utility service territory (EIA Electricity Data, 2019). These data were then used to compare the revenue per residential energy consumption for Avista to the state total's revenue per residential customer.

$$Residential\ Utility\ Costs_{Avista} = \frac{Total\ Residential\ Energy\ Revenue_{Avista}}{Total\ Residential\ Energy\ Usage\ MMBtu_{Avista}}$$

7.1.5 C&I Economic Adjustment Factors

This section covers the state and Avista economic factors used to adjust NEIs for commercial and industrial programs. C&I adjustment factors are based on the theory of profit maximization. These factors consider how the new technologies associated with energy programs affect a participant's marginal cost or total profit. Further detail explaining the economic theory behind C&I economic factors can be found in Appendix E: Non-energy Impact Theory. Each factor discussed in Section 7.1.5.1 generates a single value for a geographic region. Section 7.1.6 describes how these geographic values are used in relation to one another.

7.1.5.1 Types of C&I Economic Adjustment Factors

As with the residential adjustment factors, each adjustment factor will result in a single monomial represented by X_{Avista}. Use of these monomials and interpretation will follow in Section 7.1.6 with an example in Section 7.1.7.

Labor Costs (wage-based)

State-to-State Adjustment

Many C&I NEIs relate to cost savings such as O&M and other labor costs. These NEIs include, but are not limited to: operation and maintenance, administrative, material handling and material movement. The adjustment factor for these NEIs represents the variation in wages across states (BLS, Occupational Employment Statistics - Wage, 2018). This factor is determined for both WA and the state from which the respective study in the JS was completed.

$$Labor\ costs\ (Wage - based)_{State} = [Median\ Hourly\ Wage]_{State}$$

Intrastate Adjustment

DNV identified county level median wage for Washington counties for all jobs covered by unemployment insurance, except for private households and federal government (Washington Employment Security Department, 2018). DNV then used count of C&I customers to weight the county level wage data to a single Avista median hourly wage.

$$Labor\ costs\ (Wage - based)_{Avista} = \left[\sum (Median\ Hourly\ Wage \times \%\ Customers)_{WA\ County}\right]_{Avista}$$

Revenue & Productivity

State-to-State Adjustment

NEIs that correspond to changes in revenue and productivity are more appropriately adjusted using a measure of output than the measure of wages. DNV used GDP to reflect the level of output in a state (BEA, 2018). NEIs associated with this adjustment factor include, but are not limited to: energy savings, durability, product quality and life, sales revenue, and output. This factor is determined for both WA and the state from which the respective study in the JS was completed.

$$Revenue\ and\ Productivity_{State} = [GDP]_{State}$$

Intrastate Adjustment

DNV further differentiates the revenue and productivity of the Avista service territory using county level per capita GDP (BEA, 2019). DNV then used count of C&I customers to weight the county level GDP to a single Avista GDP.

$$Revenue\ and\ Productivity_{Avista} = \left[\sum (Per\ Capita\ GDP \times \%\ Customers)_{WA\ County}\right]_{Avista}$$

Utility Cost – C&I

State-to-State Adjustment

The final C&I NEI adjustment factor applies to utility NEIs, or NEIs that result from changes to utility costs such as bad debt, arrearages, and hedging. Assuming average cost pricing, we use the combined average energy price for each sector (commercial and industrial) to represent the C&I cost of service.

$$C\&I\ Utility\ Costs_{State} = \left[\sum \left(\frac{Total\ C\&I\ Energy\ Revenue}{Total\ C\&I\ Energy\ Usage\ MMBtu}\right)_{Sector}\right]_{State}$$

Intrastate Adjustment

For Avista, DNV used updated EIA information (EIA Electricity Data, 2019) containing utility costs segmented by sector and utility service territory. The same process as at the state level was then applied to create a Avista specific C&I utility cost that could be compared to entire state.

$$C\&I\ Utility\ Costs_{Avista} = \left[\sum \left(\frac{Total\ C\&I\ Energy\ Revenue}{Total\ C\&I\ Energy\ Usage\ MMBtu}\right)_{Sector}\right]_{Avista}$$

7.1.6 Final Economic Adjustment Calculation

The resulting output from the above calculations created values usable in two separate ratios for each NEI category. The first set of values (state-level) provides the necessary inputs for a state index from which to compare Washington's economic environment to that of an NEI study's original jurisdiction.

$$Index_{state} = \frac{X_{WA}}{X_{Original\ Jurisdiction}}$$

The second set of values (utility-level) provides the necessary inputs for a Avista-specific index to compare against Washington as a whole. This allows the NEI study to account for diversity in the populations served throughout the state by different utility providers. This index takes the form:

$$Index_{utility} = \frac{X_{Avista}}{X_{WA}}$$

When multiplied together, the Washington values will cancel out and leave a single index with which to compare Avista's service territory to the economic conditions of the original jurisdiction. One important limitation to note is the potential for discrepancy between each Washington value. In order to create a true representation of Avista's economic standing in relation to the state as a whole, the data used to create the utility value was also used to create a new Washington value. In some cases, this was because updated data were being used, and in others it was because the original state comparison used state values instead of county or service territory values. While identified as a potential limitation, this NEI study is comparing relational differences, which are more accurately depicted when the same data used for Avista's value is also used to make a new Washington value. The resulting index is shown below:

$$Index_{Avista} = \frac{X_{WA}}{X_{Original\ Jurisdiction}} * \frac{X_{Avista}}{X_{WA}}$$

With the final index created to relate Avista's service territory to the original jurisdiction, NEIs can now be calibrated to work across jurisdictions in respect to economic conditions. This is done by multiplying the index by the NEI value to scale it from one region to another. For example, if the index was equal to 0.7 (meaning Avista's economic environment for this NEI was determined to be about 70% of the original jurisdiction), and the original NEI value was $10/unit, the calibrated NEI was $7/unit. This interpretation follows for all indexes created to calibrate NEIs with the final product taking the form:

$$NEI_{Calibrated} = Index_{Avista} \times NEI_{Uncalibrated}$$

7.1.7 Example - Residential Health Impacts Adjustment

For the purposes of providing an example, DNV chose a 2018 study from Massachusetts containing values for residential health and safety NEIs. This example will focus on a 95% efficient boiler corresponding to NEI generation of $0.88/installed measure/year.

State-to-State Adjustment

Average residential health care spending differs between Massachusetts and Washington. Using the publicly available data (KFF, 2014), the state-to-state index will be 0.75.

$$Health\ Index_{WA} = \frac{\$7{,}913\ per\ Person\ Health\ Care\ Spending_{WA}}{\$10{,}599\ per\ Person\ Health\ Care\ Spending_{MA}} = 0.75$$

Intrastate Adjustment

A different and newer dataset (Medicare Geographic Variation, Public Use Files, 2018) was then used to create the Avista and updated Washington value with which to further account for economic differences impacting residential health spending. This new dataset is segmented by county and lists a new Washington value per capita value of $8,163 standardized per capita health costs. Developing county weights from the tracked energy savings means the Avista adjustment accounts for how much of a county's population Avista serves. These weights can then be applied to the county health data (Table 10).

Table 10. Customer Weighted Residential Health Costs, 2018

County	Percent of Tracked Energy Savings (MMBtu)	Per Capita Health Costs (Dollars)	Energy Savings Weighted Health Costs (Dollars)
Adams	1.38%	$9,414.98	$129.61
Asotin	3.77%	$8,736.82	$329.51
Cowlitz	0.00%	$8,382.29	$0.36
Ferry	0.24%	$6,524.97	$15.60
Franklin	0.05%	$8,711.85	$4.55
Grant	0.18%	$7,701.36	$13.91
Island	0.04%	$6,848.45	$2.64
Kitsap	0.31%	$7,557.13	$23.15
Klickitat	0.19%	$7,334.36	$14.18
Lewis	0.27%	$7,891.11	$21.25
Lincoln	1.25%	$8,980.77	$112.42
Mason	0.39%	$7,668.88	$30.04
Pend Oreille	0.20%	$6,887.21	$13.48
Pierce	1.08%	$8,241.44	$88.68
San Juan	0.61%	$6,928.36	$42.42
Skagit	0.11%	$8,374.49	$9.35
Skamania	0.09%	$7,292.57	$6.88
Snohomish	0.12%	$8,170.77	$9.55
Spokane	77.67%	$9,043.92	$7,023.99
Stevens	5.58%	$7,466.22	$416.33
Walla Walla	0.02%	$8,479.68	$1.70
Whitman	6.46%	$8,233.42	$531.58
Avista Value	**Sum of weighted health cost**		**$8,841**

Summing the customer weighted health costs produces a rounded value of $8,841 per capita health spending in the Avista service territory. The intrastate index comparing Avista with the rest of the state is then 1.08.

$$Health\ Index_{Avista} = \frac{\$8{,}841\ per\ Person\ Health\ Care\ Spending_{Avista}}{\$8{,}163\ per\ Person\ Health\ Care\ Spending_{WA}} = 1.08$$

Adjusted NEI Value

The final Avista health impacts economic adjustment for a value that originally came from Massachusetts would then be 0.75 x 1.08, or 0.81. The economically adjusted NEI value would then be $0.71/installed measure/year.

