2023 Electric Integrated Resource Plan

Appendix D – DNV Non-Energy Impact Studies

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

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

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

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

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.

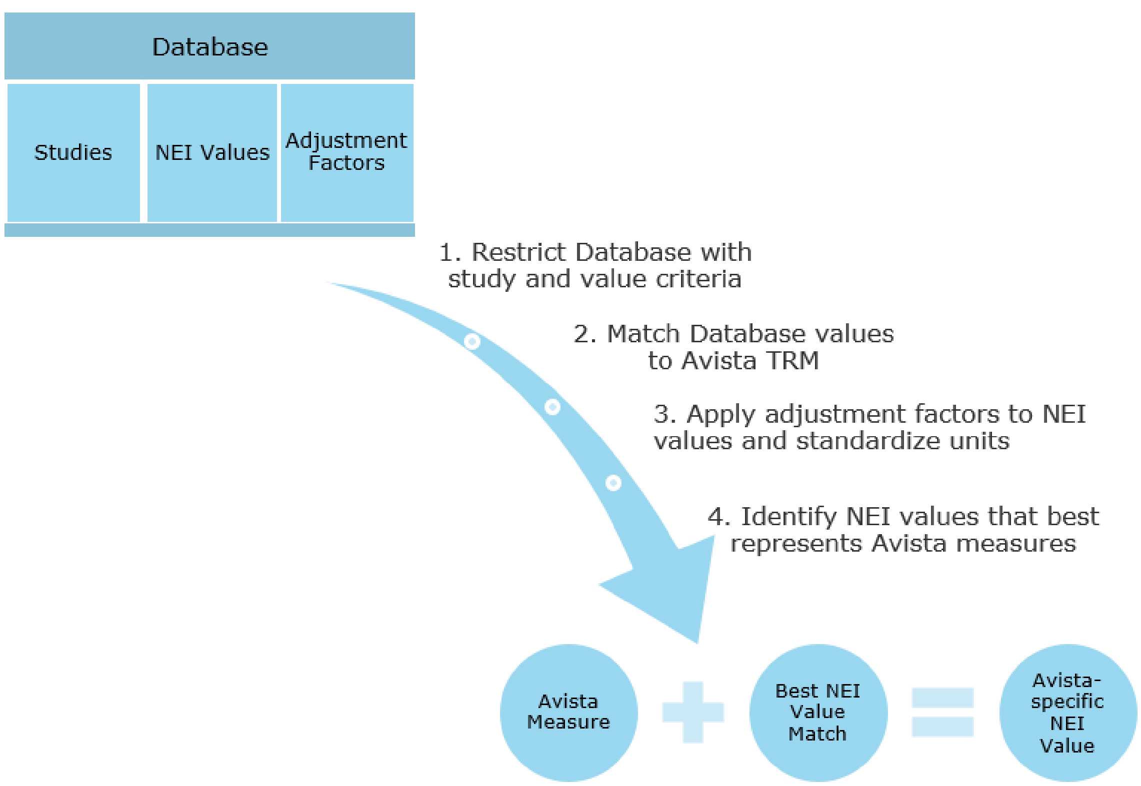
$$\$0.88/Installed\ Measure/Year_{MA} * 0.81_{Health\ Adj} = \$0.71/Installed\ Measure/Year_{Avista}$$

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

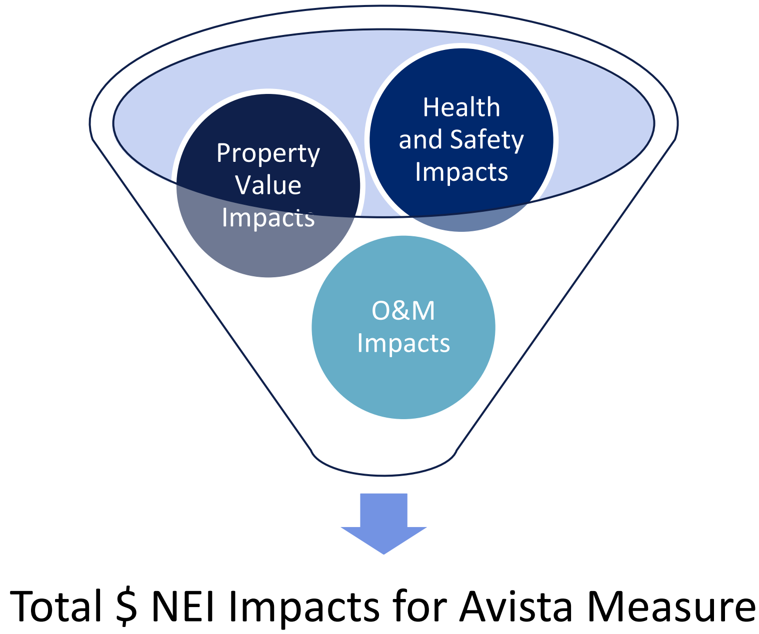
$$\$NEI\ per\ energy\ impact_{Avista} = \frac{\$\ NEI\ per\ project\ per\ lifetime}{Lifetime\ of\ measure_{Avista}} * \frac{1}{Average\ \#\ of\ L5\ measures\ per\ project} * \frac{1}{Energy\ impact\ per\ measure_{Avista}}$$

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.

12 REFERENCES

ACS 1 Year Detailed Tables State. (2017). Retrieved from U. S. Census: https://www2.census.gov/programs-surveys/acs/summary_file/2018/data/1_year_detailed_tables/State/

ACS 5 Year Detailed Tables County. (2020). Retrieved from U. C. Bureau: https://www2.census.gov/programs-surveys/acs/summary_file/2019/data/5_year_by_state/

BEA. (2018, May). *Regional Price Parities by state*. Retrieved from Bureau of Economic Analysis: https://apps.bea.gov/iTable/iTable.cfm?acrdn=6&isuri=1&reqid=70&step=1%23reqid=70&step=1&isuri=1

BEA. (2019). Retrieved from GDP and Personal Income by County: https://apps.bea.gov/itable/iTable.cfm?ReqID=70&step=1

BLS. (2018, March). *Occupational Employment Statistics - Employment*. Retrieved from Bureau of Labor Statistics: https://www.bls.gov/oes/current/oes_research_estimates.htm

BLS. (2018, March). *Occupational Employment Statistics - Wage*. Retrieved from Bureau of Labor Statistics: https://www.bls.gov/oes/tables.htm

BLS. (2019). Retrieved from Occupational Employment Statistics: https://www.bls.gov/oes/current/oes_44060.htm

Bureau, U. C. (2015). *ACS Educational Attainment by Degree-Level and Age-Group (American Community Survey)*. Retrieved from http://www.higheredinfo.org/dbrowser/index.php?measure=93

Consumer Price Index. (2020). Retrieved from Federal Reserve Bank of Minneapolis: https://www.minneapolisfed.org/about-us/monetary-policy/inflation-calculator/consumer-price-index-1913-

EIA. (2016). *State Energy Data System 2016: Consumption Technical Notes.* Energy Information Administration: State Energy Data System.

EIA. (2018, May). *Residential Energy Consumption Survey (RECS)*. Retrieved from Energy Information Agency: https://www.eia.gov/consumption/residential/data/2015/index.php?view=microdata

EIA. (2018, June 29). *State Energy Data System (SEDS): 1960-2016 (complete)*. Retrieved from Energy Information Agency: https://www.eia.gov/state/seds/seds-data-complete.php?sid=US#Consumption

EIA Electricity Data. (2019). Retrieved from EIA: https://www.eia.gov/electricity/data.php#sales

Guzman, G. G. (2018). *Household Income: 2017 (Tables B19049, B25007, B20004).* US Census Bureau. Retrieved from US Census Bureau: https://www.census.gov/content/dam/Census/library/publications/2018/acs/acsbr17-01.pdf

KFF. (2014). *Health Care Expenditures per Capita by State of Residence*. Retrieved from Kaiser Family Foundation: https://www.kff.org/other/state-indicator/health-spending-per-capita/?currentTimeframe=0&selectedRows=%7B%22wrapups%22:%7B%22united-states%22:%7B%7D%7D,%22states%22:%7B%22all%22:%7B%7D%7D%7D&sortModel=%7B%22colId%22:%22Health%20Spending%20per%20Capita%22,

Medicare Geographic Variation, Public Use Files. (2018). Retrieved from Centers for Medicare & Medicaid Services (CMS): https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Medicare-Geographic-Variation/GV_PUF

NAICS. (2017). *North American Industry Classification System.* Washington D.C.

USCB. (2018). *Household Income: 2017 (Tables B19049, B25007, B20004, B25127, B25037).* US Census Bureau. Retrieved from US Census Bureau: https://www.census.gov/content/dam/Census/library/publications/2018/acs/acsbr17-01.pdf

Utility Electricity Sales. (2020). Retrieved from U.S. Energy Information Administration: https://www.eia.gov/electricity/data.php#sales

Utility Natural Gas Sales. (2020). Retrieved from U.S. Energy Information Administration: https://www.eia.gov/naturalgas/ngqs/#?report=RP4&year1=2019&year2=2019&company=ID_Name

Washington Employment Security Department. (2018). Retrieved from Median and hourly wages: https://esd.wa.gov/labormarketinfo/median-hourly-wages

Washington Office of Financial Management. (2017). Retrieved from Median Household Income Estimates: https://ofm.wa.gov/washington-data-research/economy-and-labor-force/median-household-income-estimates

Zillow. (2018). *Zillow Research*. Retrieved from Zillow: https://www.zillow.com/research/data/

Zillow Rent Index (ZRI) Summary. (2017). Retrieved from data.world: https://data.world/zillow-data/zri-summary

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

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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.

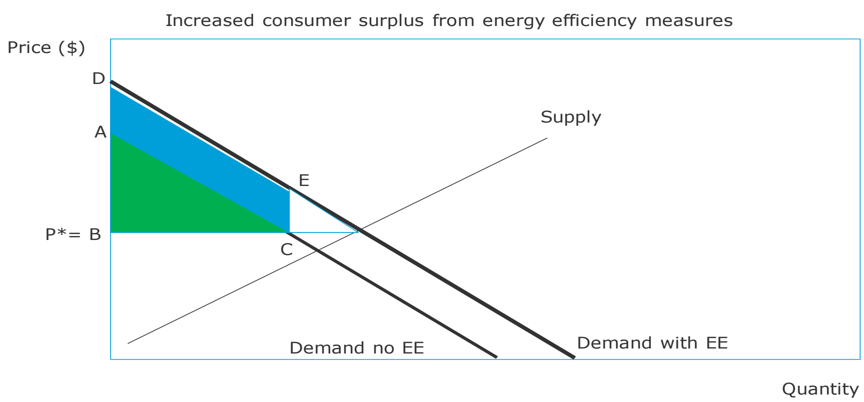
11 Rosen makes a similar case for the value of wages.

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

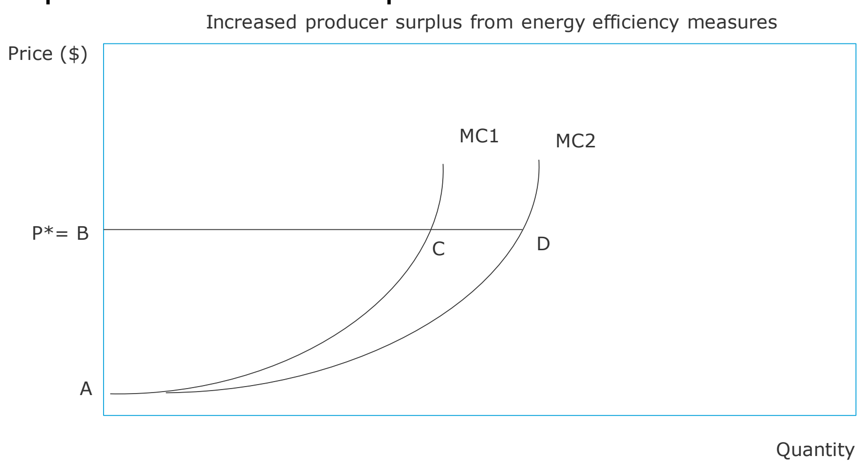
[12] Once they sell their home, this increased value will translate into an increase in price, but they still receive the increased value in terms of increased wellbeing prior to selling their home.

[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:

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

About DNV

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.

FINAL REPORT

Supply Side Non-Energy Impacts

Avista

Date: April 8, 2022

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1 INTRODUCTION

The goal of this project is to provide Avista with quantitative ($/MWh, $/kW) estimates of non-energy impacts (NEIs) for a variety of generation technologies and scenarios. Washington's Clean Energy Transition Act (CETA; https://www.commerce.wa.gov/growing-the-economy/energy/ceta/) requires investor-owned utilities to consider equity-related NEIs in integrated resource plans (IRPs). To accomplish this, DNV is building and applying a supply-side NEI database. As part of a previous project, DNV provided Avista with demand-side NEIs for measures included in energy efficiency programs. With the addition of supply-side NEIs, Avista, its advisory groups, and the Utilities and Transportation Commission (UTC) will be able to assess the full societal costs and benefits of all possible permutations of generation and efficiency options in future IRPs.

2 METHODOLOGY OVERVIEW

To compare the sustainability of different generator types, academic researchers use a method known as multi-criteria decision analysis (MCDA).[1,2] This process is conceptually similar to the preferred resource strategy (PRS) used in Avista's 2021 IRP to consider the different effects of each generator type on a variety of factors. Academic MCDA tends to include a wider range of sustainability effects than the PRS, specifically additional health, environmental, and economic effects; these are exactly the types of effects that Avista wants to quantify. These additional effects will help Avista factor into the PRS calculations more of these hidden costs and benefits that go beyond levelized cost of delivered energy to its customers (LCOE). DNV will add a monetization step to the MCDA methods to align the data into units that make it easier to integrate into the PRS.

Estimating NEIs can be a very complicated and nuanced endeavor. Specific documentation guidelines for investor-owned utilities are still being developed and will likely vary by state once completed.

DNV's approach is designed to produce defensible, levelized costs and benefits per MWh or kW, in such a way that they can be added directly to Avista's existing LCOE by generator type, for a variety of additional sustainability effects not yet considered in Avista's 2021 IRP. The approach follows four stages:

1. Conduct a jurisdictional scan to identify additional NEIs being used elsewhere and not listed in the RFP
2. Identify NEIs available through federal and regulatory publications
3. Where necessary, convert NEI units to $/MWh and/or $/kW values and apply discount rates
4. Conduct a gap analysis to provide recommendations to prioritize future research based on the necessary level of effort and anticipated value to Avista

Where available, DNV leveraged existing metanalytic data published by regulatory and government institutions such as the Environmental Protection Agency (EPA) and the National Renewable Energy Laboratory (NREL). Such official values should be readily defensible. In cases where institutional studies were not available, DNV conducted secondary research to identify data sources. Cases in which DNV was unable to identify a published data source are part of the gap analysis.

After compiling a database of NEI types (e.g., health) and values ($/MW or $/MWh) by generation technology, DNV applied the information in the database to the specific generation technologies and scenarios identified in the RFP and Avista's current generation assets.

[1] Klein, S.J. and Whalley, S. (2015). Comparing the sustainability of U.S. electricity options through multi-criteria decision analysis. Energy Policy79(2015)127–149. http://dx.doi.org/10.1016/j.enpol.2015.01.007

[2] Nock, D. and Baker, E. (2019). Holistic multi-criteria decision analysis evaluation of sustainable electric generation portfolios: New England case study. Applied Energy 242 (2019) 655–673. https://doi.org/10.1016/j.apenergy.2019.03.019

3 DATABASE COMPILATION

Database compilation involves conducting secondary research to identify and catalog the NEI values in terms of native units (e.g., tons of pollution per MWh) and to monetize those units ($/MWh or $/MW) for each level in the database. Once prepared, the database is a single location that DNV and Avista can apply to specific scenarios and generation assets.

3.1 Database structure

The database includes NEI impacts disaggregated by resource type, location, and lifecycle phase whenever possible. The resource types are shown in Table 3-1. These resources include both current and potential resource types. The abbreviations in the table are used in the tables and figures throughout the report. The database application is explained in Section 3.4.

Table 3-1. Database resource types

Group	Technology	
	Abbreviation	Generator Types
Biomass	Biomass	Biomass
Coal	Coal	Coal
	Coal CCS	Coal with Carbon Capture
Hydro	Hydro-PB	Pumped hydro - brownfield
	Hydro-GF	Pumped hydro - greenfield
	Hydro-Res	Reservoir hydro
	Hydro-RR	Run-of-river hydro
	Hydro-RRS	Run-of-river hydro with storage
Hydrogen electrolyzer	HE-LG	Hydrogen electrolyzer - large
	HE-SM	Hydrogen electrolyzer - small
Lithium-ion storage	Batt-LG	Lithium-ion Storage - Large
	Batt-SM	Lithium-ion Storage - Small
Natural gas	NG-Aero	Natural gas Aero Turbine
	NG-CCCT	Natural gas CCCT
	NG-CT	Natural gas CT
	NG-ICE	Natural gas internal combustion engine
Non-natural gas	NNG-Bio	Non-natural gas (Bio-fuel)
	NNG-CF	Clean Fuel Turbine
	NNG-Hyd	Non-natural gas (Hydrogen)
	NNG-LAir	Non-natural gas (Liquid air)
	NNG-Ren	Renewable natural gas storage tank
Nuclear	Nuclear	Nuclear
Solar	Solar-Com	Community solar
	Solar-Rft	Rooftop solar
	Solar-Utl	Utility-scale solar
Wind	Wind-LG	Large wind
	Wind-Off	Off-shore wind
	Wind-SM	Small Wind

Near/Away: For some NEI metrics, the database also includes values disaggregated into near and away from the resource site. Near-resource site impacts occur at the operations facility or nearby communities whereas impacts away from the resource site may occur in a different county, state, or country. This distinction provides the flexibility to assign near-facility impacts within or without Avista's territory depending on the location of the resource.

Generation Resource Phase: When possible, NEI metrics are also disaggregated by generation resource phase, including construction, operations, mining, and decommissioning, which are further described in Table 3-2.

Table 3-2. Generation resource phase

Phase	Description
Construction	Impacts specific to construction or manufacturing of the generation resource
Operation	Impacts associated with the operations of the generation resource
Mining	Impacts associated with fuel mining
Decommissioning	Impacts associated with decommissioning and disposing of the generation resource

3.2 Non-energy impact metrics

This section describes DNV's methods for determining values for each of the NEI types.

3.2.1 Public health

Electricity-generating technologies can cause a variety of public health impacts across their life cycles, from construction and manufacturing of components to operations and mining to decommissioning. Operational impacts due to particulate matter 2.5 ($PM_{2.5}$), sulfur dioxide (SO_2), and nitrogen oxide (NO_x) emissions are readily available across many electricity-generating technologies.[3] These emissions values can be used to estimate monetized health impacts across different counties in the US by utilizing readily available tools from the EPA. Table 3-3 summarizes the metrics used to quantify operational public health impacts.

Table 3-3. Public health metric descriptions

Metric	Description	Sources
$PM_{2.5}$ Health Effects	Particulate matter 2.5 ($PM_{2.5}$) emissions are produced through fossil fuel, biomass, and other combustion to generate electricity. Increased $PM_{2.5}$ emissions are associated with increased mortality rates, respiratory and cardiovascular illnesses, and other impacts which the COBRA model monetizes. DNV used information from eGRID and the EPA to estimate $PM_{2.5}$ emissions and COBRA to monetize them, resulting in a dollar per MWh value.	COBRA[4]; eGRID[5]; EPA[6]
SO_2 Heath Effects	Sulfur dioxide (SO_2) emissions are also emitted through combustion to produce electricity. Increased SO_2 emissions are associated with increased respiratory diseases and breathing difficulty.[7] DNV used the eGRID emissions estimates and the COBRA model to produce a dollar per MWh health impact metric.	COBRA[8]; eGRID[9]
NO_x Health Effects	Nitrogen oxides (NOx) are also produced through combustion to generate electricity. Increased NO_x emissions are associated with increased respiratory diseases, particularly asthma, hospital admissions, and emergency room visits.[10] DNV used the eGRID emissions estimate and the COBRA model to produce a dollar per MWh health impact for NO_x.	COBRA[11]; eGRID[12]

33 These emissions and health impacts do not include health impacts from upstream or downstream activities including mining, drilling, manufacturing, or disposal. Additionally, they do not include operational health impacts from soil or water contamination.

4 User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA). 2021. US EPA. November 2021. https://www.epa.gov/cobra.

5 United States Environmental Protection Agency (EPA). 2022. "Emissions & Generation Resource Integrated Database (eGRID), 2020" Washington, DC: Office of Atmospheric Programs, Clean Air Markets Division. Available from EPA's eGRID web site: https://www.epa.gov/egrid.

6 Estimating Particulate Matter Emissions for EGRID. 2020. US EPA. July 2020. https://www.epa.gov/sites/default/files/2020-07/documents/draft_egrid_pm_white_paper_7-20-20.pdf.

7 United States Environmental Protection Agency (EPA). (n.d.). "Sulfur Dioxide Basics" EPA. Retrieved February 1, 2022, from https://www.epa.gov/so2-pollution/sulfur-dioxide-basics#effects

8 Ibid

9 Ibid

10 United States Environmental Protection Agency (EPA). (n.d.). "Basic Information about NO2" EPA. Retrieved February 1, 2022, from https://www.epa.gov/no2-pollution/basic-information-about-no2#Effects

11 Ibid

12 Ibid

3.2.1.1 Emissions values

The EPA has a comprehensive database of environmental characteristics of almost all electric power generated in the US. The Emissions and Generation Resource Integrated Database (eGRID) contains data on emissions, emissions rates, generation, heat input, and many other characteristics.[13] Values from eGRID were used to supplement data provided directly by Avista for existing and proposed generation resources. DNV combined information from the two sources for plant annual heat input from combustion (MMBtu), total emissions from NO_x (tons), total emissions from SO_2 (tons), and plant annual net generation (MWh). Total emissions from $PM_{2.5}$ are not available in eGRID, however, the EPA provides $PM_{2.5}$ estimates for most electric generating units in a separate database based on the EPA's National Emissions Inventory (NEI).[14] Total emissions for $PM_{2.5}$, NO_x, and SO_2 were converted into tons/MWh based on the annual net generation from each electric generating unit.

Figure 3-1 through Figure 3-3 present the $PM_{2.5}$, SO_2, and NO_x emissions per MWh for both existing and proposed generation types. Both the existing and proposed biomass plants have the highest $PM_{2.5}$ emissions rates, followed by the existing and proposed coal plants. It is important to note that while for most technologies, the assumed counterfactual would be producing no emissions or similar emissions if the fuel were burned in a different power plant, the biomass counterfactual is less well defined. The Kettle Falls biomass facility burns sawmill or chip mill biomass residuals. In the absence of the Kettle Falls facility, it is difficult to say how the waste material would have been used and what the likely emissions would have been. The existing and proposed coal plants also had the highest SO_2 emissions, while the Northeast natural gas plant had the highest NO_x emissions. Hydro, wind, and solar had no $PM_{2.5}$, SO_2, or NO_x emissions. For SO_2 and NO_x, the coal with carbon capture and storage resource is assumed to have the same emissions rate as the current Coal Strip facility, as this is the best available data. In practice, the SO_2 and NO_x emissions rate for the coal with carbon capture and storage may be lower.

