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Code Savings Technical Assumptions Review

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Table of Contents

Executive Summary

The Northwest Energy Efficiency Alliance (NEEA) reports gas and electric energy savings from code advancements NEEA and its partners helped influence in each of the four Northwest states. While Washington, Montana, and Idaho rely on the same base code – the International Energy Conservation Code (IECC) – each makes state-specific amendments to tailor the code to the unique nature of their state. To capture changes in energy consumption between code cycles, NEEA contracts with third-party firms to estimate savings achieved through updates to code in each state, which involves modeling changes made between the base codes and the state-specific codes.

NEEA contracted with Energy 350 (the review team) to review a selection of assumptions NEEA staff and third-party contractors made to estimate savings achieved through updates to several state code versions. This report covers state-specific amendments made to the following codes:

- 2018 Washington State Energy Code for Residential (WSEC-R)
- 2021 Montana Energy Code for Residential (IECC-R)
- 2021 Montana Energy Code for Commercial (IECC-C)

The review team found that most assumptions NEEA made to adjust code savings analyses were valid, with several areas noted below where NEEA could improve assumptions either as part of this evaluation or for the next code cycle.

- **2018 Washington State Energy Code – Residential**

  Prior modeling data provided to NEEA by its third-party contractor, Ecotope, regarding home type, climate zone, and home consumption values appear to be the best available source for establishing consumption estimates for gas-heated and electric-heated homes. The methodology employed to adjust those consumption estimates using heating fuel splits determined from the Washington Residential Code Evaluation Report (2023) appears valid. However, the review team noted minor inconsistencies among the various modeling sources used which could be improved in future updates. Notably:

  - NEEA should consider using more recently available information to update assumptions about home sizes, water heating fuel choices, and climate zone differences.

- NEEA should investigate Ecotope's prior modeling assumptions and calculations to ensure consumption estimates for different home sizes are correct. Modeled consumption estimates for medium-sized homes (which comprise 80% of the housing stock in Washington) appear lower than smaller homes, which is counterintuitive. Additionally, there are small inconsistencies between referenced reports regarding home consumption estimates that should be reviewed to ensure the same assumptions are used among source data.

- **2021 Montana Energy Code – Residential**
  NEEA typically relies on modeling using the Regional Technical Forum's (RTF) Simplified Energy Enthalpy Model (SEEM) to estimate savings due to code cycle changes. For the 2021 code cycle, NEEA proposed to rely on differences between the 2018 and 2021 U.S. Department of Energy (DOE) prototype models to determine code cycle savings instead of undertaking a new analysis using SEEM. Similar to NEEA's review of DOE prototype models with state amendments, the review team found significant differences in home consumption estimates between modeling engines, as well as differences in builder practices in Montana compared to DOE models. As a result, the review team collaborated with NEEA to develop a new 2021 model that relies on the SEEM methodology used for the prior code but incorporates findings from a compliance study underway in Montana. The review team also noted the following:
    - Section R408 of the code requires builders to choose from a list of energy efficiency options to demonstrate compliance with the prescriptive path of the code. This complicates code savings analyses as there are multiple paths a builder could choose depending on the home construction type, home size, and builder preferences. NEEA originally suggested that most builders would choose the efficient water heating option to comply with code, thereby simplifying the analysis since water heating savings are more easily isolated from whole home analysis compared to other options. However, compliance studies in Montana indicate that several other option paths (for example, Ducts-Inside) are likely to be more prevalent. As such, re-running the SEEM analysis using lower-cost assumptions for R408 options yield more accurate savings estimates.
    - Consider using more recently available information to update assumptions about home sizes, water heating fuel choices, and climate zone differences.

- **2021 Montana Energy Code – Commercial**
  Until an energy savings model is available for IECC with Montana amendments, NEEA's proposed methodology to extract consumption data from DOE prototype model output files to modify the IECC-C for Montana appears valid. As prior NEEA analyses of code cycle changes relied on the same commercial prototype models, the review team agrees that modifying the DOE output files to capture several Montana amendments is a valid approach to estimating code change impacts.
    - Future code amendments are likely to increase in complexity and may require more involved model input file modifications. Therefore, NEEA should develop a framework for modifying model inputs if future code savings analyses rely on DOE commercial prototype models.

2018 Washington State Energy Code – Residential

Background

The 2018 Washington State Energy Code – Residential (WSEC-R) is based on the 2018 base International Energy Conservation Code (IECC) with numerous state-specific amendments. A key input to determining energy savings compared to the previous code (2015 WSEC-R) is the estimate of energy consumption for the average single-family home based on heating fuel type. For previous code cycles, NEEA contracted with Ecotope to model the energy consumption and intensity of each code by end-use. NEEA then used assumptions about climate zones, building prototypes, and space and water heating fuel choice to aggregate results for each home into a state-wide savings level.