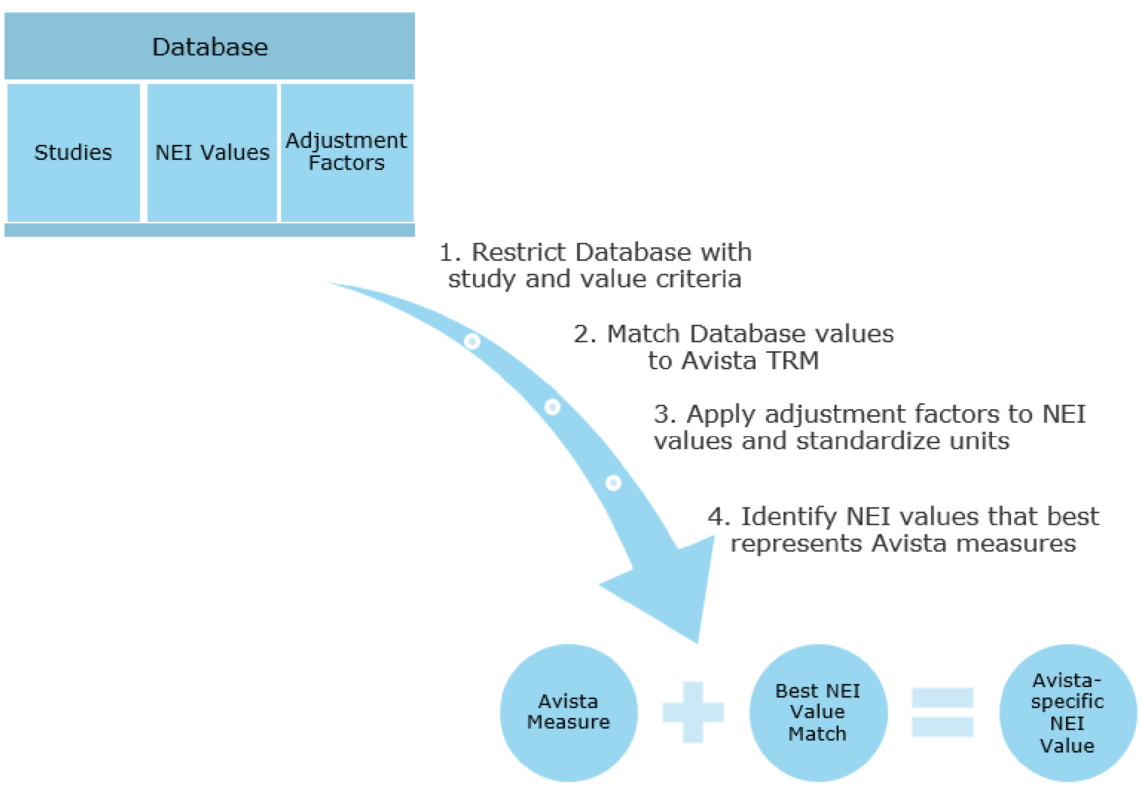
$$\$0.88/Installed\ Measure/Year_{MA} * 0.81_{Health\ Adj} = \$0.71/Installed\ Measure/Year_{Avista}$$

8 UTILITY-SPECIFIC CALCULATION AND SELECTION METHDOLOGY

DNV's NEI database contains multiple NEI values from different studies that can be applied to a single energy program measure. The goal of this analysis is to consider all options from the database, then choose the one that best represents each Avista energy program measure. This process, depicted in Figure 1, allows for a tailored NEI valuation approach with scalable specificity and confidence. For this analysis, DNV applies restrictions so NEI values are produced with a high level of specific matching accuracy and confidence in the study from which the value originates. The steps for producing these values are:

1. Restrict the Database to studies with a high degree of confidence and to values that are attributed to a specific technology (**Section 8.1**).
2. Use a standardized measure mapping to identify all possible relationships between Avista TRM and Database (**Section 8.2**).
3. Translate all potential values from their original jurisdiction to the Avista service territory, then modify with each value's associated CF and PF. Each value's unit from the original study is then converted to a standard unit (**Section 8.3**).
4. Choose the best NEI value by ranking of confidence, plausibility, and relationship of NEI value with the measure technology's energy impact (**Section 8.4**).

Figure 1. NEI Calculation and Selection Process



8.1 Database Exclusion Criteria

The first step for producing results with a high degree of confidence is to remove studies that do not meet a certain set of criteria. DNV uses three criteria to apply to the Database for producing NEI values for Avista's TRM. Note that the confidence factors (CF) and plausibility factors (PF) referenced in Section 4 and Section 5, respectively, help with this filtering but are not the only tools used. The exclusion criteria include:

1. **Accuracy of Match** – use only study NEIs where values have been identified at an end-use level specificity (e.g., HVAC, lighting, hot water) or higher (e.g., HVAC - New furnace replacement, Lighting - LED exit signs).
2. **Confidence in Study** – of all studies passing the first criteria, use only studies with CF in the top 50^{th} percentile.
3. **Relevancy of NEI** – of all studies passing the first and second criteria, use only NEI values where the category of NEI is applicable to the measure with which it is being matched (e.g., NEI for indoor air quality is applicable to HVAC measures, but not lighting measures).

8.1.1 Accuracy of Match

DNV's NEI database includes studies ranging from very specific NEI estimates for measure types (Level 6 below), to those with broad NEI estimates referencing all aspects of a given program (Level 2 below). As detailed in Section 3.2, DNV maps measures in the NEI database to Avista's TRM using 7 LoAs. DNV places extra importance on the ability for Avista measures to match with the Database by at least the end-use level (Level 4). This idea is in line with the CF scoring Question 1: ("Is the study measure specific?"). While this question could be weighted heavier in the CF calculation to exemplify the importance of using end-use relationships, the analysis team found a restriction of the database more appropriate. Therefore, DNV considers only values in the database with the ability to match Avista measures by end-use. Table 11 provides an example of the threshold of what is and is not included according to Criterion 1 (Accuracy of Match). 23 of the 46 studies contained in the database passed Criterion 1.

Table 11. Match level Accuracy Example

Match Level Accuracy	Example	Does this pass Criteria 1?
Program Level	Study 20 reports NEI values that can be applied across an entire residential low-income program, but values are not associated with specific end-use technologies.	No
End-use Level	Study 47 reports NEI values for specific end-use technologies (water pipe insulation, showerheads, wall insulation) within a residential low-income program.	Yes

8.1.2 Confidence in Study

DNV then selects studies for which there is the most confidence. DNV chooses the best studies by selecting those in the top 50^{th} percentile based on the assigned CF scoring. The median CF of the 23 studies to pass Criterion 1 (Accuracy of Match) was 0.66667. This further exclusion drops the number of studies to be used for the Avista valuation from 23 to 12, with Table 2 showing the CFs of the 23 studies to pass Criterion 1 and whether that study also passes Criterion 2 (Confidence in Study).

Table 12. Studies Meeting Criterion 1 and Whether they Pass Criterion 2: Confidence in Study

Confidence Factor	Study ID	Does this pass Criteria 2?

0.5	Study 0008	No
0.5	Study 0009	No
0.5	Study 0015	No
0.5	Study 0017	No
0.53333	Study 0011	No
0.53333	Study 0014	No
0.53333	Study 0016	No
0.53333	Study 0039	No
0.6	Study 0041	No
0.6	Study 0042	No
0.6	Study 0046	No
0.66667	Study 0010	Yes
0.66667	Study 0012	Yes
0.73333	Study 0004	Yes
0.73333	Study 0007	Yes
0.8	Study 0032	Yes
0.86667	Study 0002	Yes
0.86667	Study 0003	Yes
0.86667	Study 0005	Yes
0.86667	Study 0040	Yes
0.93333	Study 0047	Yes
0.93333	Study 0048	Yes
1	Study 0001	Yes

8.1.3 Relevancy

The last step for restricting the database values is to classify potential values as relevant or not relevant. The Database contains studies with NEI categories that might not make sense for the specific, matched Avista measures. DNV created a matrix to assign each level 4 match and NEI category combination a relevancy flag. Table 13 shows an example of where relevancy varies by end-use, but these designations can also vary by fuel, sector, program, and whether a measure is custom or prescriptive. Values stemming from combinations that are deemed not relevant are removed from the database.

Table 13. Example of Relevancy of NEI by End-Use

Level 4 Measure Categorization	NEI Category		
	O&M - Participant - Residential	Indoor Air Quality - Participant - Residential	Lighting Quality and Lifetime - Participant - Residential
Gas, Residential, Retrofit, Prescriptive, Hot Water	Relevant	Relevant	Not Relevant
Gas, Residential, Retrofit, Prescriptive, HVAC	Relevant	Relevant	Not Relevant
Electric, Residential, Retrofit, Prescriptive, Lighting	Relevant	Not Relevant	Relevant

8.2 Match Database to Avista TRM

After paring down the Database to relevant studies and NEI categories, DNV matches the measures in the Database to the Avista TRM using the standard set of Level 0 through Level 6 match codes. As discussed in Section 3.2, DNV standardizes and assigns the same LoAs listed above (Section 8.1.1) to each Avista measure. All studies in the Database had an original (observed) LoAs, but they varied in terminology from study to study. As such, these standardized codes assigned to both the Avista TRM and the Database provide matches between the two at each LoAs. A Linear LED measure is broken out into the LoAs as follows:

Table 14 - Example of Standard Level of Aggregation for Avista Measures

Standard Levels of Aggregation	Example of Standard Levels of Aggregation Details
Detailed Measure Level (Level 6)	Linear LED
Broad Measure Level (Level 5)	LED
End-Use Level (Level 4)	Lighting
Prescriptive/Custom (Level 3)	Prescriptive
Program Level (Level 2)	Retrofit
Sector (Level 1)	C&I
Fuel (Level 0)	Electricity

The following table illustrates how these Standard LoAs come together to form the matching IDs.