[13] United States Environmental Protection Agency (EPA). 2022. "Emissions & Generation Resource Integrated Database (eGRID), 2020" Washington, DC: Office of Atmospheric Programs, Clean Air Markets Division. Available from EPA's eGRID web site: https://www.epa.gov/egrid.

[14] US EPA. 2020. Review of Estimating Particulate Matter Emissions for EGRID: Draft White Paper. https://www.epa.gov/sites/default/files/2020-07/documents/draft_egrid_pm_white_paper_7-20-20.pdf.

Figure 3-1. Operational $PM_{2.5}$ emissions per MWh by generation type

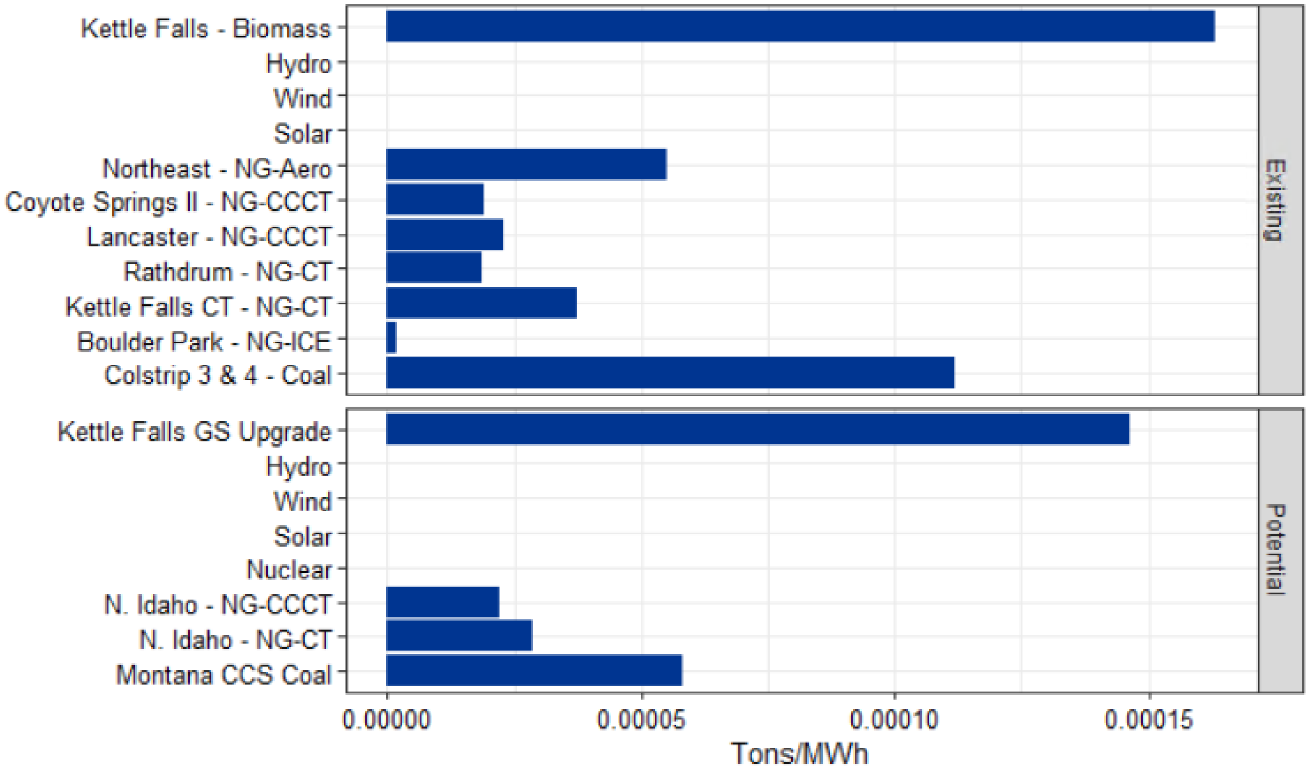


Figure 3-2. Operational SO_2 emissions per MWh by generation type

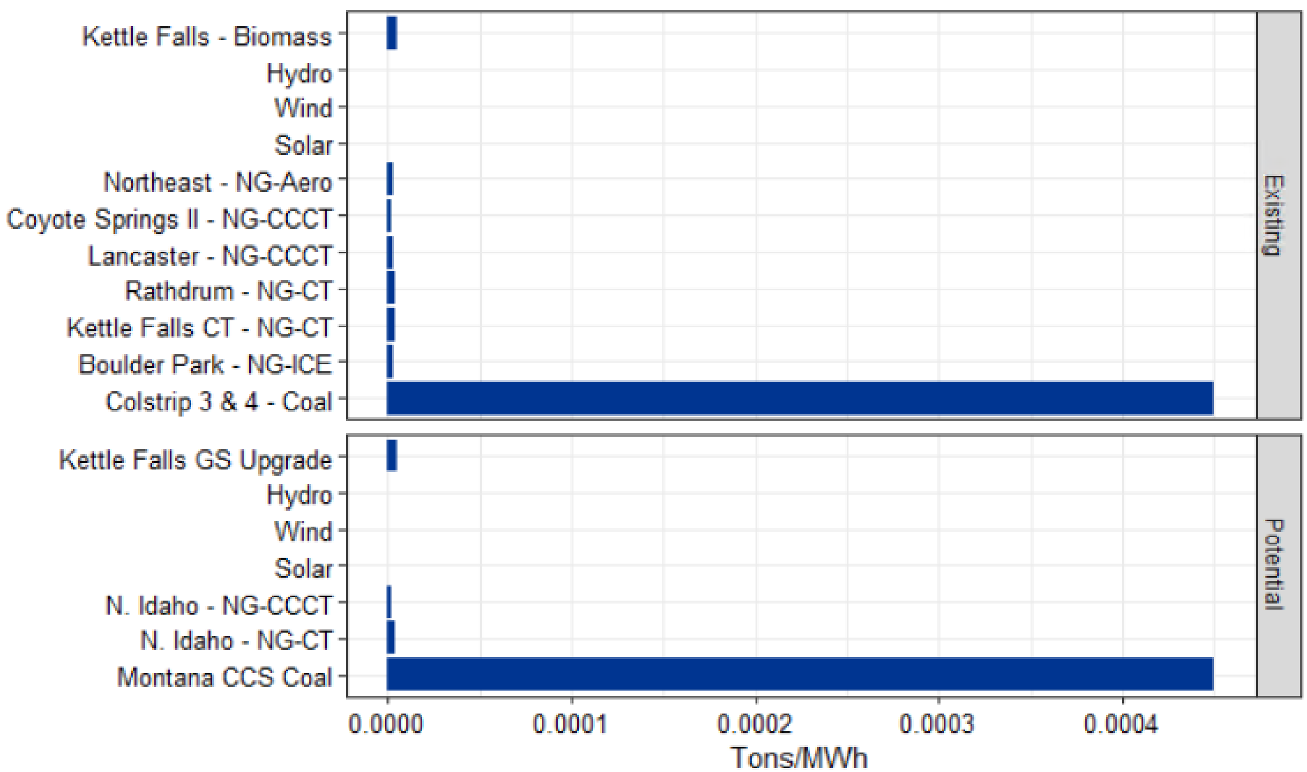
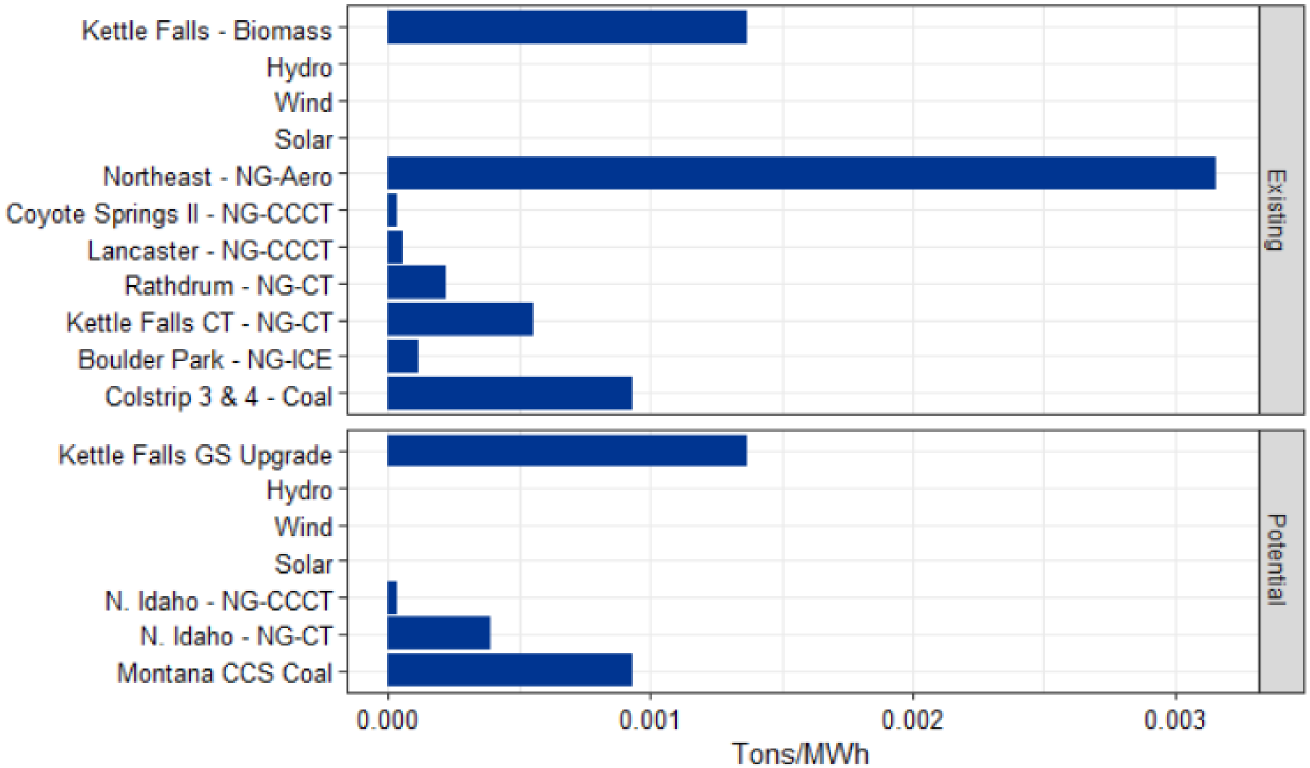


Figure 3-3. Operational NO_X emissions per MWh by generation type



3.2.1.2 Monetized impacts

Co-Benefits Risk Assessment (COBRA) is a screening and modeling tool provided by the EPA that can be used to explore how changes in air pollution can affect human health in different areas of the country and estimate the economic value of the health benefits associated with those changes.[15] [16] Emissions changes are entered at the county, state, or national level, and COBRA uses an air quality model to estimate the effects of those emissions changes across the country. The model then estimates the number of health incidences avoided and the economic value for health impacts such as mortality, non-fatal heart attacks, and respiratory admissions. The monetization for these health conditions is based on values such as the willingness to pay, the cost of illness, and the value of a statistical life that were collected from various literature reviews. DNV modeled the impacts of $PM_{2.5}$, SO_2, and NO_X emissions in the counties where combustion generation technologies, including coal, natural gas, and biomass, either exist or are proposed. When emissions are changed in one county, the COBRA model produces the monetized impacts for every county in the United States. DNV categorized those impacts in the following way:

- **Site county**: The monetized health costs in the county where the generation resource is located. Resources may be located within or outside Avista's territory.
- **Avista territory**: The monetized health costs in Avista's territory. If the site county is within Avista's service territory, those costs are not included in this estimate; in this case, total cumulative effects within Avista territory will equal the sum of the site county and Avista territory effects.

[15] User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA). 2021. US EPA. November 2021. https://www.epa.gov/cobra.

[16] It should be noted that this study assumes Avista complies with existing permitting laws that establish maximum levels of pollution that utilities are allowed to produce. While legally acceptable, these allowances do not imply that only pollution over those thresholds results in harm. Instead, they essentially establish a maximum amount of harm that a utility is legally allowed to cause.

- **Other US**: The monetized health costs for the rest of the United States

DNV combined emissions information from eGRID and Avista with the monetized health impacts from COBRA to estimate the economic impact on health from a one-ton increase in $PM_{2.5}$, SO_2, NO_x (Equation 1).

Equation 1. Monetized health impacts

$$Monetized\ Health\ impacts\left[\frac{\$}{MWh}\right] = Emissions\left[\frac{tons}{MWh}\right] \times Health\ Impacts\ from\ pollutant\left[\frac{\$}{ton}\right]$$

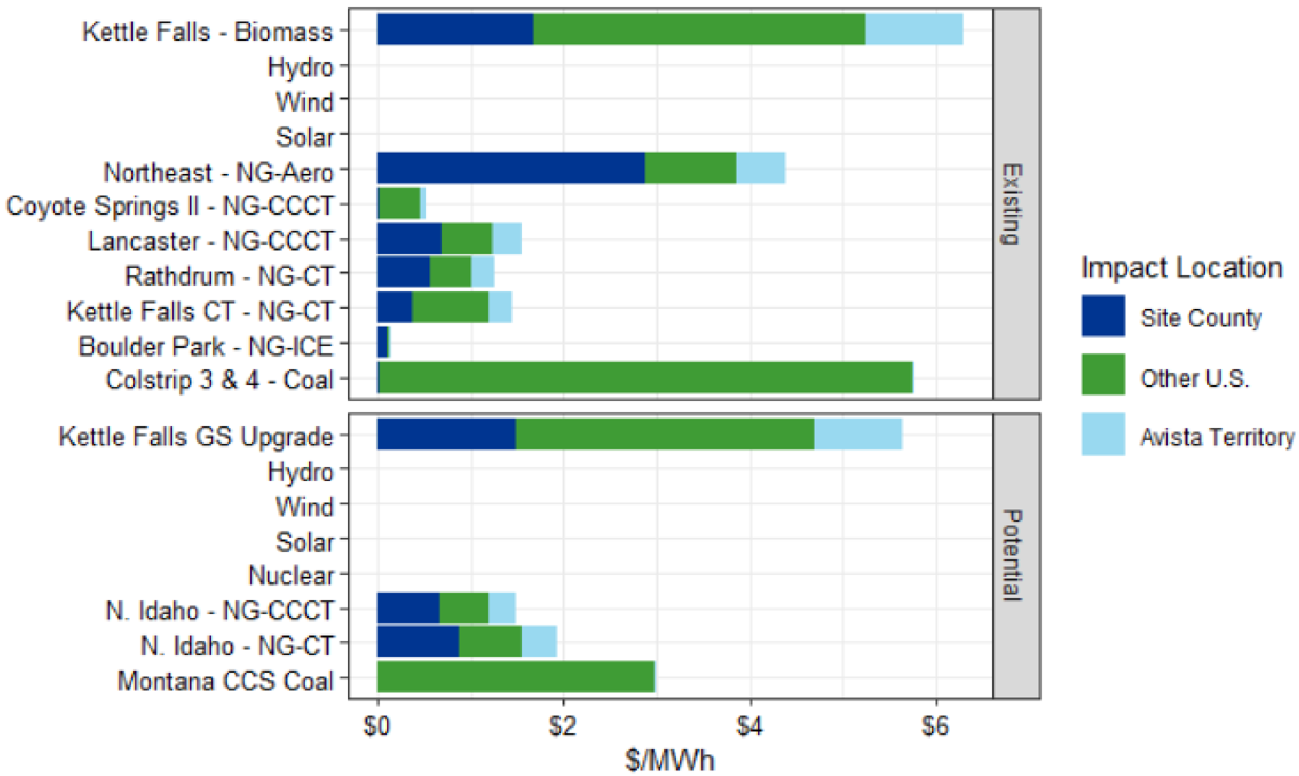
Table 3-4 displays dollars per ton of $PM_{2.5}$, NO_x, and SO_2 for each of the counties where an existing plant is located. COBRA estimates the public health costs of a change in pollutant levels by county. Estimates were only available for combustion generation technologies such as coal, gas, or biomass. The counties included in the table above are where existing plants are currently located.

Table 3-4. Dollars per ton by County

Plant County	PM2.5 ($/ton)			NOx ($/ton)			SO2 ($/ton)		
	Site County	Avista Territory	US-Other	Site County	Avista Territory	US-Other	Site County	Avista Territory	US-Other
Rosebud, MT	118.81	172.40	51,361.34	7.88	33.59	9,973.72	12.22	75.28	22,473.09
Kootenai, ID	30,724.75	13,558.21	23,330.00	1,508.19	761.88	4,304.93	2,060.74	1,071.30	10,101.90
Spokane, WA	52,237.59	9,523.47	17,869.91	2,678.17	489.07	3,266.53	3,749.00	713.52	7,578.78
Morrow, OR	1,268.66	2,891.67	23,471.96	65.68	290.51	3,038.00	253.43	1,192.13	13,335.49
Stevens, WA	10,222.35	6,399.56	21,922.87	609.91	566.63	3,954.48	867.26	866.72	9,184.79

Figure 3-4 presents the operational health costs per MWh for $PM_{2.5}$ emissions for each existing and proposed combustion resource. Renewable resources including solar, wind, and hydro do not have any reported operational $PM_{2.5}$, SO_2, or NO_x emissions. For existing resources, Colstrip and Kettle Falls have the largest impact on the US as a whole. This is expected, as biomass and coal produce more $PM_{2.5}$ than natural gas. Since Colstrip is in Montana, which is not in Avista territory, there are fewer Avista impacts. The population for Stevens county, where Kettle Falls is located, is much larger than the county where Colstrip is located, which would explain why Kettle Falls has a much larger site county impact than Colstrip.

Figure 3-4. Operational $PM_{2.5}$ health costs per MWh by generation type



In Figure 3-5, the operational SO_2 health costs per MWh are shown for existing and proposed resources and by impact location. Coal has the largest impact compared to the other resources. These impacts are nearly all outside of Avista's territory.

Figure 3-5. Operational SO_2 health costs per MWh by generation type

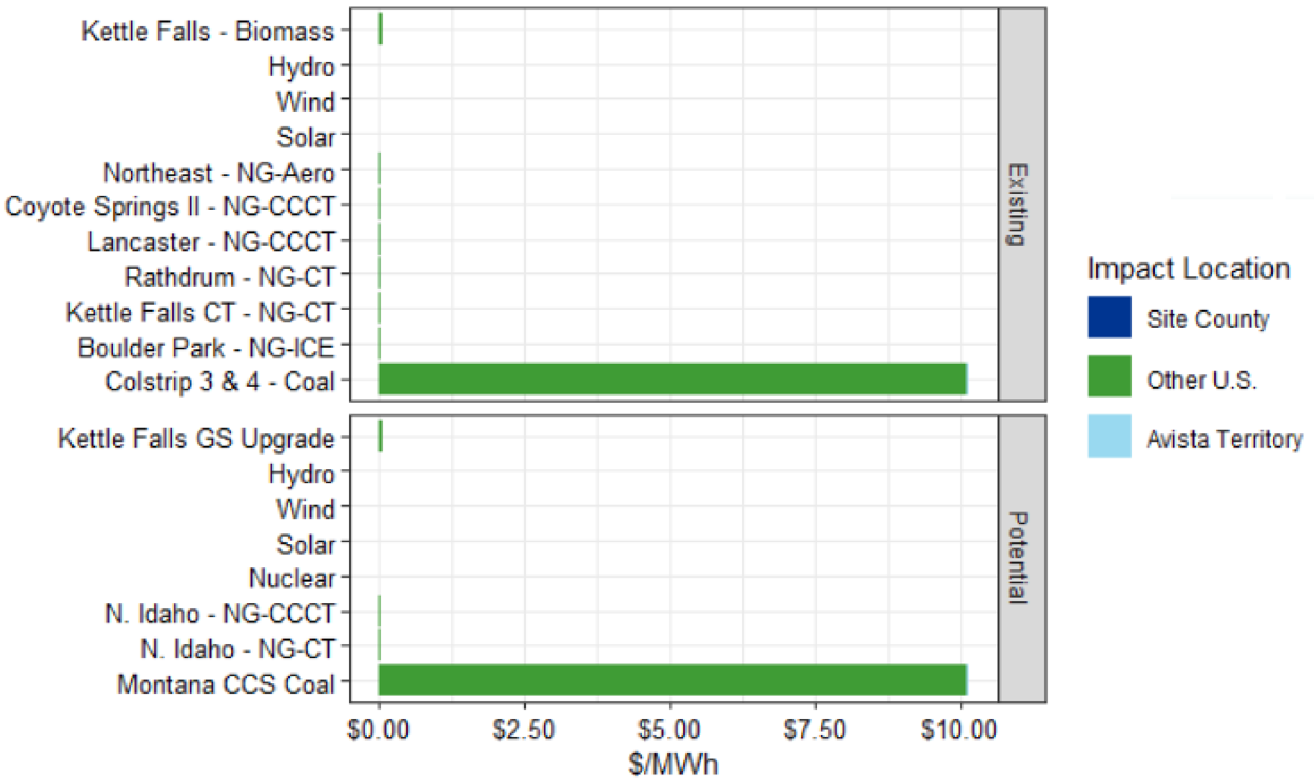
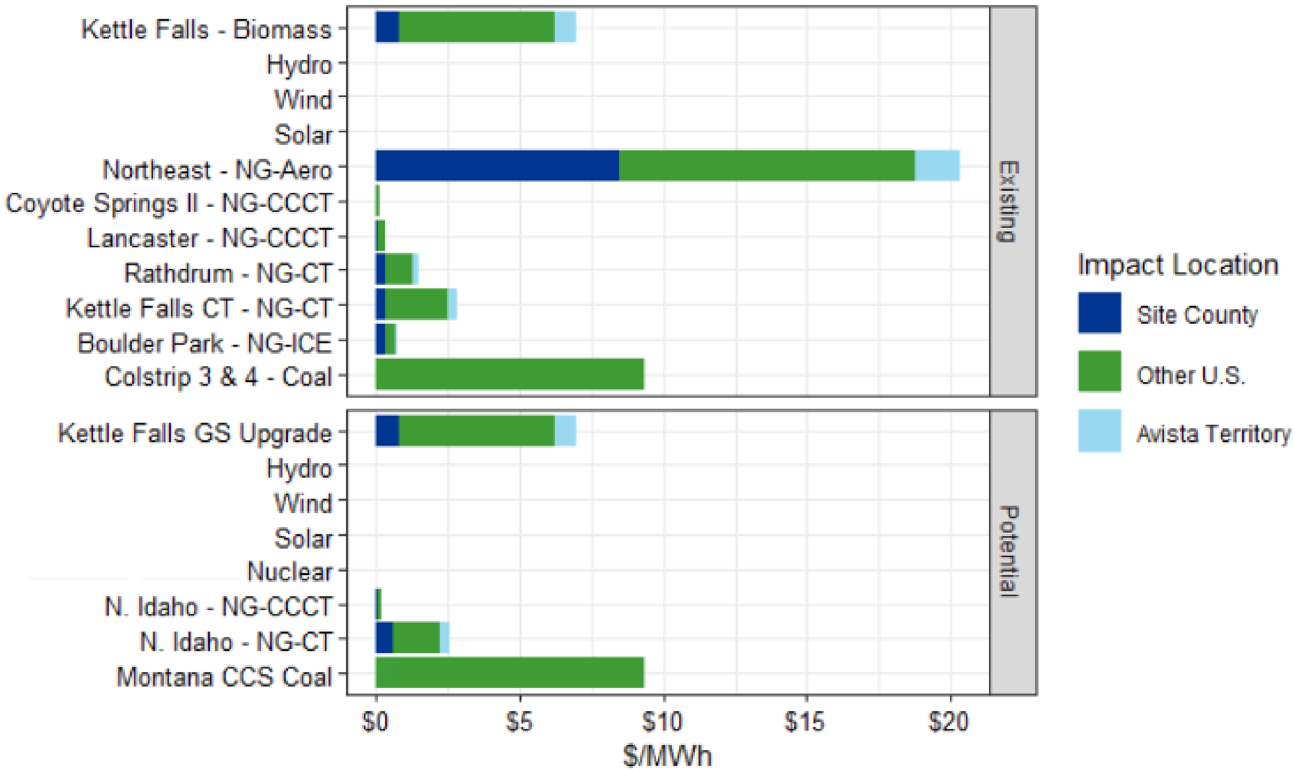


Figure 3-6 shows the operational NOx health costs per MWh for existing and proposed resources by impact location. For existing resources, Northeast natural gas has the highest NOx health costs per MWh throughout the US and in Avista's territory. Additionally, Colstrip had the next highest health costs per MWh throughout the US, and Kettle Falls had the second-highest NOx health costs in Avista's territory. For proposed facilities, the Colstrip resources had the highest national NOx health costs and Kettle Falls had the highest health costs within Avista's territory.