For the 2015 WSEC-R code, Ecotope aggregated the analysis based on the best available data at the time. Using estimates on fuel choice by new homes, the analysis assumed 83% of the homes used gas space heating. While NEEA could choose to carry over this assumption for the 2018 code cycle, NEEA's most recent Washington Residential Code Evaluation released in 2023 indicates that only 21% of new homes are built with gas space heating. The large discrepancy in heating fuel choice between these two analyses required NEEA to update its model to better reflect the market choices since the last code cycle.

To meet its annual savings reporting deadlines, NEEA has developed a method to adjust the original analysis to reflect this new mix of heating fuels reported by the most recent compliance study by combining outputs from three separate reports:

1. Modeling the Washington State Energy Code - 2006 & 2018 Baseline Energy Consumption report (2020) produced for the State of Washington
2. 2018 Washington Residential Codes Energy Savings Analysis (2021) produced for NEEA
3. Washington Residential Code Evaluation Report (2023) produced for NEEA

NEEA proposed to use this approach to report updated energy savings for the 2018 WSEC with the recent mix of heating fuel choices found in the 2023 evaluation. NEEA contracted with Energy 350 to perform a third-party verification of the calculation methodology and an assessment of whether NEEA's proposed approach to calculate a single savings rate for both electric-heated homes and gas-heated homes is reasonable.

Report and Analysis Review

The methodology Ecotope employs to determine savings resulting from energy codes relies on several home size and configuration prototypes used by the Regional Technical Forum (RTF) for determining average single-home energy use. To arrive at a single savings estimate for a representative home in Washington, Ecotope references a previously conducted characteristics study (RLW Analytics, 2007[1]) that provides documentation of residential building trends in Washington State. Ecotope's analyses of both the 2015 WSEC-R and the 2018 WSEC-R rely on the RLW Analytics study for the savings analysis. Ecotope notes that by keeping housing weights constant, code-mandated savings are better represented across different cycles. However, they also acknowledge that this assumption implies that builders will always build the same mix of homes regardless of energy code requirements and that future analyses should use updated building characteristic surveys to reflect the mix of home types that are built. The weightings for house prototype size, fuel split, and climate zones from the 2007 RLW Analytics report are shown in Figure 1 below. Most notably they indicate that at the time the study was conducted in 2007, gas-heated homes represented 83% of the homes built with the remaining 17% being electric-heated homes.

[1] RLW Analytics, Single Family Residential New Construction Characteristics and Practices Study, Accessed 3/17/2025 from https://neea.org/img/uploads/RESIDENTIANEWCONSTRUCTION5CC78C1BD226.pdf

Table 3. Residential Weighting by House Size

Prototype	SF 1344c	SF 1344s	SF 2200c	SF 2200s	SF 2688b	SF 5000b	SF 1500c	SF 1500s	MF 1000c	MF 952c	MF 952s
Weight	8%	2%	57%	10%	11%	2%	8%	2%	24%	31%	45%
	* Single family and multifamily each sum to 100%										

Table 4. Residential Weighting by Heating System Type

Heat Fuel	System	Single-family (SF)	SF – Townhomes	Multifamily R-2 (MF)
Gas	Furnace (no A/C)	55%	61%	0%
Gas	Furnace (w/ A/C)	28%	1%	0%
Elec	Air-source Central HP	13%	5%	0%
Elec	Electric Zonal (w/ DHP in 2018)	4%	33%	100%

Table 5. Residential Weighting by Climate Zone

IECC Climate Zone	Single- and Multifamily
4C (Seattle)	77%
5B (Spokane)	23%

Figure 1. Home weighting by size, heating system type, and climate zone

Notes: From Modeling the Washington State Energy Code - 2006 & 2018 Baseline Energy Consumption report for the State of Washington by Ecotope, September 18, 2020.

Ecotope also notes that they assume the domestic hot water fuel type matches the space heating fuel type for all prototypes across all years. There is insufficient data in the Modeling the Washington State Energy Code - 2006 & 2018 Baseline Energy Consumption report to substantiate or dispute that assumption.

In the subsequent 2018 Washington Energy Codes Savings Report prepared for NEEA in 2021, Ecotope calculated the weighted averages of all construction types, heating system types, and climates, with electric and gas savings broken out separately. They also provided a table detailing energy consumption by end-use for the modeled code cycles. When distilled down to the two code cycles in question (2015 and 2018 WSEC-R), the relative impact of each component on the overall consumption suggests that a single-family residence built to the 2018 code will save 1,035 kWh/year and 85 therm/year over the 2015 code. Furthermore, as shown in Table 1 below, space heating accounts for 48% of the total consumption of the home in the 2015 code but only 38% in the 2018 code, supporting the idea that the efficient space heating option in the R406 options table is being used to comply with code.