Table 15. Example of Concatenated Matching IDs

Match Level ID	Concatenated Matching ID
6	Electricity_C&I_Retrofit_Prescriptive_Lighting _LED_Linear LED
5	Electricity_C&I_Retrofit_Prescriptive_Lighting _LED

4	Electricity_C&I_Retrofit_Prescriptive_Lighting
3	Electricity_C&I_Retrofit_Prescriptive
2	Electricity_C&I_Retrofit

A match occurs when the concatenated match codes exist in both the Avista TRM and in one or more studies in the Database. First, all matches are identified that happen at a Level 6. These observations are kept and designated as a Level 6 match. Next, all matches are identified that happen at a Level 5, but which did not happen at a Level 6. These matches are designated as a Level 5 match. DNV iterated this process to Level 4 (end-use) for Avista, meaning a study value has to match with the Avista measure at least by end-use for the value to be considered.

Using the measure from Table 14, Figure 2 shows an example where 2 values are identified as potential matches. One is a perfect match (designated as Level 6 match), while the other only matches to broad measure level (LED) but not to the detailed measure level (Linear LED), thus designating it a Level 5. There can be many potential matches in this instance with values coming from multiple studies. All options will be considered, but only the best fit based on CF and PF is selected as representing that Avista measure (Section 8.4).

Figure 2. Example of 2 Potential Matches

8.3 Avista-Specific NEI Calculation

After the Database is restricted and all potential matches with Avista's TRM are identified, values are standardized so they can be compared and ultimately applied. This standardization is done in 2 steps:

1. Apply economic adjustment factors, CF, and PF
2. Standardize units

8.3.1 Apply Adjustment Factors, CF, PF

As discussed in Section 7, the economic adjustment factor gets applied to the original NEI value to account for socio-economic differences between where the original study took place and Avista's service territory. Then, this economically adjusted NEI value is multiplied by the CF and PF to derate final values, which helps account for unknowns in the original study or the strength of the NEI applicability.

Equation 8: Create Avista-Specific NEI

$$NEI\ Value_{\ Original\ Juristiction} * CF * PF * Economic\ Adjustment_{\ Avista} = NEI\ Value_{\ Avista}$$

NEI values can now be applied to Avista's service territory, but not all values are in the same unit. Having the same unit can be important for choosing a top value in the case where there are multiple values from which to choose and for applying values consistently across the TRM.

8.3.2 Standardize Units

This analysis uses $/kWh or $/Therm as the final unit for reporting NEI values. After restricting the database to studies with a high degree of confidence (Section 8.1.2), many of the values are already in $/kWh or $/Therm and are ready to be applied after Equation 8.

For NEI values that are not already in $/Therm or $/kWh, this analysis uses a combination of tracking data and information from the TRM to convert. As an example, consider a value with the original value reported in $/project/lifetime. Information necessary for making this conversion are the measure lifetime, the measure energy impact, and the number of measures per project. Synthesis of these variables is shown below:

- **Measure Lifetime –** This variable is taken from the TRM; however, it is not available for every measure. Measures without a stated lifetime will not consider any NEI values where the original value is reported by lifetime.
- **Energy Impact –** This value is derived from the historic tracking data as the average reported energy impact by measure type. Measures without an observed energy impact in the tracking will not consider any NEI values for which the original value was reported in anything except $/kWh or $/Therm.
- **Number of Measures per Project –** For units needing conversion from per building, per project, per participant, etc., ratios are developed from the tracking data to approximate what this rate might be. These ratios are developed with respect to match level and sector, so for the example of $/project/lifetime for residential there are 3 ratios that can be applied depending on match level:
    - Level 6 Ratio – Average of all tracking data for the number of identical level 6 measures installed for a single project.
    - Level 5 Ratio – Average of all tracking data for the number of identical level 5 measures installed for a single project.
    - Level 4 Ratio – Average of all tracking data for the number of identical level 4 measures installed for a single project.

The final unit conversion for a residential NEI that's originally reported as $/project/lifetime and is matching to a Avista measure as a Level 5 (L5) is then:

Equation 9: Example of unit conversion for Avista-specific NEI

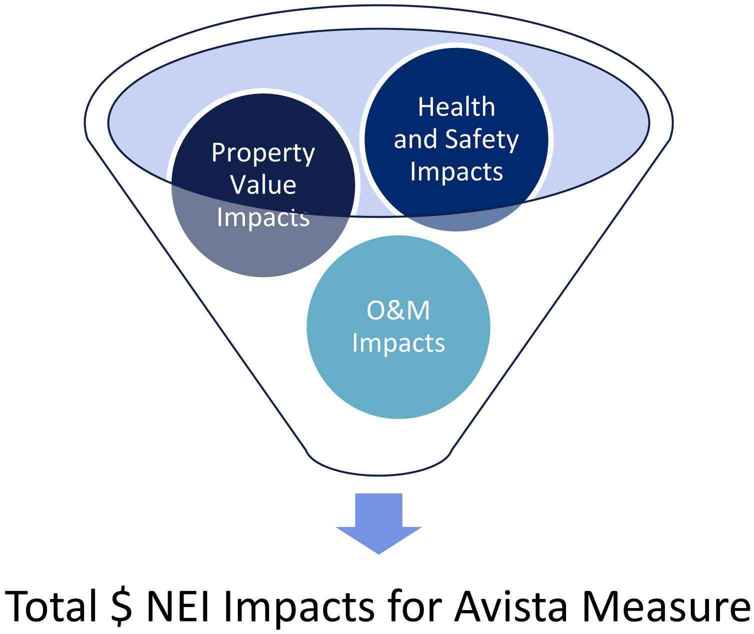
$$\$NEI\ per\ energy\ impact_{Avista} = \frac{\$\ NEI\ per\ project\ per\ lifetime}{Lifetime\ of\ measure_{Avista}} * \frac{1}{Average\ \#\ of\ L5\ measures\ per\ project} * \frac{1}{Energy\ impact\ per\ measure_{Avista}}$$

For measures that have an observed impact on both electricity and gas usage, this conversion includes the Mmbtu ratio of energy-specific impact to create a $/kWh and $/Therm value that avoids any double counting.

8.4 Identifying Best NEI Estimate from all Potential Matches

The result of Sections 8.1, 8.2, and 8.3 is a list of standardized NEI values linking to specific studies that can be applied to the correspondingly mapped Avista measure. The database contains studies with different areas of focus, meaning a single Avista measure can end up with multiple NEI categories all working toward an inclusive NEI total (Figure 3).

Figure 3. Amalgamation of NEI Categories into Measure's Total NEI



Each combination of Avista measure and NEI category can have multiple studies competing for which provides the best NEI value estimate. Because there can be only one study value associated with each NEI-measure combination, DNV chooses the best based on the product of the CF and PF, then in rare cases of a tie, the most conservative value estimate takes precedent (Section 8.4.1).

After identifying the study value that best estimates each possible measure-NEI combination, results are subject to engineering review. This review provides a more in-depth analysis of the relevancy of measure-NEI combinations than what was done in Section 8.1.3 as well as reviewing the magnitude and sign (+/-) of NEI estimates (Section 8.4.2).

8.4.1 Assignment of Best Value

Assignment of the best value to represent a unique Avista measure-NEI combination depends first on the Combined Score (CF × PF). In the rare event of a tie where values from two studies have the same Combined Score, the NEI ratio ($NEI: $Energy Impact) is used to choose the most conservative estimate.

Combined Score

The Combined Score is created by multiplying the CF (ranking of study) by the PF (ranking of match level, age of study, and end-use energy consumption changes). This Combined Score identifies the NEI value estimate with the best combination of study confidence and accuracy of study-to-Avista measure similarity.

Table 16 shows an example where Avista measure "LTGO: Lamp - TLED - 2 3 or 4 foot" corresponds with the measure mapping detailed in Section 8.2. This designation matches with 3 potential value estimates originating from 3 separate studies for the NEI category Operations and Maintenance (O&M). The table shows all potential studies match at a Level 4, meaning the Database does not currently have O&M values specific to LED lighting for measure categorizations that otherwise match at least at a Level 4 (Electricity C&I Retrofit Prescriptive Lighting). In this instance, the value from Study 01 is chosen because it has the highest combined score.

Table 16. Choosing Best Match by Combined Score to Represent O&M NEI Value for Avista Measure - LTGO: Lamp - TLED - 2 3 or 4 foot

Measure Mapping	Study ID	NEI Value	Match Level	Combined Score
Electricity, C&I, Retrofit, Prescriptive, Lighting, LED, Linear LED	01	$0.022/kWh	4	0.65
	02	$0.012/kWh	4	0.53
	05	$0.007/kWh	4	0.60

NEI Ratio

It is uncommon for ties to occur between potential values when ranking by combined score. However, when they do, the analysis team selects the NEI value with the most conservative estimate. This metric is developed as an NEI ratio relating the value of the NEI to the value of energy. This ratio is calculated by taking the absolute value of the NEI and dividing by the absolute value of the average Avista consumer price for the energy type in dollars:

Equation 10: NEI Ratio

$$NEI\ Ratio = \frac{|\$NEI\ per\ energy\ unit|}{|Average\ Avista\ consumer\ price\ of\ energy\ per\ unit|}$$

The average Avista consumer price of energy per unit represents the monetary impact of the energy savings that will be felt by installing a particular measure. That means the NEI ratio is a comparison of the (monetized) non-energy impact with the (monetized) energy impact. The analysis team calculates average costs using combined residential and C&I energy usage and come out to $0.88/Therm for natural gas (Utility Natural Gas Sales, 2020) and $0.09/kWh for electricity (Utility Electricity Sales, 2020).