Figure 3-6. Operational NO_X health costs per MWh by generation type



3.2.2 Safety

Electricity generating facilities have safety impacts associated with all supply-chain phases. These impacts can include injuries or fatalities related to mining, construction, operation, maintenance, or decommissioning of the facility. Because the monetary cost of injuries is not easily transferable across regions, and because of limited data regarding injuries, DNV used only fatalities as the benchmark for resources safety. [17]Table 3-5 presents an overview of the safety metrics and sources. Available safety information is not always disaggregated by supply-chain activity, so this report specifies when safety estimates apply to the whole supply chain or whether estimates apply to certain aspects of the supply chain.

Table 3-5. Safety metric descriptions

Metric	Description	Sources
Direct fatalities from construction and operation	Direct fatalities that occur during the construction and operation of an energy resource. These fatalities could be from normal workplace accidents, catastrophic failures, and public interaction.	Balancing safety with sustainability[18]; BLS[19]; BTS[20]; MSHA[21]; CDC[22]; DOT[23]
Indirect fatalities due to supply-chain activities	Indirect fatalities occur from accidents related to the production and transportation of materials used in either construction, operation, or decommissioning. This can include mining for fuel or base materials and accidents related to the processing and transportation of these raw materials.	

[17] DNV recognizes fatalities and injuries might already be contained within insurance costs for specific facilities. A significant portion of fatalities comes from indirect supply-chain activities, though, and might therefore fall out of insurance costs for the generating facility. Further research would be needed to identify what proportion of these fatalities are already being quantified by insurance.

[18] Sovacool, Benjamin K., Rasmus Andersen, Steven Sorensen, Kenneth Sorensen, Victor Tienda, Arturas Vainorius, Oliver Marc Schirach, and Frans Bjørn-Thygesen. 2016. "Balancing Safety with Sustainability: Assessing the Risk of Accidents for Modern Low-Carbon Energy Systems." Journal of Cleaner Production 112 (January): 3952–65.

[19] "Census of Fatal Occupational Injuries (CFOI) - Current and Revised Data." 2018. Bls.gov. December 18, 2018. https://www.bls.gov/iif/oshcfoi1.htm.

[20] "Train Fatalities, Injuries, and Accidents by Type of Accident | Bureau of Transportation Statistics." n.d. Www.bts.gov. https://www.bts.gov/content/train-fatalities-injuries-and-accidents-type-accidenta.

[21] "Coal Mining Fatality Statistics: 1900-2013." 2013. Msha.gov. 2013. https://arlweb.msha.gov/stats/centurystats/coalstats.asp.

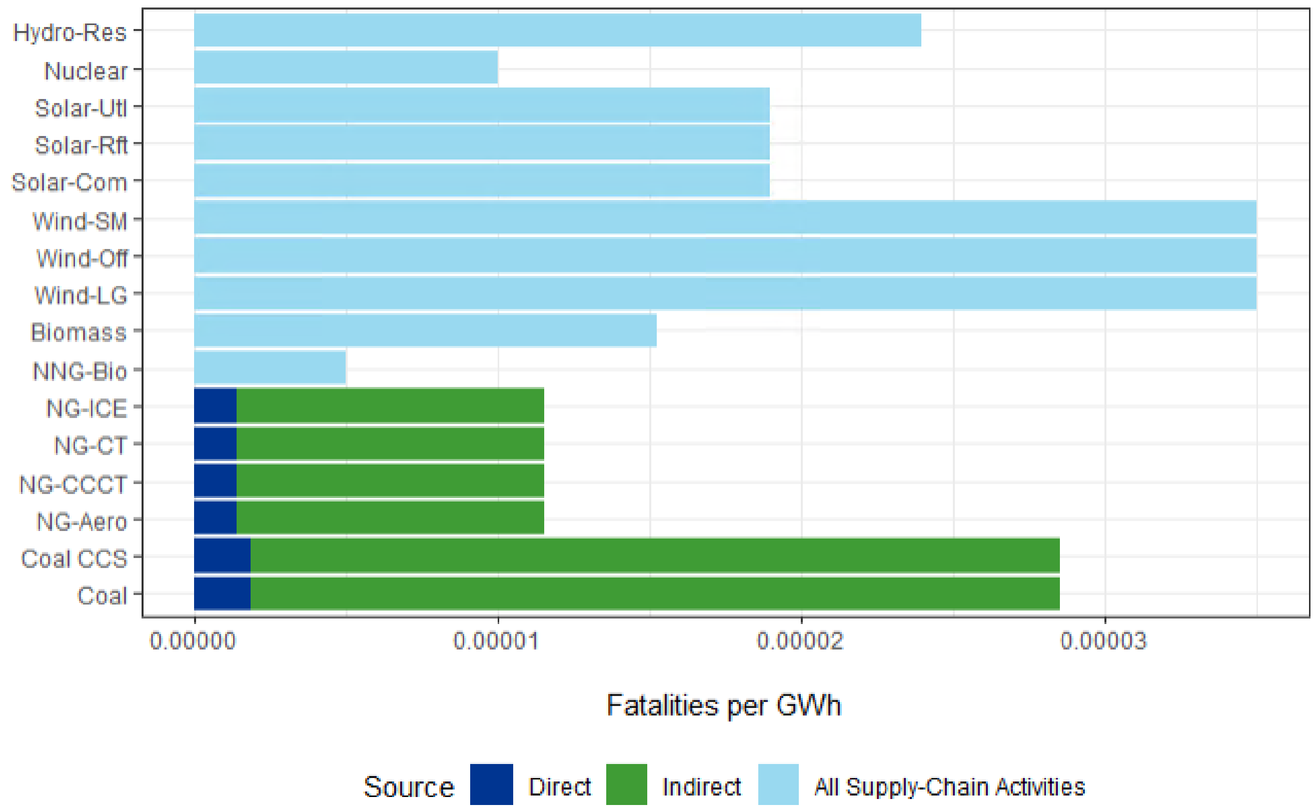
[22] "CDC - Fatalities in the Oil and Gas Extraction Industry (FOG) - NIOSH Workplace Safety & Health Topic." 2021. Www.cdc.gov. June 24, 2021. https://www.cdc.gov/niosh/topics/fog/default.html.

[23] 2022. Dot.gov. 2022. https://portal.phmsa.dot.gov/analytics/saw.dll?Portalpages&PortalPath=%2Fshared%2FPDM%20Public%20Website%2F_portal%2FSC%20Incident%20Trend&Page=Significant%20Incidents%20Consequences.

3.2.2.1 Fatality values

Fatality estimates for biomass, biofuels, hydro, nuclear, solar, and wind include reported fatalities from all aspects of the supply chain in aggregate. These values were calculated from a proprietary database to which DNV does not have access and come from accidents happening in many different countries.[24] The source data for these resources does not disaggregate fatalities by specific supply chain activity. For coal and natural gas, DNV developed fatality estimates using publicly available data for US production,[25,26] transportation,[27,28] and generation[29] (See Appendix A for more details). Fatality values are shown in Figure 3-7 and are reported in fatalities per GWh because fatalities are closely tied to fuel inputs for fossil fuel generation, and the amount of fossil fuel inputs is more dependent on output than capacity.

Figure 3-7. Fatalities by generation type[30]



Fatalities per GWh were highest for wind, followed by coal, and hydro. Wind fatalities may be higher due to the relatively high frequency of small aircraft collisions with wind turbines, dangerous maintenance work on top of turbines, and potential increased documentation due to active monitoring of operations by critics and advocates. Coal has the second-highest level

24 Sovacool, Benjamin K., Rasmus Andersen, Steven Sorensen, Kenneth Sorensen, Victor Tienda, Arturas Vainorius, Oliver Marc Schirach, and Frans Bjørn-Thygesen. 2016. "Balancing Safety with Sustainability: Assessing the Risk of Accidents for Modern Low-Carbon Energy Systems." Journal of Cleaner Production 112 (January): 3952–65.

25 "CDC - Fatalities in the Oil and Gas Extraction Industry (FOG) - NIOSH Workplace Safety & Health Topic." 2021. Www.cdc.gov. June 24, 2021. https://www.cdc.gov/niosh/topics/fog/default.html.

26 "Coal Mining Fatality Statistics: 1900-2013." 2013. Msha.gov. 2013. https://arlweb.msha.gov/stats/centurystats/coalstats.asp.

27 2022. Dot.gov. 2022. https://portal.phmsa.dot.gov/analytics/saw.dll?Portalpages&PortalPath=%2Fshared%2FPDM%20Public%20Website%2F_portal%2FSC%20Incident%20Trend&Page=Significant%20Incidents%20Consequences.

28 "Train Fatalities, Injuries, and Accidents by Type of Accident | Bureau of Transportation Statistics." n.d. Www.bts.gov. https://www.bts.gov/content/train-fatalities-injuries-and-accidents-type-accidenta.

29 "Census of Fatal Occupational Injuries (CFOI) - Current and Revised Data." 2018. Bls.gov. December 18, 2018. https://www.bls.gov/iif/oshcfoi1.htm.

30 Fatality rates are not sub-technology specific, meaning the same estimate is applied for coal and coal with carbon capture, all natural gas sub-technologies, and solar.

of fatalities likely because mining is a dangerous job. When compared to a similar resource like natural gas, it is important to note that electricity production accounts for the vast majority of coal use (91.5%).[31] For natural gas, the extraction and transportation values, while high for the entire industry, are being multiplied by the percentage of natural gas that goes for electricity production (38%).[32]

When further comparing coal against the resource with the third-highest fatalities per GWh (Reservoir Hydro), the values are not perfectly relatable because they come from different sources. Reservoir Hydro comes from a proprietary database. While DNV cannot look at all incidences in the database, the top eight are shown to be catastrophic dam failure accidents.[33] It is unknown if this database accounts for accidents during construction or mining of raw material, which would create a more even comparison with coal.

3.2.2.2 Monetized Impacts

Figure 3-8 presents the monetized impacts from fatalities by generation type. DNV monetized fatalities using the EPA's value of a statistical life,[34] adjusted to 2021 dollars using the Federal Reserves' Consumer Price Index.[35] This conversion is seen in Equation 2. This analysis treats fatalities consistently across all generation types and supply chain activities, so the proportional difference between resource sites is the same in Figure 3-8 as it is in Figure 3-7.

Equation 2. Monetized safety

$$Monetized\ safety\ \left[\frac{\$}{MWh}\right] = Safety\ \left[\frac{Fatalities}{MWh}\right] x\ Value\ of\ a\ Statistical\ Life \left[\frac{\$10{,}742{,}916.67}{Fatality}\right]$$

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[31] Use of coal - U.S. Energy Information Administration (EIA)

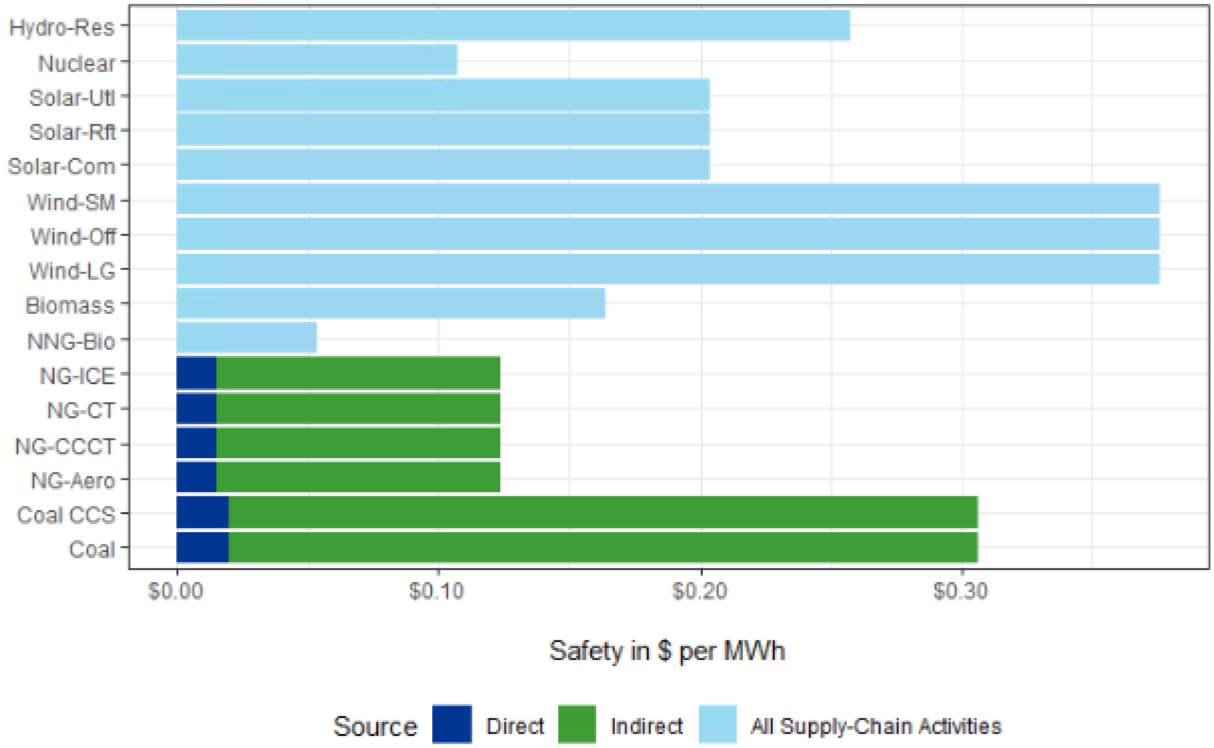
[32] https://www.eia.gov/energyexplained/natural-gas/use-of-natural-gas.php#:~:text=The%20commercial%20sector%20uses%20natural,combined%20heat%20and%20power%20systems.

[33] Sovacool, Benjamin K., Rasmus Andersen, Steven Sorensen, Kenneth Sorensen, Victor Tienda, Arturas Vainorius, Oliver Marc Schirach, and Frans Bjørn-Thygesen. 2016. "Balancing Safety with Sustainability: Assessing the Risk of Accidents for Modern Low-Carbon Energy Systems." Journal of Cleaner Production 112 (January): 3952–65.

[34] US EPA. n.d. "Mortality Risk Valuation." Accessed February 23, 2022. https://www.epa.gov/environmental-economics/mortality-risk-valuation.

[35] Federal Reserve Bank of Minneapolis. n.d. Review of Consume Price Index, 1800-. https://www.minneapolisfed.org/about-us/monetary-policy/inflation-calculator/consumer-price-index-1800-.

Figure 3-8. Monetized fatalities by generation type



3.2.3 Reliability and resiliency

The reliability and resiliency impact of generation resources could be negative or positive to Avista's customers. While some types of resources may be able to increase reliability and resiliency in certain circumstances, there are no generalizable reliability and resiliency impacts by generation resource. Detailed modeling would be necessary to assess the reliability and resiliency impacts of the existing and proposed resources as these benefits are based on the location of the resource and its interaction in the larger transmission and distribution grid. Further, any benefits may not be societal impacts, but rather impacts only to specific customers.

3.2.4 Energy security

The IEA[36] defines energy security as "the uninterrupted availability of energy sources at an affordable price." This definition has broad implications. National energy policy plays a role in the availability of fuel and other imports necessary to generate energy. At a more local scale, the uninterrupted availability component can be considered via distribution system reliability and resiliency metrics. DNV recommends using energy burden as a metric for the affordability component of the definition. Energy burden is often a component of housing burden, which is directly factored into the Washington Health Disparities score. Additionally, energy burden is also an often-considered equity-related metric.

Energy burden is calculated as the proportion of household income spent on electricity and heating. As such, the effects of different generation resources on household income and the cost of electricity are the necessary components for estimating energy burden effects. While some of these aspects are addressed by the Economic NEIs, DNV suggests addressing this metric qualitatively by assessing whether a resource is expected to increase or decrease customer's energy costs through

36 https://www.iea.org/topics/energy-security

the IRP's revenue requirement or energy rate calculation of future energy costs. This serves as an indicator of how expensive energy will be to the end user to maintain affordability of energy.

3.2.5 Environment

Electricity-generating technologies have a variety of environmental impacts throughout their life cycles. DNV considered land use, water use, wildfire risk, and wildlife impacts. These metrics vary substantially in data availability across technologies and project phases.

3.2.5.1 Land use

Land use represents the indirect and on-site operational costs of a power plant during its operation. Land use affects all generation technologies via fuel extraction for fossil fuels and nuclear and use of land for energy generation rather than food production for renewables. Table 3-6 presents the descriptions of the types of land uses included in the values for each phase.

Table 3-6. Land use phase descriptions

Land Use Phase	Description	Sources
Construction	Land used during manufacturing, construction, and for key construction inputs such as gravel.	NREL[37]; DNV subject matter experts; Stevens et al[38]
Mining	Land used for fuel mining and production.	
Operations	Land used for resource operations.	
Decommissioning	Land used to store, dispose of, or recycle the components of the resource following operations.	

[37] National Renewable Energy Laboratory (NREL). Review of Land Use by System Technology. Energy Analysis. https://www.nrel.gov/analysis/tech-size.html.

[38] Stevens, Landon, Barrett Anderson, Colton Cowan, Katie Colton, and Dallin Johnson. 2017. Review of The Footprint of Energy: Land Use of U.S. Electricity Production. Strata Policy. https://docs.wind-watch.org/US-footprints-Strata-2017.pdf.

Land use values

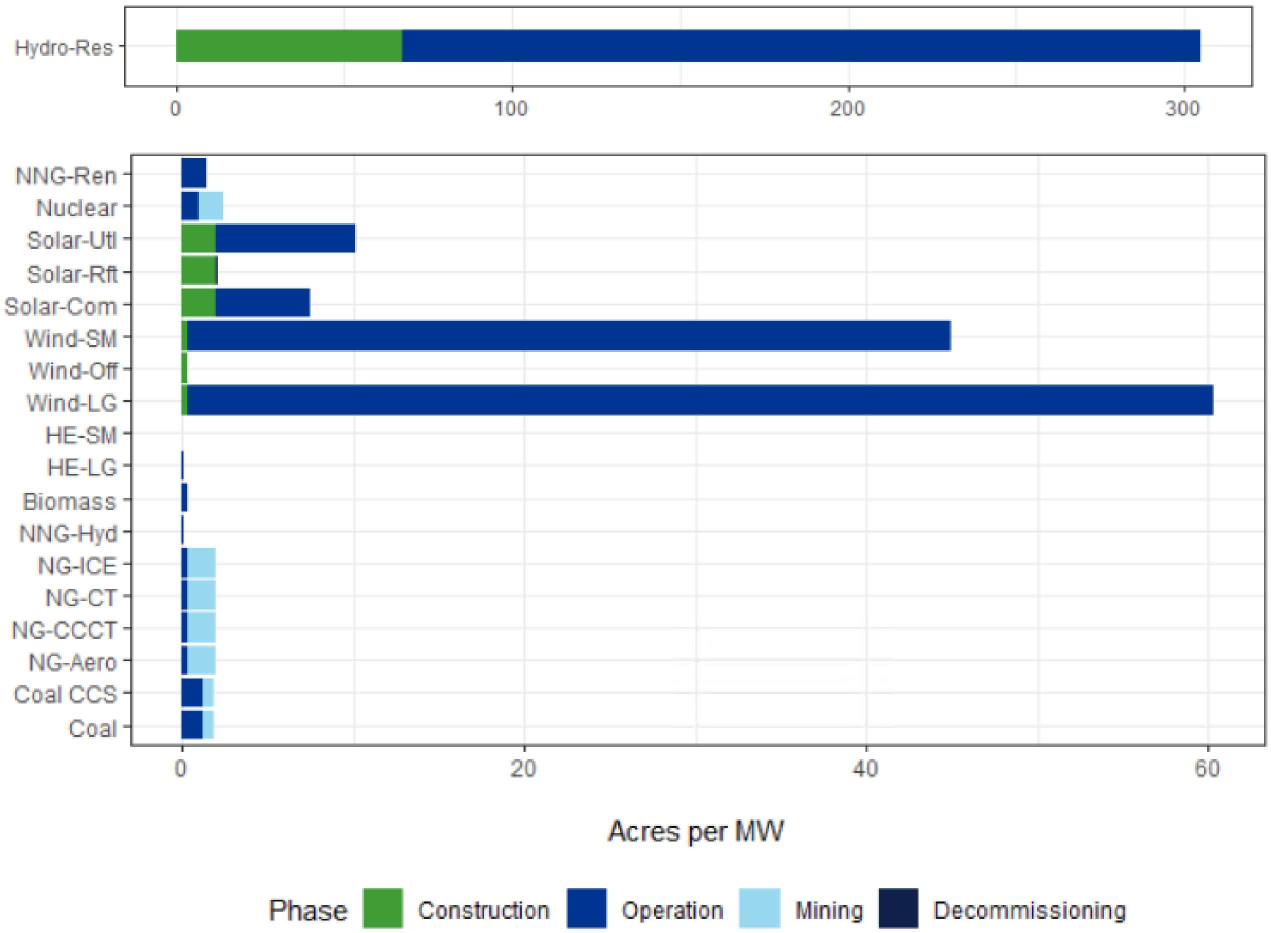
DNV compiled land use values from NREL, Stevens et al, and internal subject matter experts. Table 3-7 summarizes the land use value coverage by generator type and phase. Checks indicate identified values, circles indicate missing values, and blank cells indicate phases where no value is expected (fuel mining for renewables). While DNV was able to identify values for most phases that are expected to have the largest land use, most generator types are missing construction and manufacturing land use as well as decommissioning.