Table 1. WSEC-R end-use consumption estimates

Code	Heat (kWh Equiv.)	Cool (kWh)	Fan (kWh)	Light (kWh)	DHW (kWh)	Appliances and Plugs (kWh)	Total (kWh)	Total (therms)
WSEC-R 2015	7,651	160	327	969	2,966	3,849	6,623	317
WSEC-R 2018	4,753	125	381	727	2,650	3,366	5,588	232
Savings	2,898	35	-54	242	316	483	1,035	85
WSEC-R 2015 End-Use Impact	48%	1%	2%	6%	19%	24%		
WSEC-R 2018 End-Use Impact	38%	1%	3%	6%	21%	27%		

Notes: Adapted from the 2018 Washington Residential Codes Energy Savings Analysis report for NEEA by Ecotope, February 8, 2021.

Importantly, this savings analysis uses the same weighting as the 2007 RLW Analytics study, showing that 83% of the homes utilize gas-fired heating sources with the remaining 17% using electric heating sources. Weightings by climate zone are also the same as the 2020 Report to the State of Washington, though the reports provide more granularity here to indicate the split between single and multi-family homes.

The most recent study is the Washington Residential Code Evaluation report conducted in 2023 for NEEA. This evaluation found that out of 56 homes audited, 79% used electric space heating as their primary space heating type, a marked difference between the prior code analyses that relied on the 2007 RLW Analytics study showing an opposite split in fuel choice. Furthermore, the report found this fuel split finding similar within a subgroup of 37 homes reported to be compliant with the 2018 WSEC where 78% primarily used electric space heating. Similarly, of the 12 homes that did not comply with the 2018 WSEC, 75% used electric space heating primarily[2]. The data suggests a large shift from gas-space heating sources to electric sources and the report authors note this key takeaway in the report.

[2] The study notes there were also seven homes that were audited where compliance could not be determined due to missing permit data, and of those 86% reported using electric space heating.

> "Audit results support previous study findings that a major shift to electric space and water heating use has taken hold since the 2018 WSEC, with 79% of audited homes using electric primary space heating and 89% using electric water heating. Homes in Climate Zone 5B were more likely to have gas water heating (17%) than homes in Climate Zone 4C (6%), while the proportion of homes using gas space heating was similar in Climate Zone 4C (22%) and Climate Zone 5B (21%)."
>
> **- Ecotope**

This finding suggests that the previous split of heating fuel types in Washington is no longer reflective of the market and that electric space heating has become more prevalent in new construction compared to homes built under previous code versions.

With regards to the water heating fuel previously assumed to match the space heating fuel type, the compliance evaluation also found that of the 56 homes audited, 89% installed an electric water heating system regardless of space fuel type. This introduces a deviation from space heating and water heating fuel choices made in past code comparison studies and suggests updating future analyses to account for the increase in electric water heating irrespective of space heating fuel choice.

Findings and Recommendations

To adjust savings from the Ecotope savings analysis done in 2020 and 2021 and incorporate the most recent findings from the 2023 residential code evaluation report, NEEA first calculated the consumption of an average electric-heated home and a gas-heated home, using data from the two Ecotope studies. Those analyses use published consumption values for houses of different prototype sizes and the weighting of each home size within the Washington population using 2010 Census data. They then adjusted the fuel split between gas-heated and electric-heated homes found in the 2023 compliance study and calculated savings attribution per average home based on that fuel split. Below are several key assumptions NEEA made in the analysis to determine an updated savings value for the 2018 WSEC-R.

NEEA Assumption: NEEA assumes that it is reasonable to use Ecotope's weighted average square footage from 2010 Census data, the weighted average fuel type from the 2007 RLW Analytics report, and consumption results from the 2018 Baseline Energy Consumption Study to determine the weighted average energy use intensity (EUI) for electric-heated homes and gas-heated homes for both 2015 and 2018 WSEC-R.

Review Finding: NEEA sourced correct values from three reports regarding 2018 WSEC-R impacts to construct the savings analysis and aggregated the data per home correctly to achieve a single weighted-average EUI per home for the 2018 code.

Recommendation: The review team does not recommend any changes for this code cycle. See suggested updates for future modeling in the section below to better represent home sizes and weightings using better data.

NEEA Assumption: NEEA assumes it is reasonable to rely on the 2023 Code Compliance Evaluation report to update weighting of electric-heated versus gas-heated homes, which shows 79% are electric and 21% are gas.