Table 17 shows an example where two studies compete to provide the NEI value for Bad Debt Write-Offs associated with the Avista Measure “Duct Sealing: single family; electric.” Both study values have the same combined score, so in this case the one from Study 47 is chosen to represent the Avista measure because it has the lower NEI ratio.

Table 17. Choosing Best Match by NEI Ratio when Combined Score are Tied

Measure Mapping	Study ID	NEI Value	Match Level	Combined Score	NEI Ratio
Electricity, Residential, Low-Income, Prescriptive, HVAC	47	$0.004/kWh	4	0.79	0.04
	48	$0.050/kWh	4	0.79	0.60

8.4.2 Review of Results

The best study values to represent each NEI-measure combination as identified in Section 8.4.1 are output and reviewed. During the review process, a senior engineer considers the following questions for each NEI value estimate:

1. *Do all potential NEI-measure combinations make sense at the most detailed level*? A more detailed relevancy than that discussed in Section 8.1.3 is completed for each NEI-Measure combination. This catches nuances at the end-use level such as a situation where NEI generation from reduced incidence of fires makes sense for water heaters

(Level 4 = Hot Water), but not for aerators (Level 4 = Hot Water). The associated NEI values are removed if an NEI-measure combination is flagged by a senior engineer.

2. *Do value estimates for all potential NEI-measure combinations have the correct sign?* During the engineering review, NEI value estimates are reviewed with respect to if they are a negative or positive. If the sign seems incorrect (e.g., negative for LED O&M), the source study for this value is investigated along with the match-level and the specific measure. It could be the case that the value matched at a Level 4, but when considering the actual Avista measure the sign is incorrect. If this is the case, the analysis team identifies if there is a next best estimated NEI value not chosen in Section 8.4.1 with the correct unit, then applies it for review with the rest of the top values with respect to question 3.

3. *Do chosen NEI value estimates have the correct magnitude for what can be expected?* During the engineering review, chosen NEI value estimates are reviewed if the NEI ratio described in Section 8.4.1 is greater than 1. DNV uses this threshold because it identifies scenarios where the NEIs are the main impact from the measure's implementation, and energy is the secondary impact. While it is possible for a measure to generate more value from quantifiable NEIs than from energy impacts, it is not common. Usually, if an NEI ratio is greater than 1, it is the result of uncertainty in the unit conversion when the original study does not report values in $/kWh or $/Therm. If this is the case, the analysis team reviews the NEI estimates and assesses if it is defensible for the NEI ratio to be greater than 1. If not, an alternative source for the NEI is used.

9 FINAL RESULTS

The final output from this process is a list of Avista measures that have reasonable, defensible, and quantifiable NEIs. Each of these measures can be generating value from multiple NEI categories, with the value of each category linked to a specific study.

9.1 Avista-specific NEI Example

This section will walk through an example calculation to illustrate how Equation 8 mentioned above (and restated below) is used to generate a Avista-specific NEI value. The example will consider how the NEI quantifying changes in bad debt write-offs is calculated for a *low-income window replacement* measure matching at a Level 5 to the Database. The original study for this NEI is the *Washington Low Income Weatherization Program Evaluation, Measurement & Verification Report (2020)* referred to as Study 48.

$$NEI\ Value_{\ Original\ Juristiction} * CF * PF * Economic\ Adjustment_{\ Avista} = NEI\ Value_{\ Avista}$$

1. **Start with the unadjusted NEI value from the original study**. For this example, the starting value from Study 48 is $0.0295 per kWh from the Database. This value was calculated by dividing the 2016-2017 total program non-energy benefit for economic impact in Study 48's Table 6-5 by the net verified kWh savings in Study 48's Table 6-3.

$$NEI\ Value_{\ Original\ Juristiction} = \frac{\$10{,}024}{339{,}561\ kWh} = \$0.03/kWh$$

2. **Multiply the unadjusted NEI value by the CF and PF**. The starting NEI is first adjusted to 2021 dollars using the consumer price index (Consumer Price Index, 2020). This adjustment happens so values reflect current monetary impacts and better align with data used for economic adjustment factors. This value is then adjusted by its corresponding assigned CF and PF from the Database to obtain the Combined Score. The CF for Study 48 is 0.933, and the PF for a Level 5 match assuming a 50% minimum floor is 0.846. These values are obtained from the Database.[4]

$$NEI\ Value_{\ Original\ Juristiction\ 2018\ \$} * CF * PF = Adjusted\ NEI\ Value$$

$$\frac{\$0.03}{kWh} * 0.933 * 0.846 = \frac{\$0.024}{kWh} = Adjusted\ NEI\ Value$$

3. **Multiply by the Economic Adjustment Factor**. The economic adjustment factor used for the NEI category *Bad Debt Write-offs – Utility – Residential* is the residential utility cost factor. Since this was a Washington study, the state-to-state adjustment factor is 1. If the original study was completed in a different state, then a ratio would be used to adjust the value from the original state to Washington state. For the intrastate adjustment, DNV calculated an Avista utility cost of $8,997 per customer. For all of Washington, this value is $8,820.

$$Adjusted\ NEI\ Value * Economic\ Adjustment_{\ All\ Washington} * Economic\ Adjustment_{\ Avista} = NEI\ Value_{\ Avista}$$

$$\frac{\$0.024}{kWh} * 1 * \frac{\$9{,}232}{\$8{,}820} = \frac{\$0.025}{kWh}$$

Thus, the final *Bad Debt Write-offs – Utility – Residential* NEI value for Avista for this low-income window measure is $0.025 per kWh.

[4] Study 48 scored 14 out of 15 possible, so the CF for this would be 93% (14/15=.93). The scoring was based on the 5 CF questions previously detailed in Section 4. For the PF, the study scored a 4 for Age, 2 for UES change, and 5 for Match score. This would result in the study receiving a score of 11 out of a possible 13, so the PF for this would be 85% (11/13=.846).

9.2 Total NEI Value Example

Table 18 shows an example of three Avista measures and the associated NEI values. As described in the beginning of Section 8.4, these NEI categories can be added together to estimate the total NEI of a specific measure.

Table 18. Example of Final Results

Avista Measure	Total NEI Value	Health and Safety	Thermal Comfort	Bad Debt Write Offs	Other NEI Categories
Windows, Low-Income Retrofit Program	$0.46/kWh	$0.32/kWh	$0.08/kWh	$0.03/kWh	$0.03/kWh
Air source Heat Pump, Retrofit Program	$0.032/kWh	$0.000009/kWh	$0.0003/kWh	-	$0.03/kWh
Duct Sealing, Low-Income Retrofit Program	$0.29/Therm	$0.023/Therm	$0.006/Therm	-	$0.261/Therm
Heat Pump Water Heater, Retrofit Program	$0.002/kWh	$0.00001/kWh	-	-	$0.00199/kWh

Avista should use the results of this analysis to calculate the planned or actual NEI value generated by a program, measure, portfolio, etc. This segmentation into different categories also provides estimates for value generation for perspective program participants. In a marketing aspect, the O&M value can be factored into benefit-cost-ratios when participants are considering whether to undergo certain energy-use upgrades.

10 GAP ANALYSIS APPROACH

The purpose of the gap analysis is to classify the measures and initiatives that currently lack NEIs and identify areas in which follow-up research is worthwhile to confirm or quantify NEIs occurring within Avista territory. The gap analysis includes the following activities:

- Identify energy-efficiency measures that do not have NEIs
- Identify gaps where no NEI is matched to the TRM but NEIs exist in the published literature
- Identify NEIs that are heavily discounted
- Inventory NEI types that have not been previously studied
- Identify initial priority opportunities for future research based on the potential value gained compared to the cost to conduct the research.

10.1 Measures Without NEI Values

Of the 1,767 measures in the final TRM, 48% (n=843) of them were matched to NEI values in the Database. DNV began the gap analysis review by cataloguing the 924 unmapped measures into groups to determine whether there are any similarities to measures mapped to NEIs. This was done by sorting measures by match code irrespectively of program type in the TRM. We then flagged any measure without a mapped NEI that was “similar” to a measure mapped to an NEI. 15 unmapped measures for which a similar measure with an NEI was identified. Avista could potentially calculate NEIs for these 15 based on the differences between the unmapped measure and the similar mapped measure(s) identified.

Table 19 shows the 15 unmapped measures for which a similar measure with an NEI was identified. Avista could potentially calculate NEIs for these 15 based on the differences between the unmapped measure and the similar mapped measure(s) identified.

Table 19. NEI Values Exist for a Similar Measure

Sector	Fuel	Measure Group	Measures without NEI Values	Measures with NEI Values
Residential	Gas	Air Sealing	1	2
	Gas	Gas Furnace	1	2
	Gas	High Efficiency Windows	5	1
	Gas	Insulation	8	3
Total			**15**	**8**

In addition, two (2) of the unmapped measures did not receive an NEI value from the Database despite being matched to an NEI value; this was because calculating the NEI requires a unit conversion in order to properly allocate the NEI value to the Avista per unit measure savings. NEI values that are not already in $/Therm or $/kWh require a unit conversion. This conversion could not be performed for measures missing a mean savings value in the tracking data and/or an expected useful lifetime estimate. Unit conversation gaps can often be filled by use of assumptions that are developed based on program information or measure characteristics. The resulting NEIs are often then estimates until sufficient program activity occurs to calculate a more confident per unit NEI value.