Table 3-7. Land use value coverage by phase

Group	Technology		Phase			
	Abbreviation	Generator Types	Construction	Operation	Mining	Decommissioning
Biomass	Biomass	Biomass	○	✓	○	○
Coal	Coal	Coal	○	✓	✓	○
	Coal CCS	Coal with Carbon Capture	○	✓	✓	○
Hydro	Hydro-PB	Pumped hydro - brownfield	○	○		○
	Hydro-GF	Pumped hydro - greenfield	○	○		○
	Hydro-Res	Reservoir hydro	✓	✓		○
	Hydro-RR	Run-of-river hydro	○	○		○
	Hydro-RRS	Run-of-river hydro with storage	○	○		○
Hydrogen electrolyzer	HE-LG	Hydrogen electrolyzer - large	○	✓		○
	HE-SM	Hydrogen electrolyzer - small	○	✓		○
Lithium-ion Storage	Batt-LG	Lithium-ion Storage - Large	○	○		○
	Batt-SM	Lithium-ion Storage - Small	○	○		○
Natural gas	NG-Aero	Natural gas Aero Turbine	○	✓	✓	○
	NG-CCCT	Natural gas CCCT	○	✓	✓	○
	NG-CT	Natural gas CT	○	✓	✓	○
	NG-ICE	Natural gas internal combustion engine	○	✓	✓	○
Non-natural gas	NNG-Bio	Non-natural gas (Bio-fuel)	○	○		○
	NNG-CF	Clean Fuel Turbine	○	○		○
	NNG-Hyd	Non-natural gas (Hydrogen)	○	○		○
	NNG-LAir	Non-natural gas (Liquid air)	○	○		○
	NNG-Ren	Renewable natural gas storage tank	○	✓		○
Nuclear	Nuclear	Nuclear	○	✓	✓	○
Solar	Solar-Com	Community solar	✓	✓		✓
	Solar-Rft	Rooftop solar	✓	✓		✓
	Solar-Utl	Utility-scale solar	✓	✓		✓
Wind	Wind-LG	Large wind	✓	✓		○
	Wind-Off	Off-shore wind	✓	✓		○
	Wind-SM	Small Wind	✓	✓		○

The assembled land use values are reported in acres per MW in Figure 3-9. Reservoir hydro had the highest land use per per MW. It is important to note that actual land use for the reservoir and operational building may be greater or smaller depending on the local topography. The next highest land use was for onshore wind, which includes both direct and indirect land use. Actual land use for a project may vary, depending on how much of the land can be used for other activities such as farming. Offshore wind land use is limited to the land needed onshore to connect the resource to the grid and does not account for the ocean surface area occupied. Construction land use for hydro, solar, and wind includes the land needed for mining raw materials needed to manufacture or construct the resources. Natural gas mining includes the land needed for frac sand mining as well as fracking. Coal mining assumes that surface mining accounts for two-thirds of the mining while underground mining accounts for the remaining third.

Figure 3-9. Land use by generation type by MW



Monetized impacts

Given the cost of the land is part of capital cost or the cost of the products Avista acquires, DNV does not propose to include these land impacts as a non-energy impact. There could be additional land use impacts considered such as the effect of property values on neighboring lands. These impacts could be both positive (i.e. hydro reservoir) or negative in the case of power production facilities. DNV recommends further study on this topic as part of its study gaps section.

3.2.5.2 Water use

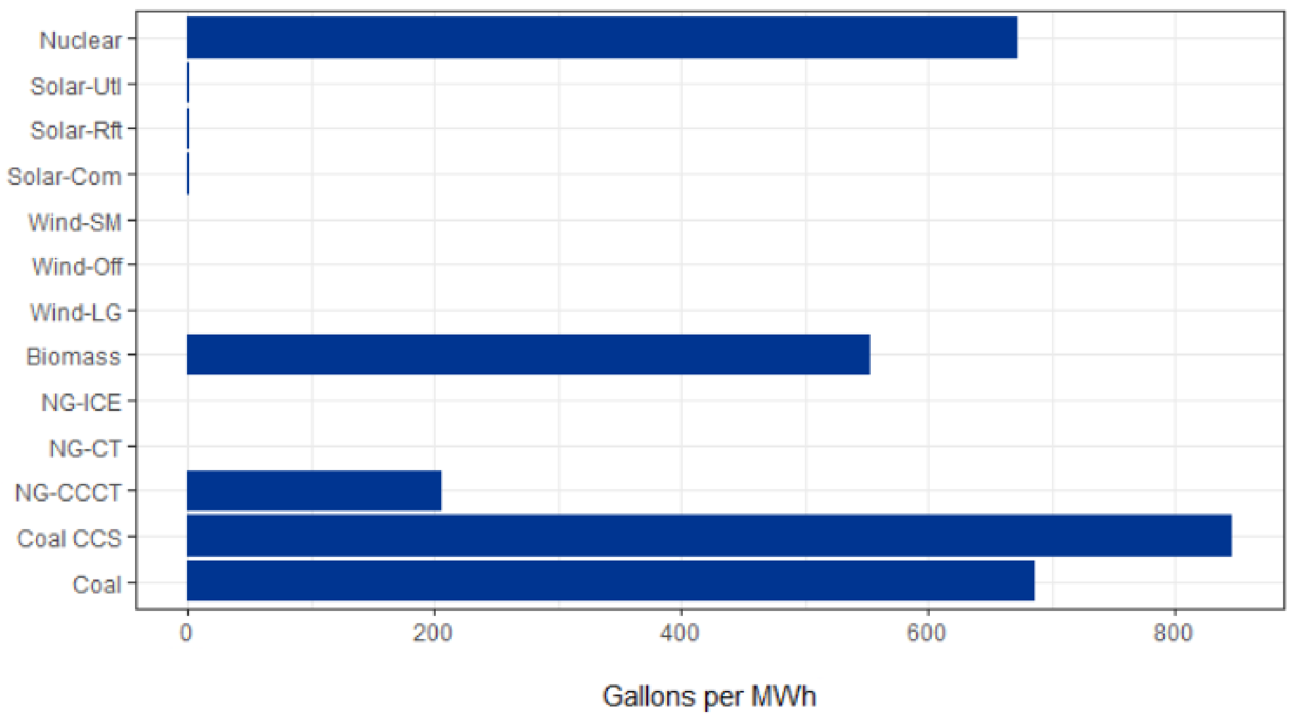
Water is often used throughout the lifecycle phases of electricity generation. It is commonly used in sustainability models and can vary substantially across generation resources.

Water use values

Water consumption during operations is a readily available metric for most generation resources. Water consumption is the water that is withdrawn and lost through evaporation, transpiration, or other causes. As water consumption is typically associated with the amount of electricity generated, this analysis compares water consumption in gallons per MWh. All water consumption values are from Macknick et al.[39]

Figure 3-10 shows the operational water use by generation type. Reservoir hydro has the highest operational water consumption based on evaporative water losses from the reservoir. The United State Geological Survey (USGS) estimates there is 21 inches of evaporation in Lake Couer d Alene which is centrally located relative to Avista hydro resources. [40] With an approximate surface area of 5,600 acres, water loss from the Noxon reservoir is approximately 2,000 gallons/MWh. This value could vary dramatically based on the surface area of the reservoir as well as the weather. The water consumption for coal, biomass, natural gas, and nuclear assume a cooling tower is used. Solar uses minimal water, assuming that the panels are washed periodically.

Figure 3-10. Operational water consumption by generation type by MWh



[39] Macknick, J, R Newmark, G Heath, and K C Hallett. 2012. “Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies: A Review of Existing Literature.” Environmental Research Letters 7 (4): 045802.

[40] Maupin, M.A., and Weakland, R.J., 2009, Water budgets for Coeur d’Alene Lake, Idaho, water years 2000–2005: U.S. Geological Survey Scientific Investigations Report 2009-5184, 16 p.

Monetized impacts

DNV recommends only monetizing water consumption for resources that do not have the cost of water included as part of the resource's cost. In this event, Avista could use the Spokane, WA commercial water utility rates for water use greater than 1,000 cubic feet[41] as an approximation for this non-energy impact.

[41] Spokane City. 2022 Commercial Utilities Rates. Spokane City Public Works & Utilities. Accessed February 16, 2022. https://my.spokanecity.org/publicworks/utility-billing/commercial-rates/.

3.2.5.3 Wildfire risk

Fossil fuels contribute to wildfires through climate change effects, and as of 2014, wildfires were not included in the EPA's social cost of carbon calculations.[42] [43] DNV was unable to identify a readily identifiable monetized wildfire metric. Because climate change has increased the severity and timing of wildfires,[44] greenhouse gas (GHG) emissions per MWh could serve as a proxy for wildfire risk. Avista currently factors this risk using the Social Cost of Carbon in its IRP's Washington Preferred Resource Strategy Analysis. Further research to develop a wildfire risk assessment could consider fire risk by technology which could result in a wildfire, length of long-range transmission lines by existing or proposed resource, or the wildfire risks associated with specific locations.

42 Environmental Defense Fund, Institute for Policy Integrity, and NRDC. 2014. Review of Flammable Planet: Wildfires and the Social Cost of Carbon. https://costofcarbon.org/files/Flammable_Planet__Wildfires_and_Social_Cost_of_Carbon.pdf.

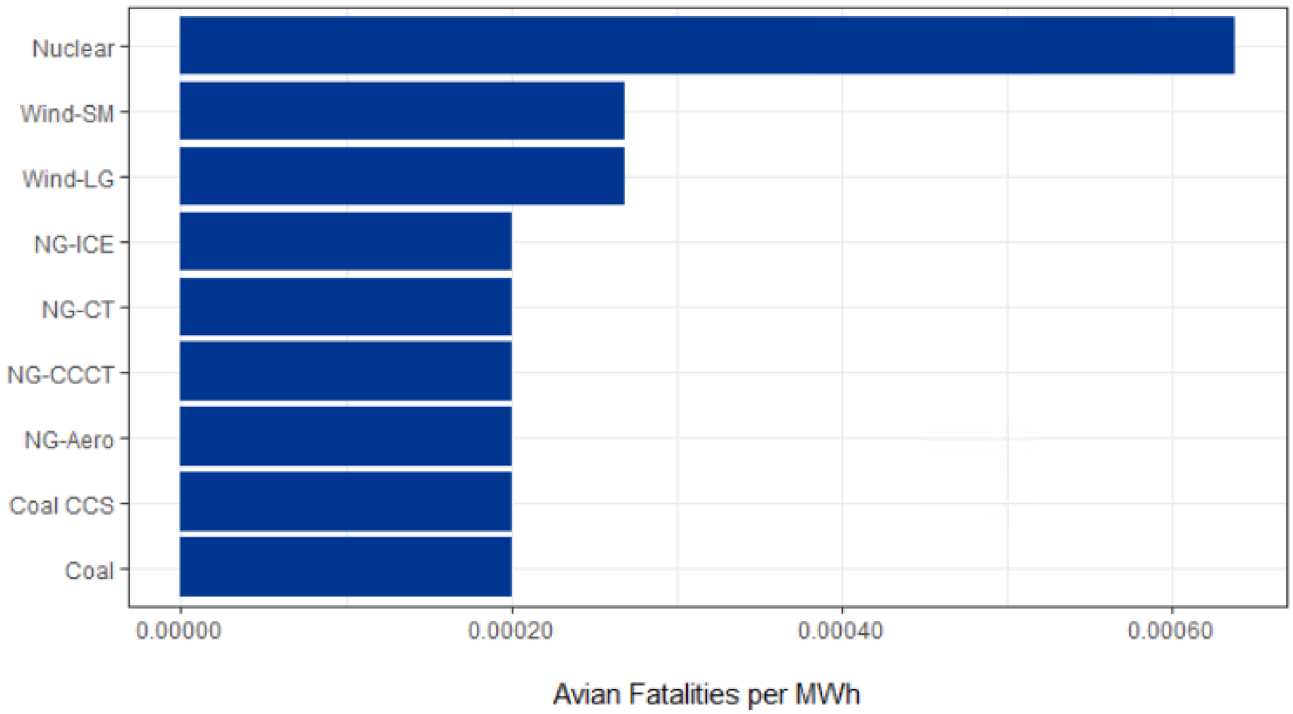
43 Avista uses the social cost of carbon as set in Executive Order 12866. This executive order cites that its estimates come from The DICE (2010), FUND (2012), and PAGE (2009) models, all versions of which were prior to the 2014 Environmental Defense Fund analysis of the EPA social cost of carbon. Additional research into available documentation of those three models failed to identify wildfire costs as included in them. The closest, specific cost cited was for the FUND model (http://www.fund-model.org/files/documentation/Fund-3-9-Scientific-Documentation.pdf), which considers timber production. However, that document makes no reference to the effects of fires either on timber production or independent of it. DICE documentation lists similar, high-level cost factors as FUND, and the HOPE model documentation does not list any specific cost factors.

44 US EPA. 2016. "Climate Change Indicators: Wildfires | US EPA." US EPA. July 2016. https://www.epa.gov/climate-indicators/climate-change-indicators-wildfires.

3.2.5.4 Wildlife impacts

Different generation technologies can adversely affect wildlife through climate change effects or direct contact with native species. Impacts can occur throughout the lifecycle of generation resources and can be highly variable depending on the location of the resource. One commonly cited metric for wildlife impacts is avian fatalities from direct and indirect operations of electricity generation. These fatalities include birds crashing into generators as well as the impacts of mining on avian populations. Figure 3-11 presents the avian fatality rates for combustion technologies, wind, and nuclear. Nuclear had the highest fatality rate, followed by wind, and fossil fuels. DNV did not monetize these impacts, as there was no readily available monetary value to use.

Figure 3-11. Avian fatalities per MWh



In addition to a dearth of monetized values of wildlife impacts, it should be noted that wildlife impacts are often included in environmental impact studies that are required as part of the permitting and relicensing process for specific generation assets. This often results in remediation costs being embedded in the cost of that generation resource. For example, to mitigate fish impacts, a hydro plant might be required to build and maintain fish hatcheries or dissolved gas might be rectified through improvements to spillway processes.

3.2.6 Economic

Jobs are the economic impact most directly affected by adding or retiring new generation, and there are readily available data on these effects. The NREL Jobs and Economic Development Impact (JEDI) models include job effects for a variety of generation technologies, including multiplier effects that take into account direct, indirect, and induced jobs. These multiplicative effects represent the full GDP effects of the jobs split into construction and operation phases. Table 3-8 describes the economic metrics produced by the JEDI model. When applying the economic metrics to the generation resources, DNV used the value added metric.

Table 3-8. Economic metric descriptions

Metric	Description	Sources
Jobs	Construction period jobs refer to full-time equivalent jobs for a year during construction period. Operating year jobs refers to the ongoing or permanent full-time equivalent jobs for each year of operation.	JEDI[45]
Earnings	Refers to the wage and salary compensation paid to workers. This monetizes the job impacts.	
Output	This covers all costs associated with the resource.	
Value Added	The difference between total gross output and the cost of intermediate inputs. It is comprised of payments made to workers (wages and salaries and benefits), proprietary income, other property type income (payments from interest, rents, royalties, dividends, and profits), indirect business taxes (excise and sales taxes paid by individuals to businesses, and taxes on production and imports less subsidies. It is equivalent to gross domestic product.	

Each of the metrics is further disaggregated into the following types of impacts:

- **Direct**: Labor directly related to onsite development, construction, and operations
- **Indirect**: Supporting industry impacts
- **Induced**: Impacts due to reinvestment and spending driven by the direct and indirect impacts

It should be noted that Avista already accounts for direct impacts in the cost to commission and run facilities and indirect costs would be assumed to be included in the costs of materials and other supporting services. Therefore, only induced impacts represent NEIs.

There are 6 JEDI models that applied to Avista’s existing and proposed resources, wind (large and small), off-shore wind, pumped hydro (greenfield and brownfield), coal, biomass, and natural gas (CT and CCCT). The JEDI models include default values but also allow users to specify many inputs. For the purposes of this study, DNV specified location, year of construction, resource size, and percent local for each existing and proposed resource. More detailed methods can be found in appendix A on model versions and assumptions.

[45] Jobs and Economic Development Impact Models (JEDI). Biofuels, Coal, Conventional Hydropower, Marine and Hydrokinetic Power, Natural Gas, and Wind. NREL.

Exceptions

DNV used slightly different methods for some of the resources as described here.

Offshore wind: The JEDI model for offshore wind is in beta. The direct economic impacts reported by the model were reasonable and in-line with expected values. However, DNV observed that the indirect and induced economic impacts from the JEDI model were much higher than for any other model and implied an unreasonably high multiplier (approximately 12:1 and 9000:1, respectively). To compensate, DNV used the direct impacts produced by the JEDI model and applied indirect and induced job multipliers from The Economic Policy Institute[46] (EPI) to estimate indirect and induced job impacts. The EPI study reports multipliers by major industries and sub-industries that corresponds with a two-digit code. DNV used the multipliers reported for the major industry, utilities, and sub-industry, electric power generation, transmission, and distribution, that corresponds with the two-digit code 12 in this source.

Solar PV: NREL does not provide JEDI models for solar PV. DNV could not identify any unbiased, third-party reports of the job impacts for solar PV installations. Organizations representing the solar PV installation industry publish reports, but DNV did not have confidence in the impartiality of these sources. To provide job values, DNV estimated direct, indirect, and induced jobs using capital cost assumptions from Avista's 2021 IRP and jobs per capital outlay ratios from EPI[47] for the Construction industry type (code 15). DNV assumed capital costs of $1000 per kW for large scale solar projects and $2000 per kW for small scale solar projects based on information from Avista. These numbers were used alongside the EPI Construction jobs per million dollars in final demand to calculate direct, indirect, and induced jobs per MW.

Coal with carbon capture: Carbon capture technology is too new for there to be reliable information or models related to construction or operations costs. However, there are established models for coal plants without carbon capture. To reflect the additional equipment needed for carbon capture, DNV multiplied the economic impacts for standard coal plants by 1.2 the ratio of the LCOE of coal with carbon capture to standard coal.

For **clean fuel non-natural gas**, DNV estimated operations economic benefits by using the proposed N. Idaho CCCT values but scaled to the MW and MWh values associated with this resource

3.2.6.2 Construction impacts

Benefits from construction are valued on a per MW basis because size is the main driver of how much a project will cost. Avista already accounts for the direct and indirect impacts as part of the cost of commissioning a facility. Therefore, only the induced impacts represent NEIs.

46 Bivens, Josh. 2019. Updated Employment Multipliers for the U.S. Economy. Economic Policy Institute. January 23, 2019. https://www.epi.org/publication/updated-employment-multipliers-for-the-u-s-economy/.

47 Bivens, Josh. 2019. Updated Employment Multipliers for the U.S. Economy. Economic Policy Institute. January 23, 2019. https://www.epi.org/publication/updated-employment-multipliers-for-the-u-s-economy/.

Figure 3-12 shows the direct, indirect, and induced construction jobs for proposed generation resources. The figure does not include the construction economic impacts for existing generation resources, as those impacts were already realized. While the direct and indirect jobs are not considered to be NEIs, they do provide useful context for interpreting the induced jobs. Rooftop solar is expected to produce the most jobs overall, although pumped hydro projects would produce more direct jobs. Greenfield and brownfield hydro projects are likely to be large, capital-intensive projects. In contrast, while any, single rooftop solar project would be very small, a very large number of these projects could be completed. It should also be noted that DNV utilized a different method to estimate Solar PV job impacts, so these values should be interpreted with caution.

Figure 3-12. Construction jobs by proposed generation type

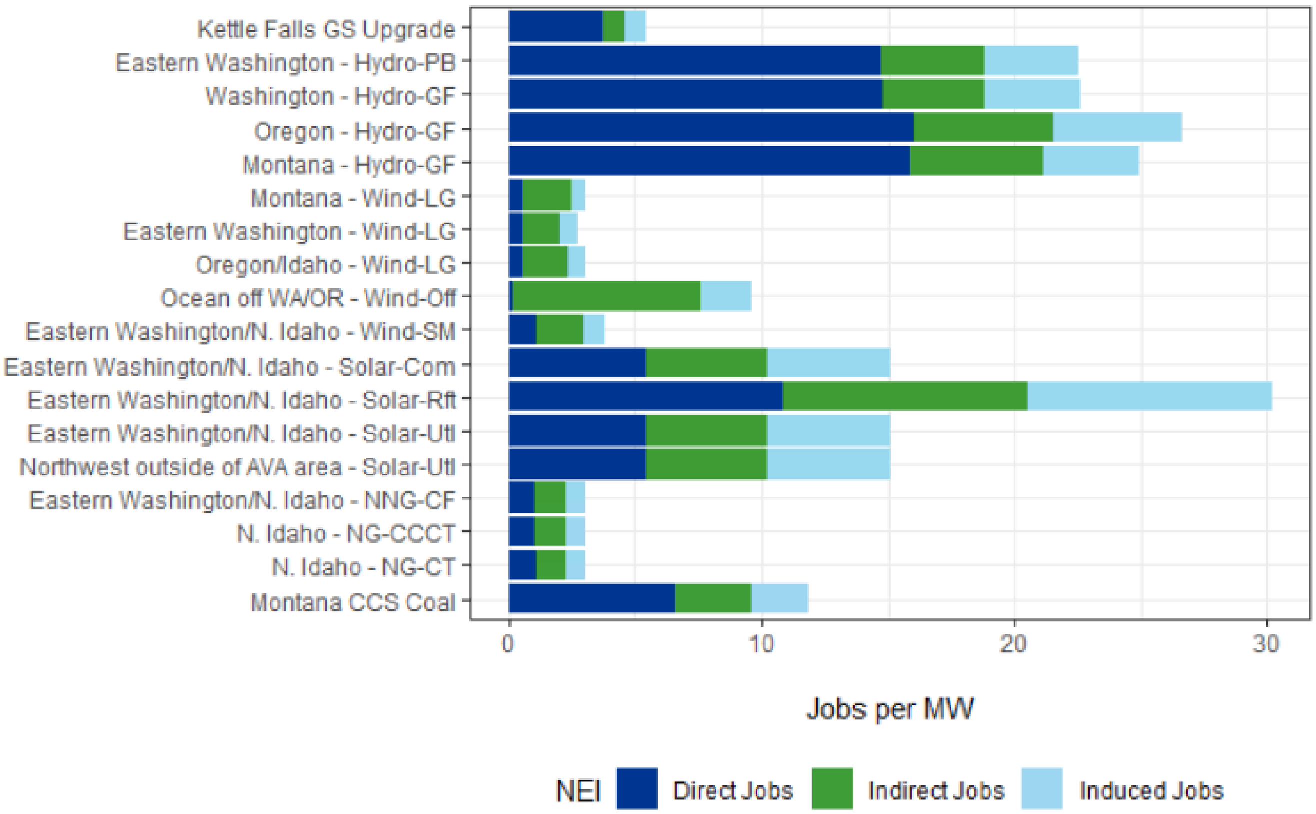


Figure 3-13 and Table 3-9 show the construction economic impacts (local impacts, value-add) by proposed generation type. DNV could not identify a trustworthy value for solar PV wages, so those generation types are left off the figure. Across the remaining generation types, wages are similar, so the relative levels of monetized values are similar to those for jobs.