Review Finding: NEEA correctly attributes fuel weights based on the findings, however there are two key assumptions buried within this attribution that may warrant further analysis. The first assumption is that electric savings are spread proportionally across electric-heated and gas-heated homes in each code cycle. This assumption may not be accurate, however, as different building characteristics between gas-heated and electric-heated homes may drive different energy consumption estimates. This could lead to electric savings being larger in one home type compared to another, but these differences may not mirror the proportion of electric-heated versus gas-heated homes.

The second assumption is that water heating fuel choices match space heating fuel choices, as assumed in prior code impact studies. Data from the 2023 code compliance study indicates that there are different fuel choices across climate zones for water heating compared to space heating. As shown in Figure 2 and Figure 3 below, the data suggests there are more gas water heaters in electric-heated homes in Climate Zone 5B, and likely more electric water heaters in gas-heated homes in Climate Zone 4C which would impact electric savings in both electric-heated and gas-heated homes.

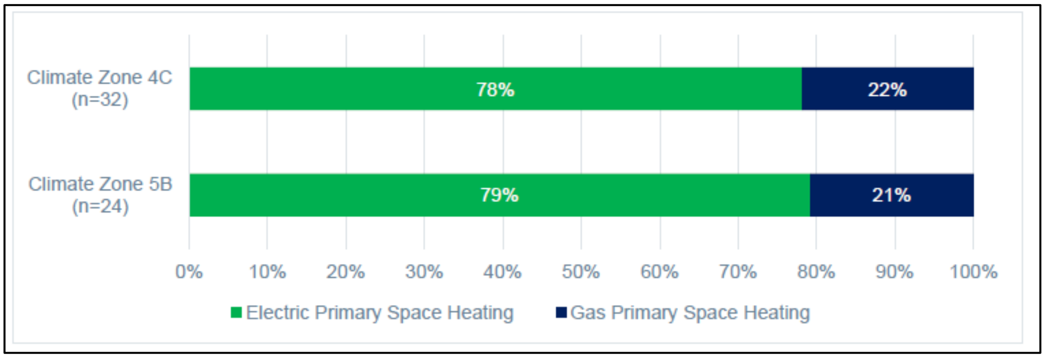

Figure 2. Space Heating Fuel by Climate Zone

Notes: From Washington Residential Code Evaluation report prepared for NEEA by TRC, July 6, 2023.

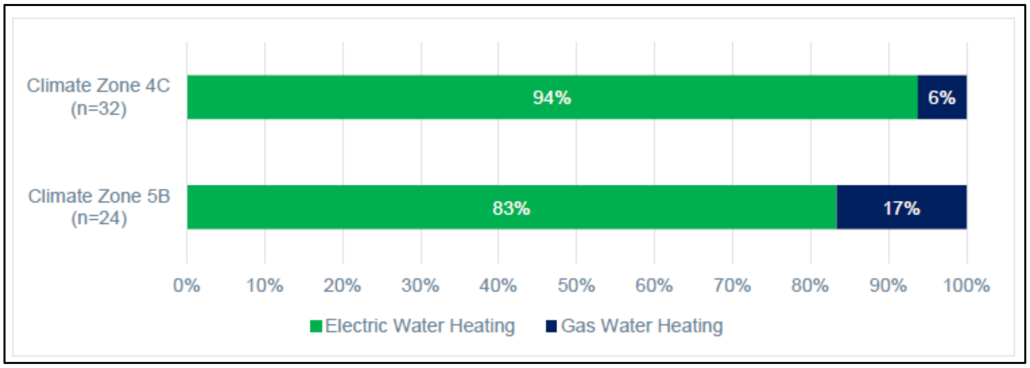

Figure 3. Water Heating Fuel by Climate Zone

Notes: From Washington Residential Code Evaluation report prepared for NEEA by TRC, July 6, 2023.

Recommendation: For the savings tracking component, there is not another way to assign savings to gas-heated homes versus electric-heated homes in a more thorough manner given the data presented in the reports. Therefore, the current methodology NEEA uses appears valid for this cycle.

Regarding water heater fuel choice, water heating comprises approximately 20% of the total home consumption under the 2018 WSEC-R. Therefore, it is important to consider water heating fuel choice independent of space heating choice, especially as most medium-sized homes (88% of the market) have chosen the efficient water heating option for both code cycles from the R406 options table for compliance as shown in Table 2 below.