10.2 Heavily Discounted NEIs

As discussed in Section 8.3.2, values in the Database must be standardized so they can be compared and accurately applied. This standardization is done in two steps:

1. Apply economic adjustment factors, CF, and PF
2. Standardize units

DNV flagged high-value NEIs that were discounted to less than 60% of their original value as a result of the first standardization step. This process identified 39 measures in the Avista TRM as heavily discounted NEIs. The heavily discounted NEIs come from the following studies in Table 20:

Table 20. Studies with Heavily Discounted NEIs

Study ID	Title	State	Year
Study0002	Final Report – Commercial and Industrial Non-Energy Impacts Study	MA	2012
Study0004	Non-Energy Impact Framework Study Report	MA	2018

There are a variety of reasons why the NEI values from a study may be discounted. For example, in Study0004 the original values were discounted in part because the original study only incorporated economic factors based on theory (e.g., property value based on the Hedonic Price theory), although they did not clearly identify the factors in the study. Section 5 details how the original NEI values were further discounted to account for the age of the study, changes in energy consumption over time, and how well the measures in the study matches to those in Avista's TRM. Furthermore, Section 7 also explains how the original NEI values were further discounted to account for socio-economic differences between where the original study took place (MA) and Avista's service territory. As shown in Table 20 above, the heavily discounted NEI values are taken from studies that originally took place in the Northeast region of the United States.

10.3 NEIs Not Previously Studied

WAC 480-100-640 (2)(a)(i) requires that Avista demonstrate progress towards ensuring all customers benefit from the transition to clean energy through,

> "the equitable distribution of energy and nonenergy benefits and reductions of burdens to vulnerable populations and highly impacted communities; long-term and short-term public health and environmental benefits and reductions of costs and risks; and energy security and resiliency."

DNV used this legislative requirement as a guide for our review. The energy security and resiliency benefit identified in the CETA legislation is the only NEI type for which there are no estimates available in the Database. Possible research areas to address this gap include,

- Property durability and resilience to climate change impacts
- Customer-specific outage costs and value of uninterrupted service

11 FRAMEWORK FOR FUTURE RESEARCH

The team developed a framework for prioritizing NEI research. This section describes the framework DNV created and the results of gap analysis.

11.1 Prioritization Criteria and Assignment of Levels of Priority

The prioritization framework is based on scoring two criteria: level of effort and value. Table 21 summarizes the four criteria and the associated scoring. Each criterion is discussed in more detail in the sections that follow.

Table 21. Framework Prioritization Scoring

Criterion	Priority Score (higher score = higher priority)		
	1	2	3
Value of NEI Research	Low value study. Meets 1 Utility Priority criterion, but NEI values already exist for measure group; or meets 0 Utility Priority criteria.	Moderate value, meets 1 Utility Priority criterion and no NEI values exist for measure group; or meets 2-3 Utility Priority criteria, but NEI values exist for measure group.	High value study. No NEI values for measure group and 2-3 Utility Priority criteria met.
Level of Effort	High level of effort, might require additional primary research	Moderate level of effort, further secondary research is likely to produce NEI values	Low level of effort, missing values likely easily accessible in regional databases (RTF, 2021 Power Plan, NEEA)
Utility Priority	Meets 1 of these criteria: 1. NEIs applicable to measure group with low cost-effectiveness; or, 2. CETA benefit categories, or 3. High install measure group	Meets 2 of the criteria	Meets all 3 of the criteria

11.1.1 Value of NEI Research

The “Value of NEI Research” criterion assigns higher priority to studies that will provide NEIs to address identified gaps for measures within initiatives and measure groups, and lower priority to studies for which the targeted group of initiatives and measures has existing NEIs. The Value of NEI Research criterion also depends on three Utility Priority criteria that account for the specific needs of Avista and the legislative requirements that a gap study should meet:

- Satisfies any requirements mandated by the CETA legislation—benefits low income households, has nonenergy benefits related to public health, energy security, or the environment,
- Top measure in the PY2021 projected program savings; and
- Had a TRC benefit-cost ratio of less than 1.2, but more than 0.00 in Avista’s 2021 program plan

- **High value:** A measure would be scored as high value if it does not have NEI values assigned it. A high value gap would also meet at least 2 of the Utility Priority criteria, as it is important to ensure the gaps being filled will meet the needs of Avista and the legislative requirements.
- **Moderate value:** Filling an NEI gap for a measure group would be considered of moderate value if it either of the following conditions are met:
    - No NEI values exist, but it would meet 1 Utility Priority criterion
    - NEI values do exist, but it would meet 2 to 3 Utility Priority criteria
- **Low value:** A measure would be score as low value if it already has NEI values associated with it or if filling the gap would not meet any of the Utility Priority criterion. These gaps would be assigned the lowest priority.

There is the highest value in filling gaps for measure groups that do not currently have NEI values associated with them. Because there is such a large gap, any secondary research into this NEI category would lead to better understanding these gaps and perhaps even conservative estimates that can be applied at a broad range of programs and end-uses. There is still moderate value in filling gaps for measure groups that have incomplete NEI values, if the measure meets multiple Utility Priority criteria. Further research into these NEI categories should be more focused on specific areas, with existing Database studies providing background on what to expect.

11.1.2 Level of Effort

The "Level of Effort" criterion assigns higher priority to research that can be completed with a lower level of effort, and thus faster and at a lower cost. Level of effort is an important planning and fiscal management metric to consider. DNV completed preliminary cost estimate ranges for the proposed studies, basing estimates on the number and types of gaps identified for the target NEIs and the type of research proposed to achieve study objectives.

- **High effort:** In order to fill the identified NEI gap, additional primary research could be required to generate a value estimate. For example, measures that did not match with the jurisdictional scan could require a new primary research study if there is no available NEI study applicable to those measures.
- **Medium effort:** All NEI gaps not clearly in the high effort or low effort category.
- **Low effort:** The NEI gap is due to a unit conversion issue, which means the bridge between Avista's measure and DNV's program exists but there is not enough information with regards to installed energy savings or installation lifetime to do the conversion. This information can be identified or approximated using similar measures, engineering review, or with the addition of supplemental data.

Measures with missing measure lifetime or observed energy impact values that are easily accessible in regional data sources such as the Regional Technical Forum (RTF) or 2021 Power Plan) were assumed to require the least amount of effort to address.

11.2 Framework output

DNV added the NEI gap's value and effort scores together to calculate the final score for any NEI gap under consideration. The higher the score, the higher priority for future research. The highest priority gaps are easy and valuable to fill. The companion excel sheet has the full break down of each measure and the priority criteria assigned. The highest possible score for an NEI gap is a 6, which represents a low effort, high value gap. While none of the NEI gaps identified in this analysis scored as a 6, several received a 5. Table 22 shows the top priorities based strictly on our scoring framework.

Table 22. Prioritization of Proposed Future NEI Studies

Total Score	Sector	Measure Group	Measure	Recommended Gap Study
5	Residential	Air Sealing	Insulated Door_R2.5 - R5_HZ2_Zonal (Energy Star Rated or Insulated R5)	Residential Weatherization
5	Residential	ELV Thermostat	Line Voltage Communicating Thermostat	Residential ELV Thermostat
5	Residential	ELV Thermostat	Line Voltage Thermostat	Residential ELV Thermostat
5	Residential	Gas Furnace	High Efficiency Wall Furnace (AFUE 90%)	None
5	Residential	Heat Pump Water Heater	Tier2-3 HPWH	Residential Heat Pump Water Heater
5	Residential	High Efficiency Windows	G Windows Dual Pane <0.30 U-value	Residential Weatherization
5	Residential	High Efficiency Windows	G Windows Single Pane <0.30 U-value	Residential Weatherization
5	Residential	High Efficiency Windows	Low E Storm Window	Residential Weatherization
5	Residential	High Efficiency Windows	NG Storm Windows	Residential Weatherization
5	Residential	High Efficiency Windows	Windows	Residential Weatherization
5	Residential	Insulation	G Attic Insulation	Residential Weatherization
5	Residential	Insulation	G Wall Insulation	Residential Weatherization
4	Commercial	Commercial Oven	Efficient convection oven full size	None
4	Commercial	Compressed Air	Compressed Air	None
4	Commercial	Food Cabinet	Efficient hot food holding cabinet, Double Size	None
4	Residential	High Efficiency Mobile Homes	Energy Star Homes - Manufactured, Electric, Dual Fuel	None
4	Residential	Insulation	Attic Insulation_R0 - R38_HZ2_Zonal	Residential Weatherization
4	Residential	Insulation	Attic Insulation_R0 - R49_HZ2_Zonal	Residential Weatherization
4	Residential	Insulation	Floor Insulation_R0 - R19_HZ2_Zonal	Residential Weatherization
4	Residential	Insulation	Floor Insulation_R0 - R30_HZ2_Zonal	Residential Weatherization
4	Residential	Insulation	G Floor Insulation	Residential Weatherization
4	Residential	Insulation	Wall Insulation_R0 - R11_HZ2_Zonal	Residential Weatherization

One additional gap that was not evaluated in this framework was the Economic Development NEI that was originally transferred from the following report that was prepared for Pacific Power by ADM: Washington Low Income Weatherization Program Evaluation, Measurement &Verification Report 2016-2017 (2020). This study met the confidence threshold used in the valuation process, although the Economic Development NEI was excluded from the final results after meeting with ADM and confirming we would need to calculate a per-kWh economic impact using lifetime savings before applying this NEI to Avista's measures.