Figure 3-13. Construction economic induced impact by proposed generation type

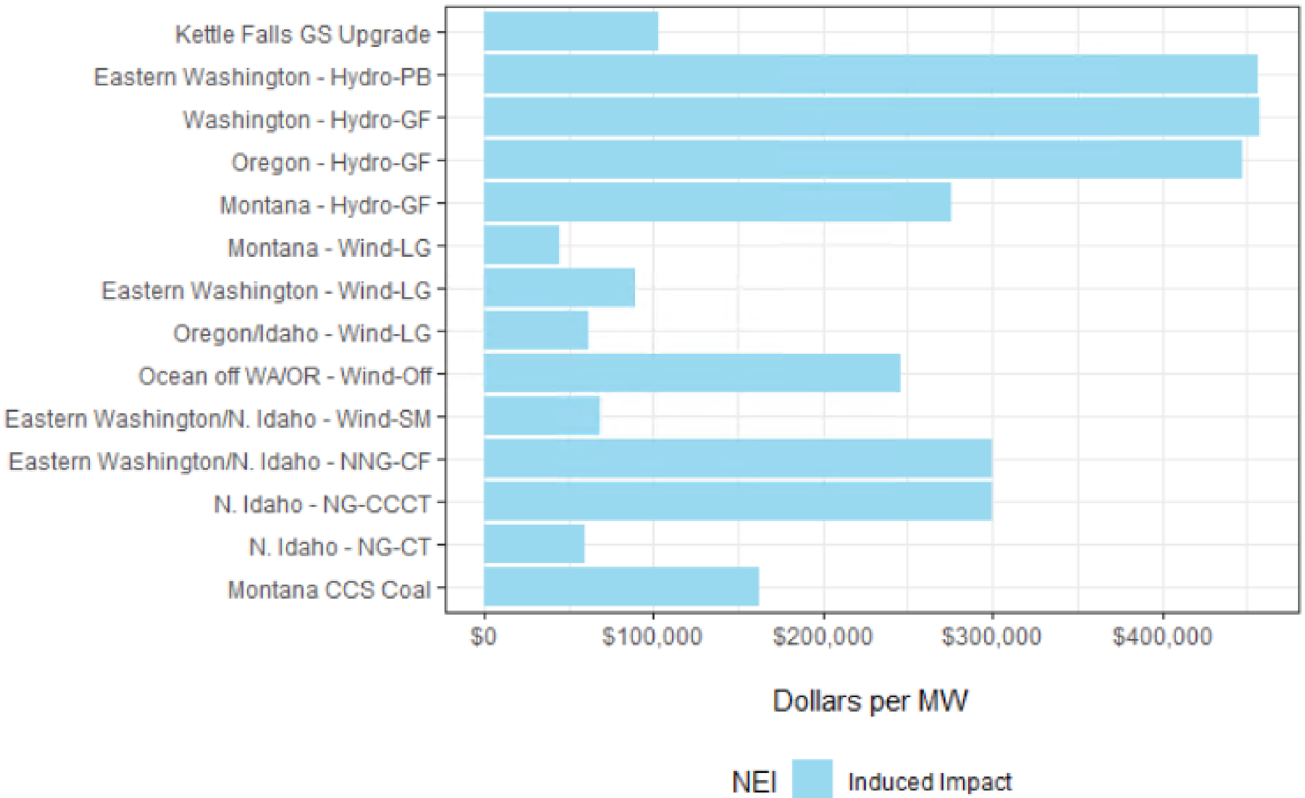


Table 3-9. Summary of Construction Induced Value Add

Fuel Type	Resource Name	Economic Construction ($/MW)
Batt-LG	Eastern Washington/N. Idaho	Gap
Batt-SM	Eastern Washington/N. Idaho	Gap
Biomass	Kettle Falls GS Upgrade	102,800
Coal CCS	Montana CCS Coal	162,822
HE-LG	Eastern Washington	Gap
HE-SM	Eastern Washington	Gap
Hydro-GF	Montana	275,500
Hydro-GF	Oregon	448,000
Hydro-GF	Washington	458,000
Hydro-PB	Eastern Washington	456,600
NG-CCCT	N. Idaho	300,280
NG-CT	N. Idaho	59,000
NNG-Bio	Eastern Washington/N. Idaho	Gap
NNG-CF	Eastern Washington/N. Idaho	300,280
NNG-Hyd	Eastern Washington/N. Idaho	Gap
NNG-LAir	Eastern Washington/N. Idaho	Gap
NNG-Ren	Eastern Washington/N. Idaho	Gap
Nuclear	Eastern Washington/N. Idaho	Gap
Solar-Com	Eastern Washington/N. Idaho	Gap
Solar-Rft	Eastern Washington/N. Idaho	Gap
Solar-Utl	Eastern Washington/N. Idaho	Gap
Solar-Utl	Northwest outside of AVA area	Gap
Wind-LG	Eastern Washington	89,600
Wind-LG	Montana	44,267
Wind-LG	Oregon/Idaho	62,267
Wind-Off	Ocean off WA/OR	245,978
Wind-SM	Eastern Washington/N. Idaho	68,600

3.2.6.3 Operations impacts

Operational economic impacts affect those directly employed by the generation resource, those supporting the project, and communities and businesses that benefit from the greater economic potential this project provides. Figure 3-14 shows the direct, indirect, and induced construction jobs for existing and proposed generation resources per MWh. DNV could not identify a trustworthy source for solar PV operations jobs. Almost all of the costs for solar PV are incurred during the construction phase, so DNV expects solar PV operations jobs to be very low per GWh. Hydro resources generate the most jobs during the operations phase as well. The most common types of indirect jobs created by the hydro resources are "professional services", "wholesale trade", and "retail trade".

Figure 3-14. Operations jobs by generation type

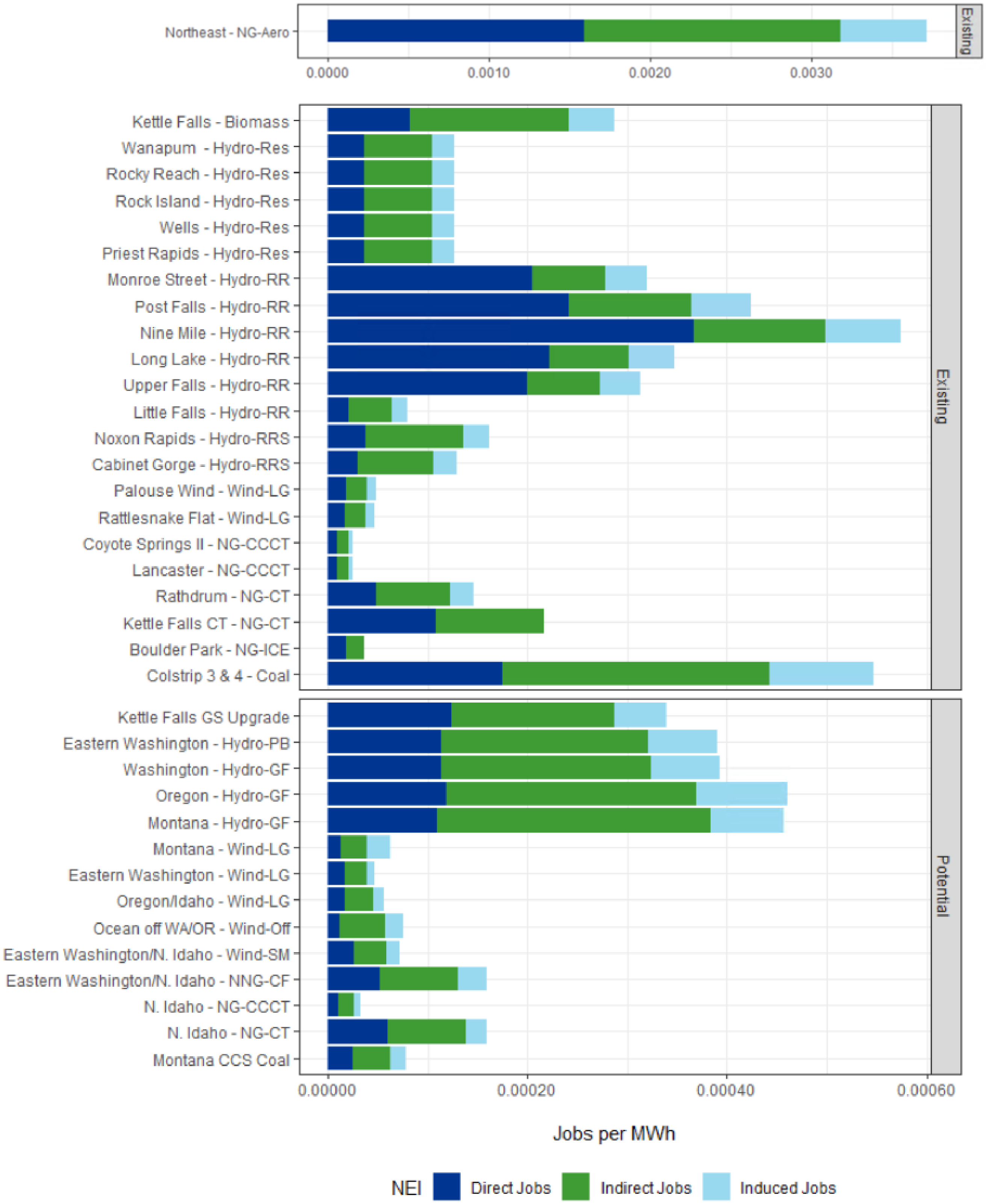


Figure 3-15 and Table 3-10 shows the operations economic impacts (local impacts, value-add) by generation type. Hydro resources generate the most economic value during operations phases, driven by the job impacts.

Figure 3-15. Operations Economic Impact by Generation Type

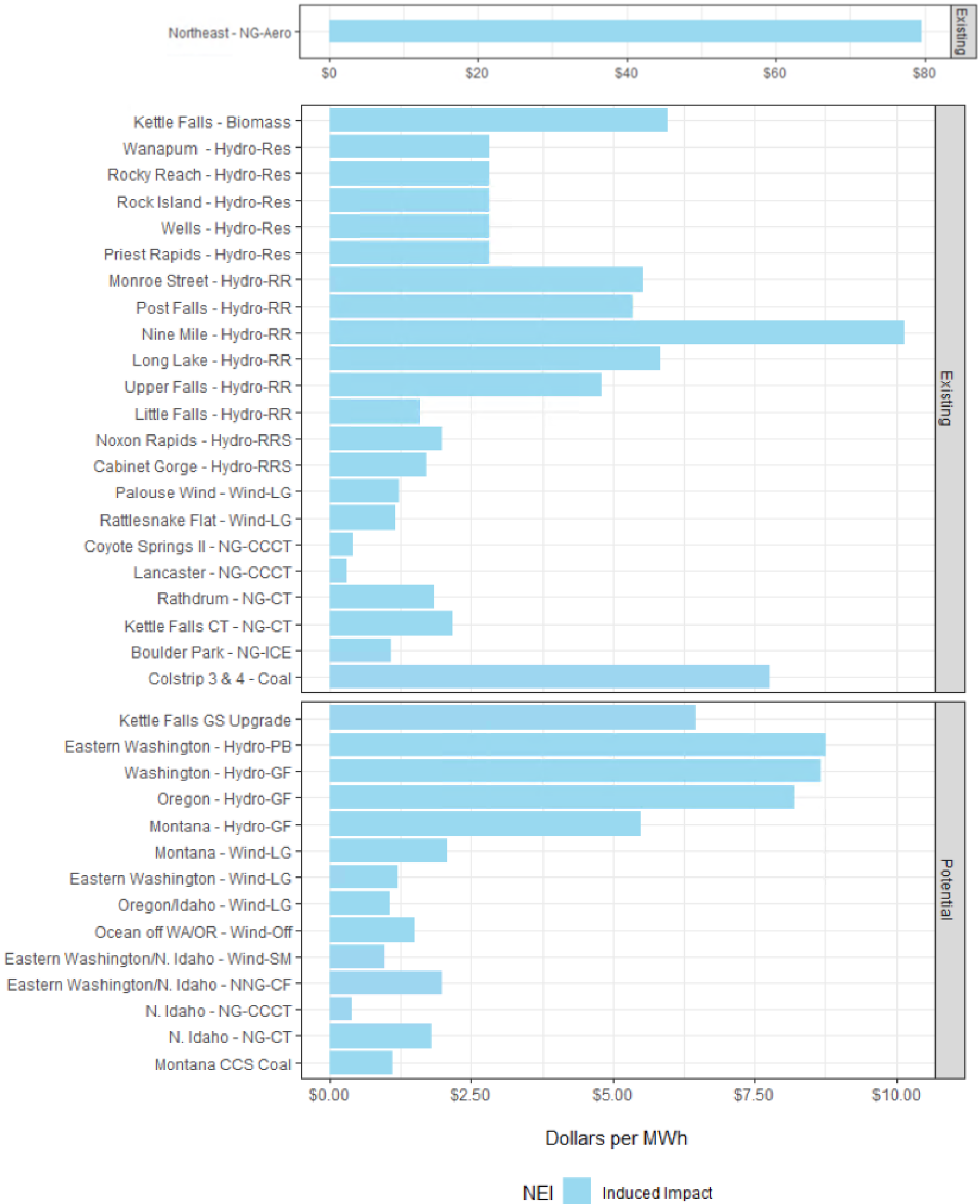


Table 3-10: Summary of Operations Induced Value Add

Existing/ Potential	Fuel Type	Resource Name	Economic Operations ($/MWh)
Existing	Biomass	Kettle Falls	5.98
	Coal	Colstrip 3 & 4	7.77
	Hydro-Res	Priest Rapids	2.82
		Rock Island	2.82
		Rocky Reach	2.82
		Wanapum	2.82
		Wells	2.82
	Hydro-RR	Little Falls	1.59
		Long Lake	5.84
		Monroe Street	5.54
		Nine Mile	10.16
		Post Falls	5.34
		Upper Falls	4.80
	Hydro-RRS	Cabinet Gorge	1.70
		Noxon Rapids	1.98
	NG-Aero	Northeast	79.53
	NG-CCCT	Coyote Springs II	0.42
		Lancaster	0.30
	NG-CT	Kettle Falls CT	2.17
		Rathdrum	1.83
	NG-ICE	Boulder Park	1.09
	Solar-Utl	Adams Neilson	Gap
	Wind-LG	Palouse Wind	1.21
		Rattlesnake Flat	1.15
Potential	Batt-LG	Eastern Washington/N. Idaho	Gap
	Batt-SM	Eastern Washington/N. Idaho	Gap
	Biomass	Kettle Falls GS Upgrade	6.46
	Coal CCS	Montana CCS Coal	1.11
	HE-LG	Eastern Washington	Gap
	HE-SM	Eastern Washington	Gap
	Hydro-GF	Montana	5.48
		Oregon	8.22
		Washington	8.68
	Hydro-PB	Eastern Washington	8.77
	NG-CCCT	N. Idaho	0.40
	NG-CT	N. Idaho	1.79
	NNG-Bio	Eastern Washington/N. Idaho	Gap
	NNG-CF	Eastern Washington/N. Idaho	1.99
	NNG-Hyd	Eastern Washington/N. Idaho	Gap
	NNG-LAir	Eastern Washington/N. Idaho	Gap
	NNG-Ren	Eastern Washington/N. Idaho	Gap
	Nuclear	Eastern Washington/N. Idaho	Gap
	Solar-Com	Eastern Washington/N. Idaho	Gap
	Solar-Rft	Eastern Washington/N. Idaho	Gap
	Solar-Utl	Eastern Washington/N. Idaho	Gap
		Northwest outside of AVA area	Gap
	Wind-LG	Eastern Washington	1.21
		Montana	2.08
		Oregon/Idaho	1.06
	Wind-Off	Ocean off WA/OR	1.50
	Wind-SM	Eastern Washington/N. Idaho	0.97

3.3 Summary of compiled data

Table 3-11 summarizes the NEI value coverage by generator type. In general, older generator types tended to have more readily available information than newer resource types.

Table 3-11. Summary of data completeness

Group	Generator Types	Public Health	Safety	Environment: Land Use	Environment: Water Use	Environment: Wildlife	Economic
Biomass	Biomass	✓	✓	✓	✓		✓
Coal	Coal	✓	✓	✓	✓	✓	✓
	Coal CCS	✓	✓	✓	✓	✓	✓
Hydro	Hydro-PB						✓
	Hydro-GF						✓
	Hydro-Res		✓	✓			✓
	Hydro-RR						✓
	Hydro-RRS						✓
Hydrogen Electrolyzer	HE-LG			✓			
	HE-SM			✓			
Lithium-ion Storage	Batt-LG						
	Batt-SM						
Natural gas	NG-Aero	✓	✓	✓	✓	✓	✓
	NG-CCCT	✓	✓	✓	✓	✓	✓
	NG-CT	✓	✓	✓	✓	✓	✓
	NG-ICE	✓	✓	✓	✓	✓	✓
Non-natural gas	NNG-Bio		✓				
	NNG-CF						
	NNG-Hyd			✓			
	NNG-LAir						
	NNG-Ren			✓			
Nuclear	Nuclear		✓	✓	✓	✓	
Solar	Solar-Com		✓	✓	✓		✓
	Solar-Rft		✓	✓	✓		✓
	Solar-Utl		✓	✓	✓		✓
Wind	Wind-LG		✓	✓	✓	✓	✓
	Wind-Off		✓	✓	✓		✓
	Wind-SM		✓	✓	✓	✓	✓

3.4 Database application

DNV applied the values in the database to existing and proposed Avista generation resources. The first step in this process was to obtain information about each generation resource from Avista, including technology type, capacity, and operating output over the past 3 years.

The next step was to match each generation resource to the resource type in the database. Then DNV could assign NEIs based on the per MWh or per MW values for each NEI type to new generation resources and resources already operated by Avista. Benefits appear as positive values and costs appear as negative values. The values are then summed to produce a final, total NEI value for each resource.

3.5 Issues and data gaps

This section documents the areas where there was insufficient information to provide an estimated NEI value for any specific NEI types for specific resources. In addition to documenting the NEIs for which values are not readily available, DNV estimates the research value and research effort that it would take to fill each gap using a high, medium, low designation on each dimension. Table 3-12 summarizes the NEIs, the gaps, and the value and effort of addressing each one. Finer-grained gaps are also identified in the database.

Table 3-12. Gap analysis

NEI	Resource	Description	Additional Research Description	Value	Effort
Public Health	All	Emissions data only available for operation phase	Locate emissions for mining, construction, decommissioning then monetize	Medium	High
	All	Soil and water contamination effects not included	Locate emissions data for these effects, including for supply-chain, plant operations, and decommissioning. Locate monetary costs of those types of contamination and multiply	Low	High
	Nuclear	Public health risks of transport and long-term storage of radioactive wastes as well as risks of catastrophic failures was not included	Identify risk analysis data for nuclear operations and waste management	Low	Medium
	Biomass	Counterfactual emissions for the biomass if not used in the power plants was not modeled	Identify likely alternative treatment of the biomass material and the resulting emissions	Low	Medium
Safety	Hydro, Nuclear, Solar, Wind, Biomass, Biogas	Fatalities data are reported in aggregate across the supply chain and within proprietary databases	Locate original data or conduct original research to disaggregate fatalities. Low effort approach could develop reasonable ratios for fatalities in each phase of supply chain and apply those ratios to the overall aggregate number.	Low	High/ Low
Reliability & Resiliency	All	Specific metrics on reliability and grid resiliency could not be calculated for this study. Monetizing these metrics is an additional challenge	An analysis of how different IRP scenarios are likely to affect grid reliability, especially in named communities would help address CETA concerns	Medium	High
Energy Security	All	This study considered LCOE values as proxies for the cost of energy	An analysis of how different IRP scenarios are likely to affect energy burdens, especially for named communities would help address CETA concerns	High	High

NEI	Resource	Description	Additional Research Description	Value	Effort
Environment: Wildfires	All	Comparative data for wildfire risks for different generation technologies is not readily available. Monetizing these risks is an additional challenge	Investigate the California wildfire risk assessment system and consider adapting for use in Washington. This assessment is done at the state level in California, so a statewide, rather than utility specific effort would be reasonable.	High	High
Environment: Land use, Water use monetization	All	The current study used publicly available, but somewhat arbitrary sources to monetize land and water values	Establish a more robust source(s) for these values, possibly applying more site-specific values or possibly blending values from multiple sources	Low	Medium
Environment: Wildlife monetization	All	Estimates of the monetary value of wildlife are not readily available.	Conduct additional secondary research with the EPA and conservation groups for data. Primary research would be very difficult and expensive.	Low	High
Environment: Surface air effects	Wind	Potential surface air effects of wind turbines was not considered	Obtain recent data, if available, on surface air downwind of wind turbines. Monetize those impacts.	Low	High
Economic	Hydrogen Electrolyzer	These technologies are too new to have robust, publicly available economic impact models. LCOEs for HE are based on compression, transportation, and storage costs, assuming a source of hydrogen is already accessible. The cost to produce the hydrogen is not included.	Conduct additional primary and secondary research into the costs to produce the storage tanks and facilities for these resources. Conduct additional research to price hydrogen generation and add to the LCOEs Create an economics impacts model similar to JEDI	Medium	High
All	Non-natural gas	Publicly available data for this technology were not readily available	Additional research on the facilities that produce this fuel are needed to estimate the NEIs associated with it, including economic modeling. Combustion pollutants are likely to be similar to geologic natural gas, so public health impacts likely to be similar to gas turbine plants	Medium	High
Economic	Solar PV,	NREL does not publish a JEDI model for these resources, and no equivalent models are publicly available	Identify a reasonable number for wage earnings for solar PV installation and operations Develop economic models for indirect and induced jobs	High	Medium

NEI	Resource	Description	Additional Research Description	Value	Effort
All	Battery Storage	Publicly available data for this technology were not readily available	Additional research on the facilities that produce this fuel are needed to estimate the NEIs associated with it, including economic modeling	High	High
Economic	Nuclear	NREL does not publish a JEDI model for these resources, and no equivalent models are publicly available	Nuclear plants are established technology so information on operational costs should be available.	Low	Low
Decommis-sioning	All	Data on decommissioning costs was not readily available	Locate data on these costs for established technologies. Survey permitting requirements for decommissioning financing for newer technologies	Medium	High

4 OVERALL IMPACTS

The NEI database can be applied to Avista's specific existing and proposed resources to estimate the overall NEIs for each resource. The impacts are aggregated by NEI metric. Some metrics are reported per MWh while others are reported by MW, depending on whether the impact is fixed or variable with electricity production.