Table 2. Least cost R406 options for 2015 and 2018 code cycles

		2015	2018	2015	2018
Dwelling size	**Base Heating Equip.**	**High-Efficiency HVAC Equipment**	**High-Efficiency HVAC Equipment**	**Water Heating Equip.**	**Water Heating Equip.**
Med	Zonal	Ductless Heat Pump (DHP)	Ductless Heat Pump (DHP)	Low Flow, Tier I Heat Pump Water Heater (HPWH)	Tier III Heat Pump Water Heater (HPWH) (split)
Med	Heat Pump	9.0 HSPF Heat Pump	9.5 HSPF Heat Pump	Tier I Heat Pump Water Heater (HPWH)	Tier III Heat Pump Water Heater (HPWH)
Med	Gas Furnace	Furnace 0.94	Furnace 0.95	Low Flow, 0.91 gas	0.91 gas Domestic Hot Water (DHW)
Med	Gas Furnace	Furnace 0.94	Furnace 0.95	Low Flow, 0.91 gas	0.91 gas Domestic Hot Water (DHW)

Notes: Adapted from Washington Residential Code Evaluation Report prepared for NEEA by TRC, July 6, 2023.

While this difference in water and space heating fuel choices exists, there is not a way to determine the percent split using the existing data sources to further analyze this difference. As such, the review team does not recommend trying to more granularly separate water heating fuel choice data for this cycle but strongly encourages it for future analysis.

NEEA Assumption: NEEA assumes that it is reasonable to calculate a ratio of consumption estimates for electric-heated homes and gas-heated homes between the 2015 and 2018 code cycles to update the fuel split attribution from 1,036 kWh/yr to 1,507 kWh/yr.

Review Finding: This method appears reasonable to estimate consumption between code cycles. However, this ratio of consumption produces 14% savings between the 2015 code and 2018 code, compared to the 2018 WSEC Residential Code Energy Savings Analysis report that indicates the savings should be closer to 22% (note this is prior to including updated space heating fuel splits). This suggests that either the data of kWh consumption by home may be incorrect somewhere within the modeling or that the 22% estimate of code cycle impacts was overstated by previous analysis. Additionally, the modeled consumption based on the home size weights (with 88% being medium sized) leads to a weighted home consumption of 10,580 kWh/yr for an electric-heated home. This contrasts with the analysis presented in the 2021

Residential Code Evaluation Report that produced a total kWh equivalent consumption of 12,387 kWh/yr for the average home.

Recommendation: Although NEEA's method to calculate a ratio of the savings between the two code cycles is valid, the inputs appear inconsistent between reports and the review team recommends further refinement in the future. Absent more details on gas-heated and electric-heated homes within each report, a straight ratio of consumption between code cycle estimates appears sufficient to determine savings impacts.

Future Gaps to Address

There are several inconsistencies between the reports (likely due to how previous analyses weighted the data) that make it difficult to rely on the same data used among reports spanning several years. Several recommendations for future modeling efforts are given below to better align code impacts and associated savings, assuming NEEA will utilize the same approach to compare code cycle savings impacts in the future.

- Neither of the code savings reports breaks out homes by climate zone, therefore there is not enough information to create a separate savings assumption by climate zone. The 2023 code compliance study by comparison provides more granular information on both heating system and water heating fuel types by climate zone and could be used to augment savings information in a new model, thereby more accurately reflecting builder choices across the state (particularly with respect to the colder heating zone).
- Adjusting home size population using more recent census data would provide NEEA with a better estimate of the current mix of home sizes. The 2020 Census data is now available and could lead to a more accurate mix of housing sizes in Washington state compared to the previously used 2010 Census data.
- Appendix B of the 2020 Modeling memo estimates that a medium-sized home uses less energy than a small home on average. While this may be attributed to medium and large homes needing to achieve twice the number of points from the R406 options table as a small dwelling unit (<1,500 sqft), NEEA should investigate the reason for this consumption difference and whether these homes are modeled correctly.
- Future modeling should replicate the Modeling the Washington State Energy Code - 2006 & 2018 Baseline Energy Consumption report (2020) Appendix which provides separate kWh and therm consumption estimates for both electric-heated and gas-heated homes. This split allows for flexibility with various weightings without revisiting the fuel choice assumptions buried within the model.

2021 IECC with Montana Amendments – Residential

Background

The current Montana energy code (made effective June 11, 2022) is based off the 2021 IECC with several state-specific amendments. After code development, the Pacific Northwest National Laboratory (PNNL) in collaboration with DOE began to perform custom analyses of adopted state energy codes, including amendments. NEEA requested and was provided a spreadsheet regarding DOE's analysis of Montana's amended 2021 IECC residential energy code, including modeled site electric (kWh), gas (therms), and total (kBtu) energy consumption for each of DOE's Residential prototype building models.