11.3 Avista-Specific Gap Analysis Example

This section walks through an example that illustrates how DNV applied the gap analysis framework discussed in Section 11 to Avista-specific measures. In this example, we focus on the "High Efficiency Wall Furnace (AFUE 90%)" measure in Avista's Gas Residential HVAC program.

First, DNV assessed the NEI gaps applicable to the measure in order to determine the 'Level of Effort' that filling the gaps would require:

- The measure does not have a mapped NEI value, but it is similar to other measures that mapped to an NEI value; and
- This specific measure was not implemented recently, preventing DNV from having the necessary information to calculate an NEI value.
- Based on the Framework Prioritization Scoring in Table 21, this measure would receive a score of 3 for the Level of Effort criterion. Since similar measures exist that were installed and have calculated NEIs, the level of effort required to find a proxy value for the missing information required is low.

Next, the 'Value of NEI Research' is determined by looking at the 'Utility Priority' criteria and whether NEI values already exist for the measure:

- This measure met the following 1 out of 3 Utility Priority criteria:
    - The measure has 'Health and Safety – Participant' benefits that are applicable to the CETA legislation.
- No NEI values are mapped to the measure.
- Based on the Framework Prioritization scoring in Table 21, this measure would receive a score of 2 for the Value of NEI Research criterion. The value of filling this NEI gap is moderate.

Lastly, DNV calculated the final priority score by adding together the level of effort score (3) plus the Value of NEI Research score (2), resulting in a NEI Study Priority score of 5 — filling its NEI gaps would be low effort and moderate value.

11.4 Prioritization of Research

DNV identified two studies that could quantify NEIs in all but one of the CETA benefit categories for 45 high priority measures. Table 5 summarizes each study and the NEIs addressed.

Table 23. Recommended Gap Studies and NEIs Addressed

Recommended Gap Study	Measure Group	# of Measures with Priority Gaps	# of Measures with Any Gaps	CETA-Benefits Addressed	NEI Values Addressed by Research											
					CETA-NEIs		Additional NEIs									
					Avoided pollution - Societal	Health and safety - Participant	Fires/insurance damage - Participant	Productivity - Participant	Thermal Comfort - Participant	Ease of Selling or Leasing - Participant	Noise - Participant	O&M - Participant	Other - Participant	Other Impacts - Utility	Bad Debt Write-offs - Utility	Calls to utility - Utility
Residential ELV Thermostat	ELV Thermostat	2	2	Public Health, Environmental	X				X						X	X
Residential Weatherization	Air Sealing	1	3	Low Income Households, Public Health, Environmental	X	X	X		X		X		X	X	X	X
Residential Weatherization	High Efficiency Windows	5	7	Public Health		X			X		X			X	X	X
Residential Weatherization	Insulation	2	8	Public Health, Environmental	X	X			X		X	X		X	X	X
Residential Heat Pump Water Heater	Heat Pump Water Heater	1	2	Low Income Households, Public Health, Environmental	X	X	X		X	X		X			X	X

Study 1: Residential Weatherization

DNV proposes that a residential weatherization study should be completed first, due to the significant existing gap in available NEI information regarding these measures. Conducting research to address the NEI gaps in the weatherization measures scoring high in the prioritization framework would address the following CETA benefit requirements:

- Public health—Avoided pollution
- Environment—Avoided pollution
- Reduction of burdens to vulnerable populations—Low income programs

DNV recommends a residential weatherization study that encompasses the Air Sealing, High Efficiency Windows, and Insulation measure groups due to the overlap in research that would be required to address the gaps. This study could potentially provide NEI values for 14 measures for which NEI values currently do not exist. This research would also touch on 4 measures in low income programs that are receiving heavily discounted NEI values. The high priority NEI gaps are in gas measures in Avista's Multifamily Weatherization, Shell, and HVAC programs. These measures did not receive any NEI values and stand out as top energy savers in Avista's PY2021 Plan and/or have low cost-effectiveness that would increase with the addition of non-energy benefits. Cross-program or cross-measure proxies may be used where applicable if no further studies can be found to fill the NEI gaps.

Study 2: Residential ELV Thermostat

Another study we recommend pursuing is a residential electronic line voltage thermostat non-energy impacts study. Conducting research to address the NEI gaps in the line voltage thermostat measures scoring high in the prioritization framework would address the following CETA benefit requirements:

- Public health—Avoided pollution, health & safety
- Environment—Avoided pollution

This study would address both the communicating and non-communicating ELV thermostats in Avista's Multifamily Weatherization program. Both measures are currently receiving partial NEI values due to a unit conversion gap. Further research to provide these measures with all of the NEI values they were matched to in the jurisdictional scan would be low effort and of moderate value to Avista.

Study 3: Low-Income Heat Pump Water Heater

Another small low effort, moderate value study we recommend pursuing is a low-income heat pump water heater non-energy impacts study. Conducting research to address the NEI gap in the low-income heat pump water heater measure would address the following CETA benefit requirements:

- Public health—Avoided pollution, health & safety
- Environment—Avoided pollution
- Reduction of burdens to vulnerable populations—Low income programs

This study would address the unit conversion gap in the Tier 2-3 Heat Pump Water Heater measure in Avista's Low-Income portfolio. The measure is missing an observed savings value that is required to calculate some of the NEI values matched to the measure in the jurisdictional scan.

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13 APPENDICES

13.1 Appendix A: NEI Studies List

Table 24 below shows the list of studies in the Database, including the Study ID, study title, jurisdiction covered in the study, and the published year. DNV does not change the Study ID once the study enters the database. DNV does remove studies from the database over time so some Study IDs are missing from this list (ex. Study 26 has been removed).

Table 24. List of Studies in the Database

Study_ID	Title	State	Year
Study0001	AEP Ohio Non-Energy Impact - Final Report	OH	2018
Study0002	Final Report – Commercial and Industrial Non-Energy Impacts Study	MA	2012
Study0003	C&I New Construction NEI Stage 2 Final Report	MA	2016
Study0004	Non-Energy Impact Framework Study Report	MA	2018
Study0005	Non-Energy Impacts (NEIs) Final Report	MA	2018
Study0006	Non-energy Benefits to Implementing Partners from the Wisconsin Focus on Energy Program: Final Report	WI	2003
Study0007	Non-Energy Impacts (NEI) Evaluation Final Report	NY	2006
Study0008	Determining the Full Value of Industrial Efficiency Programs	WA	1999
Study0009	Ancillary savings and production benefits in the evaluation of industrial energy efficiency measures	CA	2005
Study0010	Capturing the Multiple Benefits of Energy Efficiency	USA	2014
Study0011	Productivity benefits of industrial energy efficiency measures	USA	2001
Study0012	Energy efficiency and carbon dioxide emissions reduction opportunities in the U.S. iron and steel sector	USA	1999
Study0013	Non-Electric Benefits from the Custom Projects Program: A look at the effects of custom projects in Massachusetts	MA	2007
Study0014	Exploring the Application of Conjoint Analysis for Estimating the Value of Non-Energy Impacts	USA	2007
Study0015	C&I Prescriptive Non-Electric Benefits	USA	2003
Study0016	Multiple Benefits of Business Sector Energy Efficiency: A survey of Existing and Potential measures	USA	2015
Study0017	Energy Conservation Also Yields: Capital, Operations, Recognition and Environmental Benefits	USA	2012
Study0019	An Evaluation of the Energy and Non-energy impacts of VT's Weatherization Assistance Program, for VT State Office Of Economic Opportunity	VT	1999
Study0020	Low Income Public Purpose Test (LIPPT 2000)	CA	2000
Study0021	Washington Low-income Weatherization Program, for Pacific Power	WA	2007
Study0022	Low-income Arrearage Study for PacifiCorp	UT	2007
Study0023	2004-2006 Oregon REACH Program	OR	2008
Study0024	Energy Smart Program Evaluation, Oregon HEAT	OR	2008
Study0025	Analysis of Low Income Benefits in Determining Cost-effectiveness of Energy Efficiency Programs	MA	2004
Study0027	Program Progress Report of National Weatherization Assistance Program (Schweitzer and Tonn)	USA	2002

Study0028	Analysis of PG&E's Venture Partners Pilot Program, - PG&E Low Income Weatherization Assistance Program 1994	CA	1994
Study0029	Evaluation of NU - MA ESP Program NEBs	MA	2002
Study0030	Evaluation of NU - CT ESP Program NEBs	CT	2002
Study0032	Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and their Role & Values in Cost-Effectiveness Tests: State of Maryland	MD	2014
Study0033	Memo from J. Oppenheim to Laura McNaughton Low income DSM NEB	USA	2000
Study0034	An Update of the Impacts of Vermont's Weatherization Assistance Program, for VT State OEO Weatherization. Program	VT	2007
Study0035	Low Income Pub Ben Evaluation, Non-Energy Benefits of Wisconsin Low Income Weatherization. Assistance Program, Wisconsin Dept of Admin, DOE	WI	2005
Study0036	Low Income Pub benefits, Wisconsin DOE	WI	2007
Study0037	Assessment of Green Jobs Created by the OPA Multifamily Buildings Programs, for Ontario Power Authority	MA	2009
Study0039	Development and Application of Select Non-Energy Benefits for the EmPOWER Maryland Energy Efficiency Programs	MD	2014
Study0040	C1641: Impact Evaluation of the Business and Energy Sustainability Program (prepared for CT Energy Efficiency Board (EEB))	CT	2018
Study0041	New Jersey Natural Gas 2015 SAVEGREEN Evaluation Final Report	NJ	2015
Study0042	Human Health Benefits of Reducing Residential Wood Smoke Emissions in Puget Sound Energy's Service Territory	WA	2018
Study0043	Preliminary Report: Quantifying the Health Benefits of Reduced Wood Smoke from Energy Efficiency Programs in the Pacific Northwest	PNW	2014
Study0044	Public Health Benefits per kWh of Energy Efficiency and Renewable Energy in the United States: A Technical Report	USA	2019
Study0045	Assessment of the Costs Avoided through Energy Efficiency and Conservation Measures in Maryland	MD	2014
Study0046	Macroeconomic Impacts of Rhode Island Energy Efficiency Investments	RI	2014
Study0047	Final Washington Low Income Weatherization Program Evaluation for Program Years 2013-2015	WA	2018
Study0048	Washington Low Income Weatherization Program Evaluation, Measurement & Verification Report	WA	2020
Study0049	Human Health Benefits of Reducing Residential Wood Smoke Emissions in PacifiCorp's Washington State Service Territory	WA	2018
Study0050	Human Health Benefits of Reducing Residential Wood Smoke Emissions in Avista Corporation's Service Territory	WA	2018