The aggregated impacts per MWh include the following components:

- **Economic - Operations**: Induced value-added economic impacts of operations. Avista already accounts for the direct impacts as part of the cost of energy production. Therefore, only the induced impacts represent NEIs. These impacts are reported as benefits.
- **Public Health**: Health impacts occurring throughout the United States due to operations. These impacts are reported as costs.
- **Safety**: Direct and indirect fatalities occurring during construction, operations, and mining. These impacts are reported as costs.

The aggregated impacts per MW include the following components:

- **Economic - Construction**: Induced value-added economic impacts of resource operations. These impacts are reported as benefits for proposed facilities only.

Table 4-1. Net Resource Benefits for Existing Avista Resources

Fuel Type	Resource Name	Economic Operations ($/MWh)	Safety ($/MWh)	Public Health ($/MWh)	Net ($/MWh)
Biomass	Kettle Falls	5.98	-0.16	-13.36	-7.54
Coal	Colstrip 3 & 4	7.77	-0.31	-25.26	-17.80
Hydro-Res	Priest Rapids	2.82	-0.26	0.00	2.56
Hydro-Res	Rock Island	2.82	-0.26	0.00	2.56
Hydro-Res	Rocky Reach	2.82	-0.26	0.00	2.56
Hydro-Res	Wanapum	2.82	-0.26	0.00	2.56
Hydro-Res	Wells	2.82	-0.26	0.00	2.56
Hydro-RR	Little Falls	1.59	Gap	0.00	1.59
Hydro-RR	Long Lake	5.84	Gap	0.00	5.84
Hydro-RR	Monroe Street	5.54	Gap	0.00	5.54
Hydro-RR	Nine Mile	10.16	Gap	0.00	10.16
Hydro-RR	Post Falls	5.34	Gap	0.00	5.34
Hydro-RR	Upper Falls	4.80	Gap	0.00	4.80
Hydro-RRS	Cabinet Gorge	1.70	Gap	0.00	1.70
Hydro-RRS	Noxon Rapids	1.98	Gap	0.00	1.98
NG-Aero	Northeast	79.53	-0.12	-24.73	54.67
NG-CCCT	Coyote Springs II	0.42	-0.12	-0.67	-0.37
NG-CCCT	Lancaster	0.30	-0.12	-1.94	-1.76
NG-CT	Kettle Falls CT	2.17	-0.12	-4.30	-2.26
NG-CT	Rathdrum	1.83	-0.12	-2.79	-1.08
NG-ICE	Boulder Park	1.09	-0.12	-0.92	0.04
Solar-Utl	Adams Neilson	Gap	-0.20	0.00	-0.20
Wind-LG	Palouse Wind	1.21	-0.38	0.00	0.83
Wind-LG	Rattlesnake Flat	1.15	-0.38	0.00	0.78

Table 4-2: Net Resource Benefits for Potential Resource Alternatives

Fuel Type	Resource Name	$/MWh				$/MW
		Economic Operations	Safety	Public Health	Net	Economic Construction
Batt-LG	Eastern Washington/N. Idaho	Gap	Gap	0.00	0.00	Gap
Batt-SM	Eastern Washington/N. Idaho	Gap	Gap	0.00	0.00	Gap
Biomass	Kettle Falls GS Upgrade	6.46	-0.16	-12.71	-6.41	102,800
Coal CCS	Montana CCS Coal	1.11	-0.31	-22.49	-21.69	162,822
HE-LG	Eastern Washington	Gap	Gap	0.00	0.00	Gap
HE-SM	Eastern Washington	Gap	Gap	0.00	0.00	Gap
Hydro-GF	Montana	5.48	Gap	0.00	5.48	275,500
Hydro-GF	Oregon	8.22	Gap	0.00	8.22	448,000
Hydro-GF	Washington	8.68	Gap	0.00	8.68	458,000
Hydro-PB	Eastern Washington	8.77	Gap	0.00	8.77	456,600
NG-CCCT	N. Idaho	0.40	-0.12	-1.75	-1.48	300,280
NG-CT	N. Idaho	1.79	-0.12	-4.52	-2.86	59,000
NNG-Bio	Eastern Washington/N. Idaho	Gap	-0.05	0.00	-0.05	Gap
NNG-CF	Eastern Washington/N. Idaho	1.99	Gap	0.00	1.99	300,280
NNG-Hyd	Eastern Washington/N. Idaho	Gap	Gap	0.00	0.00	Gap
NNG-LAir	Eastern Washington/N. Idaho	Gap	Gap	0.00	0.00	Gap
NNG-Ren	Eastern Washington/N. Idaho	Gap	Gap	0.00	0.00	Gap
Nuclear	Eastern Washington/N. Idaho	Gap	-0.11	0.00	-0.11	Gap
Solar-Com	Eastern Washington/N. Idaho	Gap	-0.20	0.00	-0.20	Gap
Solar-Rft	Eastern Washington/N. Idaho	Gap	-0.20	0.00	-0.20	Gap
Solar-Utl	Eastern Washington/N. Idaho	Gap	-0.20	0.00	-0.20	Gap
Solar-Utl	Northwest outside of AVA area	Gap	-0.20	0.00	-0.20	Gap
Wind-LG	Eastern Washington	1.21	-0.38	0.00	0.83	89,600
Wind-LG	Montana	2.08	-0.38	0.00	1.70	44,267
Wind-LG	Oregon/Idaho	1.06	-0.38	0.00	0.68	62,267
Wind-Off	Ocean off WA/OR	1.50	-0.38	0.00	1.12	245,978
Wind-SM	Eastern Washington/N. Idaho	0.97	-0.38	0.00	0.59	68,600

5 APPENDICES

5.1 Appendix A: Detailed Methods

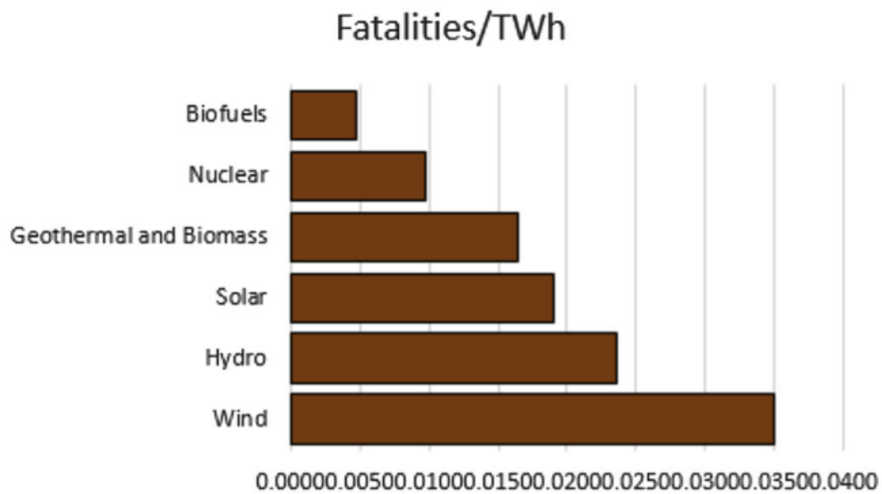
5.1.1 Safety

5.1.1.1 Biomass, bio-fuel, hydro, nuclear, solar, wind

Fatality estimates for electricity generation from biomass, bio-fuels, hydro, nuclear, solar, and wind come from a 2015 paper titled *Balancing safety with sustainability: assessing the risk of accidents for modern low-carbon energy systems*[48]. The authors of this paper develop their own dataset of energy value chain accidents. They explain the requirements for being included in the dataset as, "this means it must have occurred at a nuclear, renewable, hydrogen, or hydroelectric energy facility, its associated infrastructure, or within its fuel cycle (mine, transportation by truck or pipeline, enrichment facility, manufacturing plant, etc.)." The authors provide examples from this research such as a 2013 accident in Noxen, Pennsylvania where 5 people died when a helicopter crashed into a wind farm during bad weather, or a 2013 accident in Catanzaro, Italy, where 2 welders are killed in an explosion while working at a biofuel plant.

The authors further go on to normalize fatalities by energy use and describe using a subset of incidences ranging from 1990 – 2013. Because DNV does not have access to this full database, values cannot be disaggregated into direct and indirect fatalities. Figure 5-1 shows the graphical results of this study in fatalities/TWh:

Figure 5-1. Fatalities per TWh from original paper



5.1.1.2 Fossil fuels (natural gas and coal)

Fatality estimates for natural gas and coal are developed using publicly available data regarding US production, transportation, and generation. It is necessary to calculate new numbers because most of the value chain for these generation types takes place in the US and estimates from secondary research is not available for current, US-only values. DNV aggregates values from multiple sources to produce values for coal and natural gas.

[48] Sovacool, Benjamin K., Rasmus Andersen, Steven Sorensen, Kenneth Sorensen, Victor Tienda, Arturas Vainorius, Oliver Marc Schirach, and Frans Bjørn-Thygesen. 2016. "Balancing Safety with Sustainability: Assessing the Risk of Accidents for Modern Low-Carbon Energy Systems." Journal of Cleaner Production 112 (January): 3952–65.

Natural gas

Extraction

DNV developed numbers for natural gas using industry statistics related to extraction, transportation, and generation. For extraction, DNV used the National Institute for Occupational Safety and Health (NIOSH) database of Fatalities in the Oil and Gas Extraction Industry (FOG)[49]. This database includes land-based and offshore worker fatalities related to the U.S. oil and gas extraction industry only.

Table 5-1. Fatalities from the U.S. natural gas and oil extraction industry by state, 2015-2017

State	fatalities in 2015-2016	fatalities in 2017
Texas	45	44
North Dakota	13	3
Oklahoma	8	6
Louisiana	4	4
New Mexico	5	3
Colorado	<3	<3
Illinois	<3	<3
Ohio	<3	<3
West Virginia	<3	<3
Wyoming	<3	<3
California	<3	0
Kansas	<3	0
Kentucky	<3	0
Pennsylvania	<3	0
Virginia	<3	0
Total	**92**	**69**

Source: NIOSHA FOG database

The FOG data does not separate out which fatalities occurred from oil or natural gas extraction. DNV used the ratio between U.S. oil and natural gas production, which was 59% natural gas and 41% oil in 2019,[50] to disaggregate fatalities by fuel. This ratio makes the simplifying assumption that the risks from oil extraction and natural gas extraction are equal. DNV was unable to find any studies comparing the safety of oil vs. gas extraction and so this ratio approach could be applied absent newer evidence. Multiplying the average total fatalities from 2015-2017 by 59% produces a value of 31.7 fatalities per year from natural gas extraction.

Transportation

Besides fatalities from oil and gas extraction, there are also fatalities from the operation of gas pipelines. The federal Pipeline and Hazardous Material Safety Administration (PHMSA)[51] publishes records of "significant" pipeline incidents which involve either an injury or a fatality to either industry employees or members of the public.

[49] "CDC - Fatalities in the Oil and Gas Extraction Industry (FOG) - NIOSH Workplace Safety & Health Topic." 2021. Www.cdc.gov. June 24, 2021. https://www.cdc.gov/niosh/topics/fog/default.html.

[50] According to the EIA the U.S. produced an average of 111.5 billion cubic feet per day and 12.8 million barrels of oil in 2019. Because one barrel of oil has the energy equivalent of 6,000 cubic feet of gas, this works out to a ratio of 59% natural gas and 41% oil on an equivalent basis.

[51] 2022. Dot.gov. 2022. https://portal.phmsa.dot.gov/analytics/saw.dll?Portalpages&PortalPath=%2Fshared%2FPDM%20Public%20Website%2F_portal%2FSC%20Incident%20Trend&Page=Significant%20Incidents%20Consequences.

Table 5-2. U.S. pipeline fatalities and injuries to industry employees and members of the public, 2005-2020

Calendar year	Total fatalities	Total injuries
2005	16	46
2006	19	34
2007	15	46
2008	8	54
2009	13	62
2010	19	103
2011	11	50
2012	10	54
2013	8	42
2014	19	93
2015	9	48
2016	16	86
2017	7	30
2018	6	78
2019	11	35
2020	15	43
Total	**202**	**904**

Source: PHMSA

This source shows that over the 2005-2020 period there have been 202 fatalities and 686 injuries from these significant incidents.[52] While these data are for all types of pipelines, other studies have shown that 91% of these incidents were related to gas pipelines in general and 78% were related to gas distribution lines in particular.[53] By taking the average of this 16 year period, multiplying by 91% for the share of fatalities from natural gas pipeline operation, the yearly fatality rate from operation of natural gas pipelines is 11.5.

While most natural gas is delivered via pipelines, there has been increasing interest in the transportation of liquified natural gas (LNG) due to the challenges of building new pipeline capacity. LNG is primarily delivered by truck due to severe restrictions on LNG transport by rail.[54] One case study of LNG transport in New England indicated that this method of transportation is very safe.[55]

Generation

Lastly, DNV used the Census of Fatal Occupational Injuries (CFOI)[56] from the U.S. Bureau of Labor Statistics to develop fatality estimates from natural gas electricity generation. This source claims there were 5 fatalities in fossil fuel electric power generation (NAICS code 221112) for 2019. According to the EIA[57], 2019 energy production from natural gas was 46.7% of US energy production from fossil fuels, meaning there were 2.3 fatalities per year from natural gas generation.

Total

The last thing to consider with fatalities of natural gas extraction and transportation is the proportion of gas that goes to electricity generation compared with the proportion of gas that goes to other end uses. EIA's 2020 numbers for natural gas consumption by sector[58] calculates 38% of this is for electric power. Using this, the final value for fatalities per year associated with natural gas electricity generation is:

Equation 3

$$Fatalities\ per\ year = (31.7_{extraction} + 11.5_{transportation}) * 0.38_{electricity\ generation} + 2.3_{generation} = 18.7$$

52 Oracle BI Interactive Dashboards - SC Incident Trend (dot.gov)

53 State Gas Pipelines - Pipeline Accidents (ncsl.org)

54 Risk Assessment of Surface Transport of Liquid Natural Gas (dot.gov)

55 "Over the past 45 years, Engie has contracted with motor carriers to transport LNG to 42 storage facilities in New England. During this time, these carriers have completed over 300,000 truck trips up to 150 miles with only two incidents. One was a truck rollover and the other was a truck engine fire. In both examples the LNG product in the cargo tank was not released." (Source: Risk Assessment of Surface Transport of Liquid Natural Gas (dot.gov)

56 "Census of Fatal Occupational Injuries (CFOI) - Current and Revised Data." 2018. Bls.gov. December 18, 2018. https://www.bls.gov/iif/oshcfoi1.htm.

57 https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php#:~:text=Most%20electricity%20is%20generated%20with,wind%20turbines%2C%20and%20solar%20photovoltaics.

58 https://www.eia.gov/energyexplained/natural-gas/use-of-natural-gas.php#:~:text=The%20commercial%20sector%20uses%20natural,combined%20heat%20and%20power%20systems.

To convert this number into fatalities per unit of energy, DNV used the 2020 EIA U.S. electricity generated by major source[59]. For natural gas, this was 1.624 x 10^9 MWh, resulting in a per MWh value of 1.152 x 10^{-8} fatalities.

Coal

Extraction

Estimates for coal extraction come from the U.S. Department of Labor's Mine Safety and Health Administration (MSHA)[60]. DNV chose to average total fatalities from 2005 to 2020 to match the process used for natural gas. This comes to an average of 21.25 fatalities per year from coal extraction. These fatality values are shown in Table 5-3.

Table 5-3. US coal mining fatalities

Calendar year	Total fatalities
2005	23
2006	47
2007	34
2008	30
2009	18
2010	48
2011	20
2012	20
2013	20
2014	16
2015	12
2016	8
2017	15
2018	12
2019	12
2020	5
Total	**340**

Transportation

For valuing coal transportation DNV calculated the average number of US train fatalities[61] from 2005 to 2020 and came up with 9.94 fatalities per year. These yearly values are shown in Table 5-4.

[59] https://www.eia.gov/tools/faqs/faq.php?id=427&t=3,%20multiply%20by%20share%20of%20natural%20gas%20going%20to%20electricity%20https://www.eia.gov/tools/faqs/faq.php?id=50&t=8

[60] "Coal Mining Fatality Statistics: 1900-2013." 2013. Msha.gov. 2013. https://arlweb.msha.gov/stats/centurystats/coalstats.asp.

[61] "Train Fatalities, Injuries, and Accidents by Type of Accident | Bureau of Transportation Statistics." n.d. Www.bts.gov. https://www.bts.gov/content/train-fatalities-injuries-and-accidents-type-accidenta.

Table 5-4. US rail fatalities

Calendar year	Total fatalities
2005	33
2006	6
2007	9
2008	27
2009	4
2010	8
2011	6
2012	9
2013	11
2014	5
2015	11
2016	7
2017	7
2018	7
2019	3
2020	6
Total	**159**

According to the National Railway Labor Conference's latest estimate[62], coal accounted for 13% of carloads in the US.

Generation

Lastly, DNV used the Census of Fatal Occupational Injuries (CFOI)[63] from the U.S. Bureau of Labor Statistics to develop fatality estimates from natural gas electricity generation. This source claims there were 5 fatalities in fossil fuel electric power generation (NAICS code 221112) for 2019. According to the EIA[64], 2019 energy production from natural gas was 28.4% of US energy production from fossil fuels, meaning there were 1.42 fatalities per year from natural gas generation.

Total

The last thing to consider for coal is the proportion of coal used for electricity generation. According to EIA[65], this is 91.5%. When factoring this into all the steps above, the safety value of coal is shown in

62 Coal In Decline: The Impact on Railroads - NRLC (raillaborfacts.org)

63 "Census of Fatal Occupational Injuries (CFOI) - Current and Revised Data." 2018. Bls.gov. December 18, 2018. https://www.bls.gov/iif/oshcfoi1.htm.

64 https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php#:~:text=Most%20electricity%20is%20generated%20with,wind%20turbines%2C%20and%20solar%20photovoltaics.

65 https://www.eia.gov/energyexplained/coal/use-of-coal.php

Equation 4

$$Fatalities\ per\ year = (21.25_{\ extraction} + (9.94_{US\ rail} * 0.13_{coal\ rail})) * 0.915_{electricity\ generation} + 1.42_{generation} = 22.04$$

To convert this number into fatalities per unit of energy, DNV used the 2020 EIA U.S. electricity generated by major source[66]. For coal, this was 773 x 10^8 MWh, resulting in a per MWh value of 2.851 x 10^{-8} fatalities.

5.1.2 Economic

To produce job, output, earnings, and value added estimates DNV used applicable JEDI models downloaded from NREL's website. These models and model versions can be found below in Table 5-5.

Table 5-5. Specific JEDI models

Categorization	Model Version
Biopower	JEDI Biopower Model rel. B12.23.16
Coal	JEDI Coal Model rel. C12.23.16
Conventional hydro	JEDI CHydro Model rel.CH12.23.16
Marine and hydrokinetic	JEDI MHydro Model rel. MH12.23.16
Natural gas	JEDI NGas Model rel. NG4.17.17
Land based wind	JEDI Land Based Wind Model Beta rel. W10.30.20
Offshore wind	JEDI OffShore Wind Model rel.2021-2

The main inputs for the models are specified location, year of construction, resource size, and percent local, DNV used the information for existing and proposed resource given from Avista (Table 5-6). JEDI models have additional default values for local content that are derived from industry norms. DNV used the default values for biopower, coal, marine and hydrokinetic, natural gas, and land-based wind.

Table 5-6. JEDI imputes for specific plants

Plant Name	Categorization	Location	MW	Start Date	Capacity Factor
Colstrip 3 & 4	Coal	Colstrip, MT	1,480	1984/1986	
Rathdrum	Natural gas CT	Rathdrum, ID	166	1995	11.7%
Northeast	Natural gas Aero Turbine	Spokane, WA	62	1978	0.1%
Boulder Park	Natural gas ICE	Spokane Valley, WA	25	2002	
Coyote Springs II	Natural gas CCCT	Boardman, OR	306	2003	70.3%
Lancaster	Natural gas CCCT	Rathdrum, ID	256	2001	63.9%
Kettle Falls CT	Natural gas CT	Kettle Falls, WA	7	2002	2.0%
Kettle Falls	Biomass	Kettle Falls, WA	51	1983	59.6%
Noxon Rapids	Storage Hydro	Noxon, MT	555	1959	37.4%
Cabinet Gorge	Storage Hydro	Cabinet, ID	260	1952	43.2%
Monroe Street	Run-of-river hydro	Spokane, WA	15	1890	64.1%
Post Falls	Run-of-river hydro	Post Falls, ID	15	1906	60.6%
Nine Mile	Run-of-river hydro	Nine Mile Falls, WA	38	1908	35.8%
Little Falls	Run-of-river hydro	Ford, WA	35	1910	56.2%
Long Lake	Run-of-river hydro	Ford, WA	88	1915	82.0%
Upper Falls	Run-of-river hydro	Spokane, WA	10	1922	66.4%
Palouse Wind	Large Wind	Approx Oaksdale, WA	105	2010	39.9%
Rattlesnake Flat	Large Wind	Approx Lind, WA	144	2020	0.3%
Adams Neilson	Large Solar	Lind, WA	20	2019	27.0%
Wanapum	Reservoir hydro	Grant County, WA	2,258	1950s	25.9%
Rocky Reach	Reservoir hydro	Chelan County, WA	1,300	1950s	51.8%
Rock Island	Reservoir hydro	Chelan County, WA	629	1950s	45.4%

[66] https://www.eia.gov/tools/faqs/faq.php?id=427&t=3,%20multiply%20by%20share%20of%20natural%20gas%20going%20to%20electricity%20https://www.eia.gov/tools/faqs/faq.php?id=50&t=8

Plant Name	Categorization	Location	MW	Start Date	Capacity Factor
Wells	Reservoir hydro	Douglas County, WA	774	1950s	64.6%
Priest Rapids	Reservoir hydro	Grant County, WA	956	1950s	57.1%
Potential Resource	Large wind	MT	150	Post 2025	45.0%
Potential Resource	Large wind	Eastern WA	150	Post 2025	35.3%
Potential Resource	Large wind	Oregon/ID	150	Post 2025	35.3%
Potential Resource	Off-shore wind	Ocean off WA/OR	150	Post 2030	50.0%
Potential Resource	Small wind	Eastern WA/N. ID	50	Post 2025	35.3%
Potential Resource	Utility-scale solar	Eastern WA/N. ID	100	Post 2025	24.2%
Potential Resource	Community solar	Eastern WA/N. ID	5	Post 2025	20.0%
Potential Resource	Rooftop solar	Eastern WA/N. ID	0	Post 2025	15.0%
Potential Resource	Utility-scale solar	Northwest outside of AVA area	100	Post 2025	24.2%
Potential Resource	Natural gas CT	N. ID	50	Post 2025	11.5%
Potential Resource	Natural gas CCCT	N. ID	250	Post 2025	57.0%
Potential Resource	Pumped hydro - greenfield	WA	200	Post 2027	12.5%
Potential Resource	Pumped hydro - greenfield	OR	200	Post 2027	12.5%
Potential Resource	Pumped hydro - greenfield	MT	200	Post 2027	12.5%
Potential Resource	Pumped hydro - brownfield	Eastern WA	500	Post 2027	12.5%
Potential Resource	Hydrogen electrolyzer - small	Eastern WA	5	Post 2025	n/a
Potential Resource	Hydrogen electrolyzer - large	Eastern WA	50	Post 2025	n/a
Potential Resource	Clean Fuel Turbine	Eastern WA/N. ID	50	Post 2035	11.5%
Potential Resource	Non-natural gas (Hydrogen)	Eastern WA/N. ID		Post 2035	n/a
Potential Resource	Renewable natural gas storage tank	Eastern WA/N. ID		Post 2035	n/a
Potential Resource	Non-natural gas (Bio-fuel)	Eastern WA/N. ID		Post 2035	n/a
Potential Resource	Non-natural gas (Liquid air)	Eastern WA/N. ID		Post 2025	n/a
Potential Resource	Nuclear	Eastern WA/N. ID	200	Post 2030	92.4%
Potential Resource	Biomass	Kettle Falls GS Upgrade	25	Post 2025	70.0%
Potential Resource	Coal with Carbon Capture	Montana CCS Coal	200	Post 2030	80.0%
Potential Resource	Lithium Ion Distribution scale	Eastern WA/N. ID	1	Post 2025	n/a
Potential Resource	Lithium Ion Utility scale	Eastern WA/N. ID	1	Post 2025	n/a

Exceptions

Mentioned previously in section 3.2.6, offshore wind used JEDI estimates from direct impacts and used multipliers from EPI to estimate indirect and induced job impacts. The EPI study reports multipliers by major industries and sub-industries that corresponds with a two-digit code. DNV used the multipliers reported for the major industry, utilities, and sub-industry, electric power generation, transmission, and distribution, that corresponds with the two-digit code 12 in this source. These multipliers were 3.99 for indirect impacts and 1.65 for induced impacts.