As NEEA assigns savings due to code updates by comparing consumption estimates between code cycles, they proposed to use the prior code cycle analysis performed by Ecotope on the 2012 IECC to 2018 IECC codes in Montana as the baseline consumption reference for the 2018 to 2021 Montana code cycle. NEEA would then calculate savings as the difference between Ecotope's 2018 code analysis and the new PNNL analysis of the 2021 code. However, significant differences in modeling engines and assumptions created issues when NEEA attempted to compare home consumption estimates between code cycles using the different analyses. Instead of conducting an in-depth calibration between the models to determine the differences and implement adjustments, NEEA proposed to implement the following streamlined methodology:

1. Identify significant changes between Montana's 2018 IECC and 2021 IECC
2. Use available sources to estimate electric and gas savings for each significant change
3. Apply these savings to Ecotope's Montana 2018 IECC findings at the end use level

NEEA is proposing to use this approach for the 2021 code until the next code cycle when it will evaluate whether relying solely on DOE analyses to estimate savings from code cycles is viable.

Report and Analysis Review

NEEA relied on two primary consumption and savings sources to determine the impact of the 2021 code compared to the 2018 code. The first was Ecotope's Determination Analyses: Energy Impacts of New Residential Energy Codes in Idaho, Montana, and Oregon. With respect to Montana, this report outlines weights for housing size and prototype models, heating/cooling zones, and energy use between the 2012 and 2018 code cycles. The analysis relies on calibrated models used by the RTF in their Simplified Energy and Enthalpy Model (SEEM) and adjustments to account for differences between the two codes.

As Ecotope did not perform an analysis between the 2018 and 2021 Montana codes, NEEA sought out the newly available custom residential building prototype models[3] that DOE develops for each code cycle. Although DOE can tailor these prototype models to consider state amendments, DOE has only recently offered this service on current codes. Therefore, historical consumption estimates of prior IECC codes do not include state level amendments.

Since Montana amendments have been (and continue to be) relatively consistent to the IECC base code, a comparison between code cycles for items that are not affected by state amendments is possible. For the 2021 code cycle, Montana incorporated several notable changes from the model 2021 IECC as noted below:

1. Ventilation fan efficiency improvement (Section R403)
    a. The minimum efficiency for in-line fan efficiency increased from 2.8 to 3.8 cfm/W.
    b. Minimum efficiency for other exhaust fans increased from 1.4 to 2.8 cfm/W (if <90cfm) and from 2.8 to 3.5 cfm/W (if ≥ 90 cfm), among other changes.
2. Lighting efficiency improvement (Section R404)
    a. The percentage of permanently installed lighting that must be high efficacy (lamps at least 65 lm/W) increased from 90% to 100%.
3. Additional Efficiency Packages (new Section R408)
    a. This newly added section requires the selection of one efficiency package. The packages fall into five categories: envelope thermal resistance, HVAC equipment efficiency, water heating equipment efficiency, HVAC distribution system efficiency, and envelope air sealing + ventilation efficiency.

NEEA used the DOE models for the 2018 and 2021 code cycles for lighting and ventilation fan energy use directly, comparing the percent reduction in energy consumption between codes for those two items. As the changes have a relatively small impact on other aspects of home performance, NEEA applied the percent changes directly to Ecotope's SEEM output model and calculated the kWh savings due to those improvements.

For the R408 additional efficiency option selection, NEEA proposes to assume use of the reduced energy use in service water-heating option (R408.2.3). This requires a builder to install

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[3] U.S. Department of Energy Building Energy Codes Program, Residential Building Prototype Models, Accessed 3/17/2025 from https://www.energycodes.gov/prototype-building-models#Residential:~:text=Return%20to%20top-,Residential,-For%20residential%20buildings

a water heater with an efficiency factor (EF) of 0.82 EF for a gas water heater or a 2.0 EF for an electric water heater, effectively requiring a heat pump water heater (HPWH). Reasons NEEA gave for choosing this option path include the fact that DOE uses this same option path in their 2021 IECC analysis and that past compliance studies in Washington[4] have shown the builders typically choose more efficient equipment options (requirement shown in Figure 4 below) to comply with code. Additionally, the water heating option has a minimal interactive component with the envelope and can consistently apply across all building prototypes.

R408.2.2 More efficient HVAC equipment performance option.

Heating and cooling *equipment* shall meet one of the following efficiencies:

1. Greater than or equal to 95 AFUE natural gas furnace and 16 SEER air conditioner.
2. Greater than or equal to 10 HSPF/16 SEER air source heat pump.
3. Greater than or equal to 3.5 COP ground source heat pump.

For multiple cooling systems, all systems shall meet or exceed the minimum efficiency requirements in this section and shall be sized to serve 100 percent of the cooling design load. For multiple heating systems, all systems shall meet or exceed the minimum efficiency requirements in this section and shall be sized to serve 100 percent of the heating design load.