13.2 Appendix B: Confidence Factor Scoring

Table 25 below shows the CF scoring for the Database studies. Each of the questions are given a weight of 1. The weighted total score is the sum of the scores for each individual question, and a minimum CF floor of 50% is used. Note that some Study ID numbers are omitted in the table below since their CF scores could not be assessed. Original copies of those studies could not be found were only referenced in a different study.

Table 25. Confidence Factor Scoring for Database Studies

Study_ID	1. Is the study measure specific?	2. Is the study segmented by sector?	3. Was the sample drawn using statistical method?	4. Does the study incorporate identifiable economic factors?	5. Does the study not consider any of the following when appropriate: Open-ended questions, Additivity, Double Counting	Weighted Total Score	Adjusted Confidence Factor (no CF below Minimum CF)
Study0001	3	3	3	3	3	15	100%
Study0002	3	3	2	3	2	13	87%
Study0003	3	3	2	3	2	13	87%
Study0004	3	3	2	2	1	11	73%
Study0005	3	3	3	3	1	13	87%
Study0006	1	1	1	2	2	8	53%
Study0007	2	3	2	3	1	11	73%
Study0008	3	2	1	1	0	7	50%
Study0009	2	3	1	1	0	7	50%
Study0010	2	2	2	2	2	10	67%
Study0011	3	2	2	1	0	8	53%
Study0012	3	3	2	1	1	10	53%
Study0013	2	2	2	1	0	7	50%
Study0014	2	1	1	2	2	8	53%
Study0016	3	2	1	2	0	8	53%
Study0017	2	2	1	1	0	6	50%
Study0020	1	3	1	1	1	7	50%
Study0022	1	2	3	2	1	10	67%
Study0025	1	3	1	2	1	8	53%
Study0031	1	2	1	2	3	9	60%
Study0032	2	3	3	2	2	12	80%
Study0035	1	2	2	2	2	9	60%
Study0039	1	2	1	3	1	8	53%
Study0040	3	3	3	3	1	13	87%
Study0041	3	1	2	2	1	9	60%

Study0042	3	3	1	2	0	9	60%
Study0043	3	3	3	3	1	13	87%
Study0044	1	3	3	1	1	9	60%
Study0045	1	1	1	3	0	6	50%
Study0046	1	3	1	3	1	9	60%
Study0047	3	3	3	3	2	14	93%
Study0048	3	3	3	3	2	14	93%
Study0049	3	3	2	3	0	11	73%
Study0050	3	3	2	3	0	11	73%

13.3 Appendix C: Plausibility Scoring Metrics

Table 26 shows the scoring assignment for the end-use UEC efficiency change index. End-use categories that change very little over time are scored higher (maximum of 3) while technologies that change significantly over time are scored lower.

Table 26. End-Use UEC Change Score

Compound Annual Growth Rate by end-use		UEC change score
CAGR <= 3%	End-use with little change over time	3
CAGR >3% but <6%	End-use with some change over time.	2
CAGR >=6%	End-use with significant change over time.	1

Table 27 shows the end-use UEC scores for 2003-2012 using data from CBECS.

Table 27. CBECS End-Use Energy Consumption Scoring

	Electricity energy intensity (thousand Btu/square foot in buildings using electricity for the end use)										
	Total	**Space heating**	**Cooling**	**Ventilation**	**Water heating**	**Lighting**	**Cooking**	**Refrigeration**	**Office equipment**	**Computing**	**Other**
All Buildings-2003	50.7	2.4	6.9	6.2	1.3	19.1	0.3	5.4	1	2.2	6
All buildings - 2012	50	1.7	8.3	8.1	0.5	8.7	3.7	9.1	2.1	5.2	9.1
Compound Annual Growth Rate (CAGR) in UEC	-3.2%	3.9%	-2.0%	-2.9%	11.2%	9.1%	-24.4%	-5.6%	-7.9%	-9.1%	-4.5%
CAGR % of Total Change		(1.21)	0.63	0.91	(3.47)	(2.83)	7.55	1.75	2.45	2.83	1.40
ABS of CAGR	3.2%	3.9%	2.0%	2.9%	11.2%	9.1	24.4%	5.6%	7.9%	9.1%	4.5%
Efficiency change index		1.21	0.63	0.91	3.47	2.83	7.55	1.75	2.45	2.83	1.40
1-3 Score (3 is best, 1 is worst)		**2.0**	**3.0**	**3.0**	**1.0**	**1.0**	**1.0**	**2.0**	**1.0**	**1.0**	**2.0**

Table 28 shows the end-use UEC scores for 2009-2015 using data from RECS.

Table 28. RECS End-Use Energy Consumption Scoring

	Average site energy consumption (million Btu per household using the end use)					
	Total	**Space heating**	**Water heating**	**Air conditioning**	**Refrigerators**	**Other**
All homes-2009	89.6	38.7	16.0	6.8	4.3	26.7
All homes - 2015	77.1	35.3	14.8	7.1	2.6	20.2
Compound Annual Growth Rate (CAGR) in UEC	3.1%	1.6%	1.3%	-0.8%	8.6%	4.8%
CAGR % of Total Change		51%	42%	-27%	280%	155%
ABS of CAGR	3.1%	1.6%	1.3%	0.8%	8.6%	4.8%
Efficiency change index		51%	42%	-27%	280%	155%
1-3 Score (3 is best, 1 is worst)		**3.0**	**3.0**	**3.0**	**1.0**	**2.0**

13.4 Appendix D: Plausibility Combinations

Table 29 shows the PF scores for the possible combinations of study age, UEC efficiency change index, and match level. Studies that are less than 5 years old receive the highest Age of Study Score while studies that are greater than 15 years old receive the lowest score.

Table 29. Plausibility Factor Scoring Table (assumes equal weighting)

Age of Study Score (<5, score=4) (6-10, score=3) (11-15, score=2) (>15, score=1) (A)	Unit Energy Consumption Change Score (B)	Matching Level Score (C)	Total Score (A+B+C)	% of Max Score (A+B+C)/13	Adjusted Plausibility Factor (No PF below Min PF)
4	3	6	13	100%	100%
4	3	5	12	92%	92%
3	3	6	12	92%	92%
4	2	6	12	92%	92%
4	3	4	11	85%	85%
3	3	5	11	85%	85%
2	3	6	11	85%	85%
4	2	5	11	85%	85%
3	2	6	11	85%	85%
4	1	6	11	85%	85%
4	3	3	10	77%	77%
3	3	4	10	77%	77%
2	3	5	10	77%	77%
1	3	6	10	77%	77%
4	2	4	10	77%	77%
3	2	5	10	77%	77%
2	2	6	10	77%	77%
4	1	5	10	77%	77%
3	1	6	10	77%	77%
4	3	2	9	69%	69%
3	3	3	9	69%	69%
2	3	4	9	69%	69%
1	3	5	9	69%	69%
4	2	3	9	69%	69%
3	2	4	9	69%	69%
2	2	5	9	69%	69%
1	2	6	9	69%	69%
4	1	4	9	69%	69%
3	1	5	9	69%	69%
2	1	6	9	69%	69%
3	3	2	8	62%	62%

2	3	3	8	62%	62%
1	3	4	8	62%	62%
4	2	2	8	62%	62%
3	2	3	8	62%	62%
2	2	4	8	62%	62%
1	2	5	8	62%	62%
4	1	3	8	62%	62%
3	1	4	8	62%	62%
2	1	5	8	62%	62%
1	1	6	8	62%	62%
2	3	2	7	54%	54%
1	3	3	7	54%	54%
3	2	2	7	54%	54%
2	2	3	7	54%	54%
1	2	4	7	54%	54%
4	1	2	7	54%	54%
3	1	3	7	54%	54%
2	1	4	7	54%	54%
1	1	5	7	54%	54%
1	3	2	6	46%	50%
2	2	2	6	46%	50%
1	2	3	6	46%	50%
3	1	2	6	46%	50%
2	1	3	6	46%	50%
1	1	4	6	46%	50%
1	2	2	5	38%	50%
2	1	2	5	38%	50%
1	1	3	5	38%	50%
1	1	2	4	31%	50%

13.5 Appendix E: Non-energy Impact Theory

NEIs for Residential Programs

A key concern for program evaluation is ensuring that the benefits claimed by utilities reflect true economic gains to the jurisdiction. This theoretical background focuses on how incentivizing technological change through EE results in economic benefits that manifest through increased wellbeing for consumers and increased profit for producers. We then define the factors used to adjust different types of NEIs that apply to residential programs.