The JEDI model for run-of-the-river hydropower requires project cost inputs in order to reflect jobs, earning, output, and value added according to the project specifications. In the absence of project specific project costs, these inputs were scaled in reference to the default MW project size of 5 MW. Therefore, any project costs are multiplied by the proportion of the project MW size to 5 MW.

5.2 Appendix B: Detailed Non-Energy Impacts Values

This appendix includes the applied NEI values and monetized values for each NEI category.

5.2.1 Public health

Table 5-7 shows the applied operational emissions values and Table 5-8 shows the monetized health impacts from the emissions.

Table 5-7. Operational Emissions in Tons per GWh

Type	Technology Abbreviation	Generator Name/ Location	NOx	SOx	PM2.5
Existing	Biomass	Kettle Falls	1.37	0.01	0.16
	Coal	Colstrip 3 & 4	0.93	0.45	0.11
	Hydro-Res	Wanapum	0.00	0.00	0.00
		Rocky Reach	0.00	0.00	0.00
		Rock Island	0.00	0.00	0.00
		Wells	0.00	0.00	0.00
		Priest Rapids	0.00	0.00	0.00
	Hydro-RR	Monroe Street	0.00	0.00	0.00
		Post Falls	0.00	0.00	0.00
		Nine Mile	0.00	0.00	0.00
		Long Lake	0.00	0.00	0.00
		Upper Falls	0.00	0.00	0.00
		Little Falls	0.00	0.00	0.00
	Hydro-RRS	Noxon Rapids	0.00	0.00	0.00
		Cabinet Gorge	0.00	0.00	0.00
	NG-Aero	Northeast	3.16	0.00	0.05
	NG-CCCT	Coyote Springs II	0.03	0.00	0.02
		Lancaster	0.06	0.00	0.02
	NG-CT	Rathdrum	0.22	0.00	0.02
		Kettle Falls CT	0.55	0.00	0.04
	NG-ICE	Boulder Park	0.11	0.00	0.00
	Solar-Utl	Adams Neilson	0.00	0.00	0.00
	Wind-LG	Palouse Wind	0.00	0.00	0.00
		Rattlesnake Flat	0.00	0.00	0.00
Potential	Biomass	Kettle Falls GS Upgrade	1.37	0.01	0.15
	Coal CCS	Montana CCS Coal	0.93	0.45	0.06
	Hydro-PB	Eastern Washington	0.00	0.00	0.00
	Hydro-GF	Washington	0.00	0.00	0.00
		Oregon	0.00	0.00	0.00
		Montana	0.00	0.00	0.00
	HE-LG	Eastern Washington	-	-	-
	HE-SM	Eastern Washington	-	-	-

Type	Technology Abbreviation	Generator Name/ Location	NOx	SOx	PM2.5
	Batt-LG	Eastern Washington/N. Idaho	-	-	-
	Batt-SM	Eastern Washington/N. Idaho	-	-	-
	NG-CCCT	N. Idaho	0.03	0.00	0.02
	NG-CT	N. Idaho	0.39	0.00	0.03
	NNG-Bio	Eastern Washington/N. Idaho	-	-	-
	NNG-Hyd	Eastern Washington/N. Idaho	-	-	-
	NNG-LAir	Eastern Washington/N. Idaho	-	-	-
	NNG-CF	Eastern Washington/N. Idaho	-	-	-
	NNG-Ren	Eastern Washington/N. Idaho	-	-	-
	Nuclear	Eastern Washington/N. Idaho	-	-	0.00
	Solar-Com	Eastern Washington/N. Idaho	0.00	0.00	0.00
	Solar-Rft	Eastern Washington/N. Idaho	0.00	0.00	0.00
	Solar-Utl	Eastern Washington/N. Idaho	0.00	0.00	0.00
		Northwest outside of AVA area	0.00	0.00	0.00
	Wind-LG	Montana	0.00	0.00	0.00
		Eastern Washington	0.00	0.00	0.00
		Oregon/Idaho	0.00	0.00	0.00
	Wind-Off	Ocean off WA/OR	0.00	0.00	0.00
	Wind-SM	Eastern Washington/N. Idaho	0.00	0.00	0.00

Table 5-8. Operational Public Health Costs in Dollars per MWh

Type	Technology Abbreviation	Generator Name/ Location	NOx			SOx			PM2.5			Total Impact, All Regions
			Site County	Avista Territory	Other U.S.	Site County	Avista Territory	Other U.S.	Site County	Avista Territory	Other U.S.	
Existing	Biomass	Kettle Falls	$ 0.83	$ 0.77	$ 5.40	$ 0.00	$ 0.00	$ 0.05	$ 1.67	$ 1.04	$ 3.58	$ 13.36
	Coal	Colstrip 3 & 4	$ 0.01	$ 0.03	$ 9.31	$ 0.01	$ 0.03	$ 10.11	$ 0.01	$ 0.02	$ 5.73	$ 25.26
	Hydro-Res	Wanapum	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Rocky Reach	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Rock Island	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Wells	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Priest Rapids	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Hydro-RR	Monroe Street	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Post Falls	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Nine Mile	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Long Lake	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Upper Falls	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Little Falls	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Hydro-RRS	Noxon Rapids	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Cabinet Gorge	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	NG-Aero	Northeast	$ 8.46	$ 1.54	$10.32	$ 0.01	$ 0.00	$ 0.02	$ 2.87	$ 0.52	$ 0.98	$ 24.73
	NG-CCCT	Coyote Springs II	$ 0.00	$ 0.01	$ 0.11	$ 0.00	$ 0.00	$ 0.03	$ 0.02	$ 0.05	$ 0.44	$ 0.67
		Lancaster	$ 0.08	$ 0.04	$ 0.24	$ 0.00	$ 0.00	$ 0.02	$ 0.70	$ 0.31	$ 0.53	$ 1.94
	NG-CT	Rathdrum	$ 0.34	$ 0.17	$ 0.96	$ 0.01	$ 0.00	$ 0.04	$ 0.58	$ 0.25	$ 0.44	$ 2.79
		Kettle Falls CT	$ 0.34	$ 0.31	$ 2.18	$ 0.00	$ 0.00	$ 0.03	$ 0.38	$ 0.24	$ 0.82	$ 4.30
	NG-ICE	Boulder Park	$ 0.31	$ 0.06	$ 0.37	$ 0.01	$ 0.00	$ 0.02	$ 0.10	$ 0.02	$ 0.03	$ 0.92
	Solar-Utl	Adams Neilson	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Wind-LG	Palouse Wind	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Rattlesnake Flat	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Potential	Biomass	Kettle Falls GS Upgrade	$ 0.83	$ 0.77	$ 5.40	$ 0.00	$ 0.00	$ 0.05	$ 1.50	$ 0.94	$ 3.21	$ 12.71
	Coal CCS	Montana CCS Coal	$ 0.01	$ 0.03	$ 9.31	$ 0.01	$ 0.03	$ 10.11	$ 0.01	$ 0.01	$ 2.98	$ 22.49
	Hydro-PB	E. WA	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Hydro-GF	WA	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Oregon	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Montana	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	HE-LG	E. WA	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	HE-SM	E. WA	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Batt-LG	E. WA/N. ID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Batt-SM	E. WA/N. ID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	NG-CCCT	N. ID	$ 0.05	$ 0.03	$ 0.15	$ 0.00	$ 0.00	$ 0.02	$ 0.68	$ 0.30	$ 0.52	$ 1.75

Type	Technology Abbreviation	Generator Name/ Location	NOx			SOx			PM2.5			Total Impact, All Regions
			Site County	Avista Territory	Other U.S.	Site County	Avista Territory	Other U.S.	Site County	Avista Territory	Other U.S.	
	NG-CT	N. ID	$ 0.58	$ 0.29	$ 1.67	$ 0.01	$ 0.00	$ 0.04	$ 0.88	$ 0.39	$ 0.67	$ 4.52
	NNG-Bio	E. WA/N. ID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	NNG-Hyd	E. WA/N. ID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	NNG-LAir	E. WA/N. ID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	NNG-CF	E. WA/N. ID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	NNG-Ren	E. WA/N. ID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Nuclear	E. WA/N. ID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Solar-Com	E. WA/N. ID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Solar-Rft	E. WA/N. ID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Solar-Utl	E. WA/N. ID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Northwest outside of AVA area	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Wind-LG	Montana	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		E. WA	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Oregon/ID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Wind-Off	Ocean off WA/OR	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Wind-SM	E. WA/N. ID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

5.2.2 Safety

Table 5-9 shows the applied fatalities per TWh and Table 5-10 shows the monetized impacts.

Table 5-9. Fatalities per TWh

Type	Technology Abbreviation	Generator Name/ Location	Direct Fatalities	Indirect Fatalities		Total Fatalities
			Construction and Operation	Mining	Operation	All Value Chain
Existing	Biomass	Kettle Falls	0.0153	-	-	0.0153
	Coal	Colstrip 3 & 4	0.0018	0.0251	0.0015	0.0285
	Hydro-Res	Wanapum	0.0240	-	-	0.0240
		Rocky Reach	0.0240	-	-	0.0240
		Rock Island	0.0240	-	-	0.0240
		Wells	0.0240	-	-	0.0240
		Priest Rapids	0.0240	-	-	0.0240
	Hydro-RR	Monroe Street	-	-	-	-
		Post Falls	-	-	-	-
		Nine Mile	-	-	-	-
		Long Lake	-	-	-	-
		Upper Falls	-	-	-	-
		Little Falls	-	-	-	-
	Hydro-RRS	Noxon Rapids	-	-	-	-
		Cabinet Gorge	-	-	-	-
	NG-Aero	Northeast	0.0014	0.0074	0.0027	0.0115
	NG-CCCT	Coyote Springs II	0.0014	0.0074	0.0027	0.0115
		Lancaster	0.0014	0.0074	0.0027	0.0115
	NG-CT	Rathdrum	0.0014	0.0074	0.0027	0.0115
		Kettle Falls CT	0.0014	0.0074	0.0027	0.0115
	NG-ICE	Boulder Park	0.0014	0.0074	0.0027	0.0115
	Solar-Utl	Adams Neilson	0.0190	-	-	0.0190
	Wind-LG	Palouse Wind	0.0350	-	-	0.0350
		Rattlesnake Flat	0.0350	-	-	0.0350
Potential	Biomass	Kettle Falls GS Upgrade	0.0153	-	-	0.0153
	Coal CCS	Montana CCS Coal	0.0018	0.0251	0.0015	0.0285
	Hydro-PB	Eastern Washington	-	-	-	-
	Hydro-GF	Washington	-	-	-	-
		Oregon	-	-	-	-

Type	Technology Abbreviation	Generator Name/ Location	Direct Fatalities	Indirect Fatalities		Total Fatalities
			Construction and Operation	Mining	Operation	All Value Chain
		Montana	-	-	-	-
	HE-LG	Eastern Washington	-	-	-	-
	HE-SM	Eastern Washington	-	-	-	-
	Batt-LG	Eastern Washington/N. Idaho	-	-	-	-
	Batt-SM	Eastern Washington/N. Idaho	-	-	-	-
	NG-CCCT	N. Idaho	0.0014	0.0074	0.0027	0.0115
	NG-CT	N. Idaho	0.0014	0.0074	0.0027	0.0115
	NNG-Bio	Eastern Washington/N. Idaho	0.0050	-	-	0.0050
	NNG-Hyd	Eastern Washington/N. Idaho	-	-	-	-
	NNG-LAir	Eastern Washington/N. Idaho	-	-	-	-
	NNG-CF	Eastern Washington/N. Idaho	-	-	-	-
	NNG-Ren	Eastern Washington/N. Idaho	-	-	-	-
	Nuclear	Eastern Washington/N. Idaho	0.0100	-	-	0.0100
	Solar-Com	Eastern Washington/N. Idaho	0.0190	-	-	0.0190
	Solar-Rft	Eastern Washington/N. Idaho	0.0190	-	-	0.0190
	Solar-Utl	Eastern Washington/N. Idaho	0.0190	-	-	0.0190
		Northwest outside of AVA area	0.0190	-	-	0.0190
	Wind-LG	Montana	0.0350	-	-	0.0350
		Eastern Washington	0.0350	-	-	0.0350
		Oregon/Idaho	0.0350	-	-	0.0350
	Wind-Off	Ocean off WA/OR	0.0350	-	-	0.0350
	Wind-SM	Eastern Washington/N. Idaho	0.0350	-	-	0.0350

Table 5-10. Monetized Fatalities per MWh

Type	Technology Abbreviation	Generator Name/ Location	Direct Fatalities	Indirect Fatalities		Total Fatalities
			Construction and Operation	Mining	Operation	All Value Chain
Existing	Biomass	Kettle Falls	$0.16	-	-	$ 0.16
	Coal	Colstrip 3 & 4	$0.02	$0.27	$0.02	$ 0.31
	Hydro-Res	Wanapum	$0.26	-	-	$ 0.26
		Rocky Reach	$0.26	-	-	$ 0.26
		Rock Island	$0.26	-	-	$ 0.26
		Wells	$0.26	-	-	$ 0.26
		Priest Rapids	$0.26	-	-	$ 0.26
	Hydro-RR	Monroe Street	-	-	-	-
		Post Falls	-	-	-	-
		Nine Mile	-	-	-	-
		Long Lake	-	-	-	-
		Upper Falls	-	-	-	-
		Little Falls	-	-	-	-
	Hydro-RRS	Noxon Rapids	-	-	-	-
		Cabinet Gorge	-	-	-	-
	NG-Aero	Northeast	$0.02	$0.08	$0.03	$ 0.12
	NG-CCCT	Coyote Springs II	$0.02	$0.08	$0.03	$ 0.12
		Lancaster	$0.02	$0.08	$0.03	$ 0.12
	NG-CT	Rathdrum	$0.02	$0.08	$0.03	$ 0.12
		Kettle Falls CT	$0.02	$0.08	$0.03	$ 0.12
	NG-ICE	Boulder Park	$0.02	$0.08	$0.03	$ 0.12
	Solar-Utl	Adams Neilson	$0.20	-	-	$ 0.20
	Wind-LG	Palouse Wind	$0.38	-	-	$ 0.38
		Rattlesnake Flat	$0.38	-	-	$ 0.38
Potential	Biomass	Kettle Falls GS Upgrade	$0.16	-	-	$ 0.16
	Coal CCS	Montana CCS Coal	$0.02	$0.27	$0.02	$ 0.31
	Hydro-PB	Eastern Washington	-	-	-	-
	Hydro-GF	Washington	-	-	-	-
		Oregon	-	-	-	-
		Montana	-	-	-	-
	HE-LG	Eastern Washington	-	-	-	-
	HE-SM	Eastern Washington	-	-	-	-
	Batt-LG	Eastern Washington/N. Idaho	-	-	-	-

Type	Technology Abbreviation	Generator Name/ Location	Direct Fatalities	Indirect Fatalities		Total Fatalities
			Construction and Operation	Mining	Operation	All Value Chain
	Batt-SM	Eastern Washington/N. Idaho	-	-	-	-
	NG-CCCT	N. Idaho	$0.02	$0.08	$0.03	$ 0.12
	NG-CT	N. Idaho	$0.02	$0.08	$0.03	$ 0.12
	NNG-Bio	Eastern Washington/N. Idaho	$0.05	-	-	$ 0.05
	NNG-Hyd	Eastern Washington/N. Idaho	-	-	-	-
	NNG-LAir	Eastern Washington/N. Idaho	-	-	-	-
	NNG-CF	Eastern Washington/N. Idaho	-	-	-	-
	NNG-Ren	Eastern Washington/N. Idaho	-	-	-	-
	Nuclear	Eastern Washington/N. Idaho	$0.11	-	-	$ 0.11
	Solar-Com	Eastern Washington/N. Idaho	$0.20	-	-	$ 0.20
	Solar-Rft	Eastern Washington/N. Idaho	$0.20	-	-	$ 0.20
	Solar-Utl	Eastern Washington/N. Idaho	$0.20	-	-	$ 0.20
		Northwest outside of AVA area	$0.20	-	-	$ 0.20
	Wind-LG	Montana	$0.38	-	-	$ 0.38
		Eastern Washington	$0.38	-	-	$ 0.38
		Oregon/Idaho	$0.38	-	-	$ 0.38
	Wind-Off	Ocean off WA/OR	$0.38	-	-	$ 0.38
	Wind-SM	Eastern Washington/N. Idaho	$0.38	-	-	$ 0.38

5.2.3 Environment

5.2.3.1 Land Use

Table 5-11 presents the applied land use in acres per MW.

Table 5-11. Land Use in Acres per MW

Type	Technology Abbreviation	Generator Name/ Location	Land Use (Acres/ MW)				
			Construction	Mining	Operation	Decommissioning	Total
Existing	Biomass	Kettle Falls	-	-	0.30	-	0.30
	Coal	Colstrip 3 & 4	-	0.72	1.18	-	1.90
	Hydro-Res	Wanapum	67.36	-	237.55	-	304.91
		Rocky Reach	67.36	-	237.55	-	304.91
		Rock Island	67.36	-	237.55	-	304.91
		Wells	67.36	-	237.55	-	304.91
		Priest Rapids	67.36	-	237.55	-	304.91
	Hydro-RR	Monroe Street	-	-	-	-	-
		Post Falls	-	-	-	-	-
		Nine Mile	-	-	-	-	-
		Long Lake	-	-	-	-	-
		Upper Falls	-	-	-	-	-
		Little Falls	-	-	-	-	-
	Hydro-RRS	Noxon Rapids	-	-	-	-	-
		Cabinet Gorge	-	-	-	-	-
	NG-Aero	Northeast	-	1.66	0.34	-	2.00
	NG-CCCT	Coyote Springs II	-	1.66	0.34	-	2.00
		Lancaster	-	1.66	0.34	-	2.00
	NG-CT	Rathdrum	-	1.66	0.34	-	2.00
		Kettle Falls CT	-	1.66	0.34	-	2.00
	NG-ICE	Boulder Park	-	1.66	0.34	-	2.00
	Solar-Utl	Adams Neilson	1.98	-	8.10	0.04	10.12
	Wind-LG	Palouse Wind	0.28	-	60.00	-	60.28
		Rattlesnake Flat	0.28	-	60.00	-	60.28
	Biomass	Kettle Falls GS Upgrade	-	-	0.30	-	0.30

Type	Technology Abbreviation	Generator Name/ Location	Land Use (Acres/ MW) Construction	Mining	Operation	Decommissioning	Total
	Coal CCS	Montana CCS Coal	-	0.72	1.18	-	1.90
	Hydro-PB	Eastern Washington	-	-	-	-	-
	Hydro-GF	Washington	-	-	-	-	-
		Oregon	-	-	-	-	-
		Montana	-	-	-	-	-
	HE-LG	Eastern Washington	-	-	0.03	-	0.03
	HE-SM	Eastern Washington	-	-	0.01	-	0.01
	Batt-LG	Eastern Washington/N. Idaho	-	-	-	-	-
	Batt-SM	Eastern Washington/N. Idaho	-	-	-	-	-
	NG-CCCT	N. Idaho	-	1.66	0.34	-	2.00
	NG-CT	N. Idaho	-	1.66	0.34	-	2.00
	NNG-Bio	Eastern Washington/N. Idaho	-	-	-	-	-
	NNG-Hyd	Eastern Washington/N. Idaho	-	-	0.10	-	0.10
	NNG-LAir	Eastern Washington/N. Idaho	-	-	-	-	-
	NNG-CF	Eastern Washington/N. Idaho	-	-	-	-	-
	NNG-Ren	Eastern Washington/N. Idaho	-	-	1.36	-	1.36
	Nuclear	Eastern Washington/N. Idaho	-	1.42	0.97	-	2.39
	Solar-Com	Eastern Washington/N. Idaho	1.98	-	8.10	0.04	10.12
	Solar-Rft	Eastern Washington/N. Idaho	1.98	-	0.00	0.04	2.02
	Solar-Utl	Eastern Washington/N. Idaho	1.98	-	8.10	0.04	10.12
		Northwest outside of AVA area	1.98	-	8.10	0.04	10.12
	Wind-LG	Montana	0.28	-	60.00	-	60.28
		Eastern Washington	0.28	-	60.00	-	60.28
		Oregon/Idaho	0.28	-	60.00	-	60.28
	Wind-Off	Ocean off WA/OR	0.28	-	-	-	0.28
	Wind-SM	Eastern Washington/N. Idaho	0.28	-	44.70	-	44.98

5.2.3.2 Water Use

Table 5-12 presents the applied water use in gallons per MWh.