Figure 4. IECC Section R408 Efficient HVAC equipment option

Notes: Adapted from the 2021 IECC base code.

NEEA combined these IECC base improvements over the 2018 code along with the respective house weights and provided the following consumption reductions shown in Table 3 below.

Table 3. Proposed Montana amendment reductions per home

2021 Montana Amendment	kWh/yr reduction (per home)	kWh/yr reduction (per electric-heated home)	Therms/yr reduction (per gas-heated home)
100% efficient lighting	39.2	-	-
Increased fan cfm/W	59.6	-	-
R408 water heating	-	1891.8	52.3

Notes: Lighting and fan kWh/yr reductions apply to all home prototypes. The R408 water heating kWh/yr reduction applies to electric-heated homes and the therms/yr reduction applies to gas-heated homes.

[4] Washington has had their own version of the R408 options path for several code cycles, irrespective of the 2021 IECC inclusion.

Findings and Recommendations

Below are several key assumptions made in NEEA's analysis of the 2018 Ecotope savings report when linked with the 2021 Montana Energy code analysis from DOE.

NEEA Assumption: The only three significant differences between Montana's 2021 IECC and Montana's 2018 IECC were with regards to ventilation fan efficiency improvement, lighting efficiency improvement, and the additional efficiency packages section.

Review Finding: There are few amendments in the Montana code compared to the base IECC. Additionally, most other Montana specific amendments were also present in the 2018 Montana code and therefore the SEEM analysis of the 2018 code already captures them (most notably the reduced envelope requirements.)

Recommendation: This method appears sound, and the review team does not recommend any adjustments.

NEEA Assumption: Both fan end-use and lighting efficiency entries from DOE's 2021 IECC model prototypes can be compared with the corresponding entries in DOE's 2018 IECC models without modification.

Review Finding: This assumption appears valid since Montana did not amend these sections of the code and therefore a direct comparison between DOE models should accurately capture the consumption differences between these code provisions. However, when checking the decrease in lighting energy use between DOE models and the housing prototypes in SEEM, the differences between models appeared significant. While the DOE model predicts only a 39kWh/yr difference due to lighting efficiency upgrades, the SEEM model predicts closer to 230kWh/yr. Therefore, using DOE models to estimate consumption differences of certain end-uses will not align with the SEEM estimates for total home consumption and may introduce significant error into the overall consumption estimates on a per home basis.

Recommendation: The review team and NEEA discussed the options available to align energy consumption estimates from previous Montana code analyses with the IECC-2021 code changes. They agreed that re-running the SEEM analysis for the 2018 and 2021 IECC codes with Montana amendments is the most accurate method to estimate savings due to lighting and ventilation fan efficiency changes without introducing new errors into the consumption estimates. Table 4 below shows the final estimated savings due to lighting efficiency changes and ventilation fan improvements noted above for the 2021 IECC with Montana amendments.

Table 4. SEEM savings for lighting and fan amendments

kWh Savings by Amendment				
	SF	**SF**	**MF**	**MF**
End-Use	**CZ5**	**CZ6**	**CZ5**	**CZ6**
Lighting	230	228	61	60
Fans	212	212	141	141
Total	442	439	201	201

Notes: Totals may appear different due to rounding.

NEEA Assumption: To comply with the newly added R408 section of the 2021 IECC, builders will choose the water heating package in R408 as the additional option in all cases. This assumption was made due to a DOE analysis that used market insights from the ENERGY STAR® new homes program and compliance studies in Washington state.

Review Finding: While this assumption aligns with DOE's analysis and significantly lessens the burden to parse out energy savings from other code options related to HVAC or envelope measures, there is evidence that suggests other options may be more attractive to builders in Montana.

Notably, Montana amended the 2021 IECC Section R403.3.6[5], which requires duct testing and sealing for ducts inside the thermal envelope to less than or equal to 8.0 cfm/100 sqft. The amendment states that builders are not required to perform duct leakage testing if all ducts and the air handler are located within the thermal envelope. The "ducts inside" optional efficiency package (R408.2.4 - More efficient duct thermal distribution system) allows compliance when 100% of the ducts and air handlers are located within the building thermal envelope. Therefore, Montana's amendment would enable a builder to comply with the optional efficiency credit and forego duct testing so long as all ductwork (and the air handler) were included inside the thermal envelope.

As support for the prevalence of this amendment, in a 2018 Montana Residential Energy Code Field Study, PNNL visited 129 homes and found that 81% had systems located entirely in the conditioned space, as shown in Figure 5 below.

[5] The Administrative Rules of Montana notes this exception under subpart (m) when noting changes to Section R403.3.7.