EE programs result in NEIs that impact consumer or producer surplus[5 6 7], which reflect changes to the economic efficiency of society. By incorporating NEIs into TRC cost-efficiency tests, policy makers can better measure the economic efficiency of EE programs on the population.[8]

The concept of NEIs stems largely from the hedonic price theory of property values and wages developed by Rosen.[9] This theory states that "housing prices reflect differences in the quantities of various characteristics of housing and that these differences have significance in applied welfare analysis."[10,11] Rosen (1976) shows that house price is derived from the wellbeing (utility) that one receives from occupying a residence with a given set of attributes. One set of the attributes included in the individual's utility are the improved amenities, health, and well-being resulting from EE measures:

U(z, x, s):

Where

Hedonic z - measures the individual attributes of each housing unit

x – all other goods the household can purchase

s – measures the characteristics of the household residents (are they old, do they swim, how many people, how many cars)

The individual's utility function and budget constraints are then used to determine the individual's marginal utility (or demand) for the housing attributes at different prices, holding their income constant. The price function shows the bundles of housing attributes at which the household's willingness to pay for a property with that bundle of attributes is equal to its market price.

Given Rosen's theory, an individual's demand for housing represents the trade-off they are willing to make between receiving bundles of these attributes at different prices, given their income constraint and level of technology in the home. The maximum bundle of attributes they can afford is restricted by their income and a measure of their total wellbeing. Figure 4 shows an individual's demand for the housing attributes they receive at different prices before EE improvements (Demand

5 Consumer Surplus as defined by Nicolson (1995) is "the Difference between the total value consumers receive from the consumption of a particular good and the total amount they pay for the good. It is the area under the compensated demand curve and above the market price, and can be approximated by the area under the Marshallian demand curve and above the market price."

6 Producer Surplus as defined by Nicolson (1995) is "the additional compensation a producer receives from participating in market transactions rather than having no transactions. Short-run producer surplus consists of short-run profits plus fixed-costs. Long-run producer surplus consists of short-run producer surplus plus increased rents earned by inputs. In both cases the concept is illustrated as the area below market price and above the respective supply (marginal cost) curve."

7 Nicholson, Water. "Microeconomic Theory: Basic Principles and Extensions." Sixth edition. Dryden Press. Harcourt Brace College Publishing. 1995.

8 The Total Resource Cost (TRC) Test measures the net cost of an energy conservation program, viewing the program as a utility resource option. Both utility and participant costs and benefits are included. The TRC Test reflects the impacts of a program on both participating and non-participating customers. The test provides a measure of the cost-effectiveness of a utility-sponsored EE program, per the California Standard Practice Manual. https://beopt.nrel.gov/sites/beopt.nrel.gov/files/help/Total_Resource_Cost_Test.htm

9 Rosen, Sherwin. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," Journal of Political Economy 82, no. 1 (Jan. - Feb., 1974): 34-55.

10 Freeman III, Merick A. "The Measurement of Environment and Resource Values: Theory and Methods." Resources for the Future. Washington D.C. 1993.

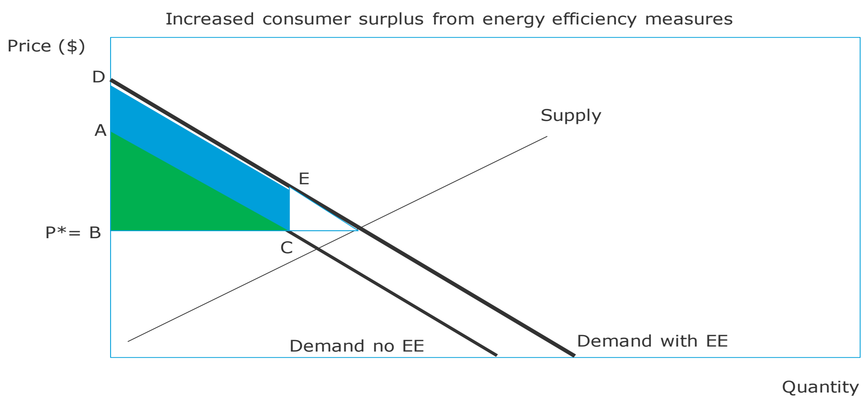
11 Rosen makes a similar case for the value of wages.

no EE). The supply of housing attributes is measured by S, providing a market clearing price for housing of P. Notice that the demand curve extends above the market clearing price, P. This is because residents would be willing to pay incrementally more for the initial set of housing attributes from market clearing point C up to point A, but they only pay one price for each unit of housing they purchase. The amount measured by triangle ABC is called Consumer Surplus. It measures the additional benefit consumers receive for paying only one price for the housing attributes they receive, rather than separate prices for each unit they receive.

Introducing EE improvements into their existing home represents a technological change to the home that raises the level of attributes the homeowner receives at each price point. In economic theory, this is explained as increasing the homeowner's utility (or wellbeing) while holding their income constant. In other words, when a person invests in improved insulation for their home, they receive energy impacts through reduced costs, but they also experience greater comfort and possibly greater health. The impact of these added benefits to consumers is shown by shifting their demand curve up to the right. This means for all prices, they now receive additional housing attributes that were previously only attainable through increased income. This implies that investing in EE measures increases the value of a home because the overall bundle of attributes offered by the home increases. However, the resident does not have to pay any more for their home because their price is fixed (i.e., they have a mortgage or lease with a fixed price). Therefore, they are seen to receive increased benefit, or wellbeing, beyond what they originally paid.[12]

In another example, an upgraded HVAC system can increase health and improve comfort. These benefits provide a range of benefits that were not included in price P, the price the homeowner paid for their home. This increase in benefits reflects an increase in that resident's demand for their home, shifting the demand curve out and to the right. This shift means that residents would be willing to pay more for each additional unit of housing they receive, however, the price they pay is fixed at point P* since they are most likely locked into a mortgage or lease. The additional benefits they receive can be measured by the area ACED. Residents will receive these benefits until they sell their home, at which time the benefits translate into an increase in property value and are included in the price of their home. The focus on NEI studies is to estimate these economic benefits absent the market transaction.[13]

Figure 4. Impact of NEIs on consumer surplus



NEIs for C&I Programs

For commercial and industrial (C&I) customers, NEIs reflect increased profitability resulting from EE measures. The increase in profitability can exist either because the installed measures decreased the cost of production (such as reduced O&M costs) or increased revenue (such as increased sales or production). Theoretically, a firm would be willing to pay more for a

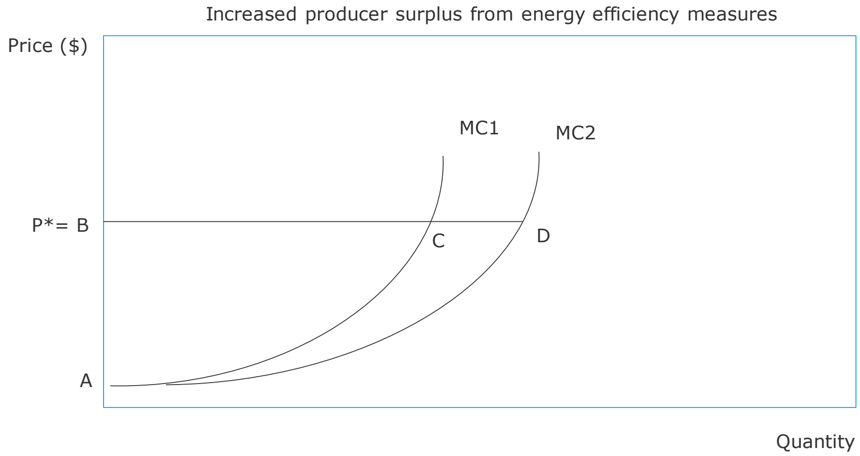
[12] Once they sell their home, this increased value will translate into an increase in price, but they still receive the increased value in terms of increased wellbeing prior to selling their home.

[13] The willingness-to-pay techniques outlined in 110 are well documented and used extensively to estimate such impacts

facility that either lowered its costs of production or increased revenues. Again, because rents typically do not change unless the firm renegotiates a lease or sells the facility, this provides increased profitability.

Figure 5 presents the impact of EE measures on the O&M costs and profitability of a firm. The figure shows that, prior to installing EE measures, the firm operates with marginal costs MC_1, which reflects the cost of producing each additional unit of a product, with market clearing price of P*, denoted by point B. The firm's profit can be measured by the area of the shape ABC. If the firm then installs EE equipment that reduces their marginal costs of production, this shifts the marginal cost curve out and to the right. This means they can produce more for each unit of cost they incur. This change in costs results in an increase in profitability that can be measured by the shape ACD. This increase in profit is one measure of NEIs resulting from the installation of EE measures. Other NEIs may impact profit through direct revenue increases resulting from increased sales.

Figure 5. Impact of EE on O&M costs and profit



Finally, firms may also experience an increase in revenue resulting from increased sales. For example, installing LEDs is argued to improve the visual display of showrooms. If this results in greater sales, this will increase the firm's revenue directly which can be measured by the formula:

$$Revenue = (Price\ of\ the\ good) \times (Quantity\ sold)$$

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DNV is a global quality assurance and risk management company. Driven by our purpose of safeguarding life, property and the environment, we enable our customers to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas, power and renewables industries. We also provide certification, supply chain and data management services to customers across a wide range of industries. Operating in more than 100 countries, our experts are dedicated to helping customers make the world safer, smarter and greener.