Table 5-12. Water Use in Gallons per MWh

Type	Technology Abbreviation	Generator Name/ Location	Water Use (Gallons/ MWh)
Existing	Biomass	Kettle Falls	553
	Coal	Colstrip 3 & 4	687
	Hydro-Res	Wanapum	4491
		Rocky Reach	4491
		Rock Island	4491
		Wells	4491
		Priest Rapids	4491
	Hydro-RR	Monroe Street	-
		Post Falls	-
		Nine Mile	-
		Long Lake	-
		Upper Falls	-
		Little Falls	-
	Hydro-RRS	Noxon Rapids	-
		Cabinet Gorge	-
	NG-Aero	Northeast	-
	NG-CCCT	Coyote Springs II	205
		Lancaster	205
	NG-CT	Rathdrum	0
		Kettle Falls CT	0
	NG-ICE	Boulder Park	0
	Solar-Utl	Adams Neilson	1
	Wind-LG	Palouse Wind	0
		Rattlesnake Flat	0
Potential	Biomass	Kettle Falls GS Upgrade	553
	Coal CCS	Montana CCS Coal	846
	Hydro-PB	Eastern Washington	-
		Washington	-
	Hydro-GF	Oregon	-
	HE-LG	Montana	-
	HE-LG	Eastern Washington	-
	HE-SM	Eastern Washington	-
	Batt-LG	Eastern Washington/N. Idaho	-
	Batt-SM	Eastern Washington/N. Idaho	-
	NG-CCCT	N. Idaho	205
	NG-CT	N. Idaho	0

Type	Technology Abbreviation	Generator Name/ Location	Water Use (Gallons/ MWh)
	NNG-Bio	Eastern Washington/N. Idaho	-
	NNG-Hyd	Eastern Washington/N. Idaho	-
	NNG-LAir	Eastern Washington/N. Idaho	-
	NNG-CF	Eastern Washington/N. Idaho	-
	NNG-Ren	Eastern Washington/N. Idaho	-
	Nuclear	Eastern Washington/N. Idaho	672
	Solar-Com	Eastern Washington/N. Idaho	1
	Solar-Rft	Eastern Washington/N. Idaho	1
	Solar-Utl	Eastern Washington/N. Idaho	1
	Wind-LG	Northwest outside of AVA area	1
	Wind-LG	Montana	0
		Eastern Washington	0
	Wind-Off	Oregon/Idaho	0
	Wind-Off	Ocean off WA/OR	0

5.2.3.3 Wildlife Impacts

Table 5-13 presents the applied values for avian fatalities per GWh.

Table 5-13. Avian fatalities per GWh

Type	Technology Abbreviation	Generator Name/ Location	Wildlife Impacts (Avian Fatalities/GWh)
Existing	Biomass	Kettle Falls	-
	Coal	Colstrip 3 & 4	0.20
	Hydro-Res	Wanapum	-
		Rocky Reach	-
		Rock Island	-
		Wells	-
		Priest Rapids	-
	Hydro-RR	Monroe Street	-
		Post Falls	-
		Nine Mile	-
		Long Lake	-
		Upper Falls	-
		Little Falls	-
	Hydro-RRS	Noxon Rapids	-
		Cabinet Gorge	-
	NG-Aero	Northeast	0.20
	NG-CCCT	Coyote Springs II	0.20
		Lancaster	0.20
	NG-CT	Rathdrum	0.20
		Kettle Falls CT	0.20
	NG-ICE	Boulder Park	0.20
	Solar-Utl	Adams Neilson	-
	Wind-LG	Palouse Wind	0.27
		Rattlesnake Flat	0.27
Potential	Biomass	Kettle Falls GS Upgrade	-
	Coal CCS	Montana CCS Coal	0.20
	Hydro-PB	Eastern Washington	-
	Hydro-GF	Washington	-
		Oregon	-
		Montana	-
	HE-LG	Eastern Washington	-
	HE-SM	Eastern Washington	-
	Batt-LG	Eastern Washington/N. Idaho	-
	Batt-SM	Eastern Washington/N. Idaho	-
	NG-CCCT	N. Idaho	0.20
	NG-CT	N. Idaho	0.20

Type	Technology Abbreviation	Generator Name/ Location	Wildlife Impacts (Avian Fatalities/GWh)
	NNG-Bio	Eastern Washington/N. Idaho	-
	NNG-Hyd	Eastern Washington/N. Idaho	-
	NNG-LAir	Eastern Washington/N. Idaho	-
	NNG-CF	Eastern Washington/N. Idaho	-
	NNG-Ren	Eastern Washington/N. Idaho	-
	Nuclear	Eastern Washington/N. Idaho	0.64
	Solar-Com	Eastern Washington/N. Idaho	-
	Solar-Rft	Eastern Washington/N. Idaho	-
	Solar-Utl	Eastern Washington/N. Idaho	-
		Northwest outside of AVA area	-
	Wind-LG	Montana	0.27
		Eastern Washington	0.27
		Oregon/Idaho	0.27
	Wind-Off	Ocean off WA/OR	-
	Wind-SM	Eastern Washington/N. Idaho	0.27

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5.2.4 Economic

Table 5-14 shows the applied construction jobs and economic impacts.Table 5-15 shows the applied operations jobs and economic impacts.

Table 5-14. Construction Jobs and Economic Impacts

Type	Technology Abbreviation	Generator Name/ Location	Direct Impact				Indirect Impact				Induced Impact			
			Jobs/MW	Earnings in 2021$/MW	Output in 2021$/MW	Value Added in 2021$/MW	Jobs/MW	Earnings in 2021$/MW	Output in 2021$/MW	Value Added in 2021$/MW	Jobs/MW	Earnings in 2021$/MW	Output in 2021$/MW	Value Added in 2021$/MW
Existing	Biomass	Kettle Falls	3.00	$300,603	$372,189	$330,178	0.71	$47,638	$147,929	$86,588	0.69	$45,105	$136,686	$83,037
	Coal	Colstrip 3 & 4	5.44	$466,653	$902,905	$597,432	2.44	$110,203	$345,878	$176,486	1.82	$79,865	$250,743	$133,446
	Hydro-Res	Wanapum	15.51	$1,106,541	$2,034,243	$1,335,911	4.25	$285,630	$901,729	$517,882	3.92	$260,677	$789,639	$480,274
		Rocky Reach	15.51	$1,106,541	$2,034,243	$1,335,911	4.25	$285,630	$901,729	$517,882	3.92	$260,677	$789,639	$480,274
		Rock Island	15.51	$1,106,541	$2,034,243	$1,335,911	4.25	$285,630	$901,729	$517,882	3.92	$260,677	$789,639	$480,274
		Wells	15.51	$1,106,541	$2,034,243	$1,335,911	4.25	$285,630	$901,729	$517,882	3.92	$260,677	$789,639	$480,274
		Priest Rapids	15.51	$1,106,541	$2,034,243	$1,335,911	4.25	$285,630	$901,729	$517,882	3.92	$260,677	$789,639	$480,274
	Hydro-RR	Monroe Street	1.07	$87,838	$202,703	$128,378	4.26	$358,108	$1,317,568	$621,622	2.16	$148,649	$452,703	$277,027
		Post Falls	1.55	$82,759	$200,000	$117,241	5.28	$317,241	$1,296,552	$496,552	2.57	$117,241	$379,310	$200,000
		Nine Mile	1.07	$85,106	$202,128	$130,319	4.26	$61,170	$1,319,149	$622,340	2.15	$148,936	$454,787	$276,596
		Long Lake	1.07	$85,227	$201,136	$131,818	4.26	$354,545	$1,318,182	$621,591	2.15	$150,000	$453,409	$276,136
		Upper Falls	1.07	$90,000	$200,000	$130,000	4.26	$350,000	$1,320,000	$620,000	2.15	$150,000	$450,000	$280,000
		Little Falls	15.20	$1,085,714	$1,965,714	$1,302,857	4.11	$277,143	$874,286	$502,857	3.83	$254,286	$771,429	$468,571
	Hydro-RRS	Noxon Rapids	15.86	$925,045	$1,817,838	$1,087,027	5.22	$240,000	$771,351	$382,703	3.74	$164,505	$516,216	$274,775
		Cabinet Gorge	16.29	$932,692	$1,858,462	$1,083,077	5.63	$261,923	$851,154	$435,000	4.03	$177,692	$570,000	$302,308
	NG-Aero	Northeast	0.92	$141,129	$196,129	$150,968	0.85	$54,677	$199,516	$114,839	0.65	$44,677	$135,323	$82,258
	NG-CCCT	Coyote Springs II	0.98	$139,608	$196,699	$147,712	1.03	$52,255	$190,359	$104,281	0.71	$38,137	$109,902	$63,595
		Lancaster	1.07	$134,727	$196,680	$141,211	1.19	$51,914	$206,328	$100,039	0.76	$34,648	$111,211	$58,984
	NG-CT	Rathdrum	1.07	$135,060	$197,169	$141,566	1.19	$52,048	$206,867	$100,301	0.76	$34,699	$111,506	$59,157
		Kettle Falls CT	0.97	$141,667	$197,222	$151,389	0.83	$54,167	$200,000	$115,278	0.69	$44,444	$136,111	$81,944
	NG-ICE	Boulder Park	0.92	$139,200	$179,200	$149,200	0.84	$54,000	$196,800	$113,200	0.64	$44,000	$133,600	$81,200
	Solar-Utl	Adams Neilson	5.45	$293,973	-	-	4.80	$258,912	-	-	4.88	$263,227	-	-
	Wind-LG	Palouse Wind	0.63	$45,810	$50,000	$47,143	1.50	$109,143	$316,095	$173,048	0.67	$46,857	$144,952	$90,381
		Rattlesnake Flat	0.56	$41,319	$45,486	$42,569	1.50	$41,319	$316,042	$172,986	0.66	$46,528	$143,819	$89,653
Potential	Biomass	Kettle Falls GS Upgrade	3.72	$371,600	$460,400	$408,000	0.88	$58,800	$182,800	$107,200	0.84	$55,600	$168,800	$102,800
	Coal CCS	Montana CCS Coal	6.63	$569,380	$1,101,667	$728,948	2.97	$134,462	$422,018	$215,337	2.22	$97,446	$305,941	$162,822
	Hydro-PB	E. WA	14.75	$1,052,400	$1,933,000	$1,270,200	4.04	$271,400	$856,800	$492,200	3.73	$247,800	$750,800	$456,600
	Hydro-GF	WA	14.81	$1,056,500	$1,937,000	$1,274,000	4.05	$272,350	$858,500	$493,000	3.74	$248,500	$753,000	$458,000
		OR	16.04	$1,076,500	$1,994,500	$1,254,000	5.50	$290,000	$861,500	$477,500	5.11	$269,000	$775,000	$448,000
		MT	15.91	$929,000	$1,821,500	$1,091,000	5.24	$240,500	$773,000	$383,500	3.76	$165,000	$518,000	$275,500
	HE-LG	E. WA	-	-	-	-	-	-	-	-	-	-	-	-
	HE-SM	E. WA	-	-	-	-	-	-	-	-	-	-	-	-

Type	Technology Abbreviation	Generator Name/ Location	Direct Impact				Indirect Impact				Induced Impact			
			Jobs/MW	Earnings in 2021$/MW	Output in 2021$/MW	Value Added in 2021$/MW	Jobs/MW	Earnings in 2021$/MW	Output in 2021$/MW	Value Added in 2021$/MW	Jobs/MW	Earnings in 2021$/MW	Output in 2021$/MW	Value Added in 2021$/MW
	Batt-LG	E. WA/N. ID	-	-	-	-	-	-	-	-	-	-	-	-
	Batt-SM	E. WA/N. ID	-	-	-	-	-	-	-	-	-	-	-	-
	NG-CCCT	N. ID	1.07	$134,720	$196,680	$141,200	1.19	$51,920	$206,360	$100,040	0.76	$34,640	$111,240	$300,280
	NG-CT	N. ID	1.08	$134,800	$196,600	$141,200	1.20	$52,000	$206,400	$100,000	0.76	$34,600	$111,200	$59,000
	NNG-Bio	E. WA/N. ID	-	-	-	-	-	-	-	-	-	-	-	-
	NNG-Hyd	E. WA/N. ID	-	-	-	-	-	-	-	-	-	-	-	-
	NNG-LAir	E. WA/N. ID	-	-	-	-	-	-	-	-	-	-	-	-
	NNG-CF	E. WA/N. ID	1.07	$134,720	$196,680	$141,200	1.19	$51,920	$206,360	$100,040	0.76	$34,640	$111,240	$300,280
	NNG-Ren	E. WA/N. ID	-	-	-	-	-	-	-	-	-	-	-	-
	Nuclear	E. WA/N. ID	-	-	-	-	-	-	-	-	-	-	-	-
	Solar-Com	E. WA/N. ID	5.45	$293,973	-	-	4.80	$258,912	-	-	4.88	$263,227	-	-
	Solar-Rft	E. WA/N. ID	10.90	$587,946	-	-	9.60	$517,824	-	-	9.67	$526,454	-	-
	Solar-Utl	E. WA/N. ID	5.45	$293,973	-	-	4.80	$258,912	-	-	4.88	$263,227	-	-
		Northwest outside of AVA area	5.45	$293,973	-	-	4.80	$258,912	-	-	4.88	$263,227	-	-
	Wind-LG	MT	0.57	$31,733	$36,067	$32,267	1.91	$96,000	$306,867	$136,867	0.59	$25,267	$80,800	$44,267
		E. WA	0.56	$40,667	$44,867	$41,933	1.50	$109,200	$316,000	$172,933	0.66	$46,467	$143,667	$89,600
		OR/ID	0.56	$35,933	$40,400	$37,467	1.83	$108,000	$308,867	$154,400	0.68	$35,800	$104,933	$62,267
	Wind-Off	Ocean off WA/OR	0.15	$11,227	$11,227	$11,227	7.49	$770,052	$1,816,213	$991,067	1.96	$120,076	$412,474	$245,978
	Wind-SM	E. WA/N. ID	1.08	$54,400	$59,000	$55,200	1.92	$94,600	$314,800	$144,200	0.84	$38,200	$125,200	$68,600

Table 5-15. Operations Jobs and Economic Impacts

Type	Technology Abbreviation	Generator Name/ Location	Direct Impact				Indirect Impact				Induced Impact			
			Jobs/MWh	Earnings in 2021 $/MWh	Output in 2021 $/MWh	Value Added in 2021 $/MWh	Jobs/MWh	Earnings in 2021 $/MWh	Output in 2021 $/MWh	Value Added in 2021 $/MWh	Jobs/MWh	Earnings in 2021 $/MWh	Output in 2021 $/MWh	Value Added in 2021 $/MWh
Existing	Biomass	Kettle Falls	<0.0001	$3.40	$3.40	$3.40	0.0002	$11.26	$35.23	$19.87	<0.0001	$3.25	$9.87	$5.98
	Coal	Colstrip 3 & 4	0.0002	$15.71	$15.71	$15.71	0.0003	$15.71	$64.08	$30.18	0.0001	$4.63	$14.64	$7.77
	Hydro-Res	Wanapum	<0.0001	$2.81	$2.81	$2.81	<0.0001	$4.73	$17.54	$10.15	<0.0001	$1.53	$4.64	$2.82
		Rocky Reach	<0.0001	$2.81	$2.81	$2.81	<0.0001	$4.73	$17.54	$10.15	<0.0001	$1.53	$4.64	$2.82
		Rock Island	<0.0001	$2.81	$2.81	$2.81	<0.0001	$4.73	$17.54	$10.15	<0.0001	$1.53	$4.64	$2.82
		Wells	<0.0001	$2.81	$2.81	$2.81	<0.0001	$4.73	$17.54	$10.15	<0.0001	$1.53	$4.64	$2.82
		Priest Rapids	<0.0001	$2.81	$2.81	$2.81	<0.0001	$4.73	$17.54	$10.15	<0.0001	$1.53	$4.64	$2.82
	Hydro-RR	Monroe Street	0.0002	$15.51	$15.51	$15.51	<0.0001	$5.54	$22.15	$12.18	<0.0001	$3.32	$8.86	$5.54
		Post Falls	0.0002	$17.37	$17.37	$17.37	0.0001	$6.68	$28.06	$12.03	<0.0001	$2.67	$9.35	$5.34
		Nine Mile	0.0004	$27.35	$27.35	$27.35	0.0001	$10.16	$39.06	$21.09	<0.0001	$5.47	$16.41	$10.16
		Long Lake	0.0002	$16.52	$16.52	$16.52	<0.0001	$6.24	$23.56	$12.69	<0.0001	$3.22	$9.67	$5.84
		Upper Falls	0.0002	$14.41	$14.41	$14.41	<0.0001	$6.40	$20.81	$11.21	<0.0001	$3.20	$8.01	$4.80
	Hydro-RRS	Little Falls	<0.0001	$1.59	$1.59	$1.59	<0.0001	$3.18	$11.14	$6.36	<0.0001	$1.06	$2.65	$1.59
		Noxon Rapids	<0.0001	$2.74	$2.74	$2.74	<0.0001	$4.60	$18.87	$9.26	<0.0001	$1.17	$3.73	$1.98
		Cabinet Gorge	<0.0001	$2.18	$2.18	$2.18	<0.0001	$3.79	$15.15	$7.38	<0.0001	$1.04	$3.31	$1.70
	NG-Aero	Northeast	0.0016	$106.04	$106.04	$106.04	0.0016	$121.95	$413.56	$243.89	0.0005	$42.42	$132.55	$79.53
	NG-CCCT	Coyote Springs II	<0.0001	$0.57	$0.57	$0.57	<0.0001	$0.68	$2.22	$1.24	<0.0001	$0.25	$0.73	$0.42
		Lancaster	<0.0001	$0.53	$0.53	$0.53	<0.0001	$0.59	$2.16	$1.10	<0.0001	$0.18	$0.57	$0.30
	NG-CT	Rathdrum	<0.0001	$3.24	$3.24	$3.24	<0.0001	$3.60	$13.26	$6.72	<0.0001	$1.10	$3.48	$1.83
		Kettle Falls CT	0.0001	$2.17	$2.17	$2.17	0.0001	$3.26	$9.77	$5.43	0.0000	$1.09	$3.26	$2.17
	NG-ICE	Boulder Park	<0.0001	$1.45	$1.45	$1.45	<0.0001	$1.63	$5.61	$3.26	0.0000	$0.54	$1.81	$1.09
	Solar-Utl	Adams Neilson	-	$-	$-	$-	-	$-	$-	$-	-	$-	$-	$-
	Wind-LG	Palouse Wind	<0.0001	$1.48	$1.48	$1.48	<0.0001	$1.54	$5.48	$3.60	<0.0001	$0.64	$1.97	$1.21
		Rattlesnake Flat	<0.0001	$1.28	$1.28	$1.28	<0.0001	$1.47	$5.21	$3.44	<0.0001	$0.60	$1.84	$1.15
Potential	Biomass	Kettle Falls GS Upgrade	0.0001	$5.22	$5.22	$5.22	0.0002	$11.48	$36.14	$20.48	<0.0001	$3.52	$10.57	$6.46
	Coal CCS	Montana CCS Coal	<0.0001	$2.24	$2.24	$2.24	<0.0001	$2.24	$9.12	$4.29	<0.0001	$0.66	$2.08	$1.11
	Hydro-PB	E. WA	0.0001	$8.58	$8.58	$8.58	0.0002	$14.61	$54.06	$31.23	<0.0001	$4.75	$14.25	$8.77
	Hydro-GF	WA	0.0001	$8.68	$8.68	$8.68	0.0002	$14.61	$53.88	$31.51	<0.0001	$4.57	$14.16	$8.68
		OR	0.0001	$9.13	$9.13	$9.13	0.0003	$14.61	$54.34	$31.51	<0.0001	$5.02	$14.16	$8.22
		MT	0.0001	$7.76	$7.76	$7.76	0.0003	$12.79	$53.42	$26.03	<0.0001	$3.20	$10.50	$5.48
	HE-LG	E. WA	-	-	-	-	-	-	-	-	-	-	-	-
	HE-SM	E. WA	-	-	-	-	-	-	-	-	-	-	-	-
	Batt-LG	E. WA/N. ID	-	-	-	-	-	-	-	-	-	-	-	-
	Batt-SM	E. WA/N. ID	-	-	-	-	-	-	-	-	-	-	-	-
	NG-CCCT	N. ID	<0.0001	$0.64	$0.64	$0.64	<0.0001	$0.80	$2.95	$1.47	<0.0001	$0.23	$0.76	$0.40
	NG-CT	N. ID	<0.0001	$3.18	$3.18	$3.18	<0.0001	$3.57	$12.90	$6.55	<0.0001	$0.99	$3.38	$1.79

Type	Technology Abbreviation	Generator Name/ Location	Direct Impact				Indirect Impact				Induced Impact			
			Jobs/MWh	Earnings in 2021 $/MWh	Output in 2021 $/MWh	Value Added in 2021 $/MWh	Jobs/MWh	Earnings in 2021 $/MWh	Output in 2021 $/MWh	Value Added in 2021 $/MWh	Jobs/MWh	Earnings in 2021 $/MWh	Output in 2021 $/MWh	Value Added in 2021 $/MWh
	NNG-Bio	E. WA/N. ID	-	-	-	-	-	-	-	-	-	-	-	-
	NNG-Hyd	E. WA/N. ID	-	-	-	-	-	-	-	-	-	-	-	-
	NNG-LAir	E. WA/N. ID	-	-	-	-	-	-	-	-	-	-	-	-
	NNG-CF	E. WA/N. ID	<0.0001	$3.18	$3.18	$3.18	<0.0001	$3.97	$14.61	$7.31	<0.0001	$1.15	$3.77	$1.99
	NNG-Ren	E. WA/N. ID	-	-	-	-	-	-	-	-	-	-	-	-
	Nuclear	E. WA/N. ID	-	$-	$-	$-	-	$-	$-	$-	-	$-	$-	$-
	Solar-Com	E. WA/N. ID	-	$-	$-	$-	-	$-	$-	$-	-	$-	$-	$-
	Solar-Rft	E. WA/N. ID	-	$-	$-	$-	-	$-	$-	$-	-	$-	$-	$-
	Solar-Utl	E. WA/N. ID	-	$-	$-	$-	-	$-	$-	$-	-	$-	$-	$-
		Northwest outside of AVA area	-	$-	$-	$-	-	$-	$-	$-	-	$-	$-	$-
	Wind-LG	MT	<0.0001	$0.79	$0.79	$0.79	<0.0001	$1.29	$9.01	$5.73	<0.0001	$1.18	$3.79	$2.08
		E. WA	<0.0001	$1.34	$1.34	$1.34	<0.0001	$1.55	$5.48	$3.60	<0.0001	$0.63	$1.94	$1.21
		OR/ID	<0.0001	$1.19	$1.19	$1.19	<0.0001	$1.64	$4.96	$2.98	<0.0001	$0.60	$1.79	$1.06
	Wind-Off	Ocean off WA/OR	<0.0001	$0.91	$0.91	$0.91	<0.0001	$3.63	$3.63	$3.63	<0.0001	$1.50	$1.50	$1.50
	Wind-SM	E. WA/N. ID	<0.0001	$1.36	$1.36	$1.36	<0.0001	$1.49	$5.63	$3.30	<0.0001	$0.52	$1.81	$0.97

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