3.1.2.4 Duct & Piping Systems

- **Profile:**
  - Ducts were generally located within conditioned space (percentage of duct system):
    - Supply: 88%
    - Return: 88%
  - 80% of duct systems located *supply* ducts entirely within conditioned space (129 homes with 103 duct systems entirely within conditioned space)
  - 82% of duct systems located *return* ducts entirely within conditioned space (129 homes with 106 duct systems entirely within conditioned space)
  - 81% of duct systems had the *entire* system within conditioned space.
  - Pipe Insulation (R-value): 2.5

Figure 5. Percent of ducts inside for 2018 Montana code

Notes: Adapted from Montana Residential Energy Code Field Study prepared for the DOE by PNNL, April, 2019.

A similar compliance study being conducted for NEEA is still in draft phase to assess similar metrics for the 2021 code, and preliminary estimates show that this percentage is similar to the findings from 2018.

Recommendation: Similar to lighting and fan improvements, modeling consumption for R408 options using the SEEM analysis is the most straightforward method to avoid introducing new errors through different modeling techniques. Adjusting the SEEM inputs to reflect R408 choices is straightforward, however determining which option to model can be subjective.

In field studies on the previous code cycle, a significant majority of homes had ducts inside the conditioned space already. The Montana amendment that allows a builder to forego testing when ducts are inside is a cost saving opportunity for the homebuilder. If the least-cost option has been the de-facto path most builders take when faced with efficiency options, it is likely most builders would choose one that they are doing already with no additional cost. Therefore, models should reflect that a large percentage of homes choose to do ducts-inside to satisfy the R408 compliance options.

While investigating the model inputs, the review team discovered that prototype home models with basements (2,688 and 5,000 sqft prototypes) used duct leakage rates equivalent to having the ducts located inside the conditioned space. Therefore, the model already considered savings for ducts-inside for these models and no additional savings should be claimed for R408 option for these homes.

The remainder of home prototypes modeled were either on slab or over a crawlspace, making ducts-inside a harder option to comply with. For these home types, the review team recommends using the more efficient heating system option as that has often been the most widely used efficiency option among builders in other states. Furthermore, the same 2018 field report from PNNL shows space heating in most homes under Montana’s 2012 code had high efficiency furnaces already as shown inFigure 6 below.

3.1.2.5 HVAC Equipment

- **Profile:**
  - Heating: Mostly gas furnaces with an average efficiency of 92 AFUE
  - Cooling: Mostly central AC with an average efficiency of 13 SEER
  - Water Heating: Mix of gas (64%) and electric (36%) storage (95%) with an average capacity of 51 gallons and average efficiency rating of EF 0.73

Figure 6. HVAC and water heating system types installed in Montana

Notes: Adapted from Montana Residential Energy Code Field Study prepared for the DOE by PNNL, April, 2019.

The 2018 Montana Residential Energy Code field study findings also highlight that 64% of water heaters are gas and 95% of those are tank-type. If builders choose the efficient water heating path in R408, it indicates that homes with gas water heating would need to upgrade to more costly tankless units to meet the 0.82 EF requirement. This appears unlikely when alternate paths exist with a much lower cost to the builder.

Discussions with NEEA on the validity of various R408 path assumptions led to the following decisions about how to model R408 options depending on home types:

1. Single-family Homes
   a. Basement prototype homes will choose the ducts-inside path (no net savings since these homes models already include the same leakage rates as the 2018 code)
   b. Crawlspace and Slab homes will choose the efficient HVAC systems path (assuming a 92% AFUE furnace and a 10 HSPF/16 SEER Heat Pump)
2. Multi-family
   a. Zonal home prototypes will choose the ducts-inside path (no net savings since these homes models already include the same leakage rates as the 2018 code)

Once these changes were made, the weighting of home size prototypes, heating system types, and climate zone population were updated to reflect current findings from the draft 2023 compliance study. Results from re-running the SEEM analysis for all amendments and updated weighting factors are given in Table 5 below.

Table 5. SEEM savings for all 2021 amendments

Lighting, Fan and R408 Adjustments			Whole Home Savings (Current over previous Code)				Percent Savings per State
State	Code Years	Fuel	SF	SF	MF	MF	All Home Types
			CZ5	CZ6	CZ5	CZ6	All Climate Zones
MT	2021 - 2018	Gas (therms)	-5	-5	2	2	1.98%
MT	2021 - 2018	Elec (kWh)	619	641	249	252	

Future Gaps to Address

PNNL completed a code compliance study in Montana in 2019 based on the IECC 2012. NEEA is conducting a compliance study of the 2018 and 2021 IECC with Montana amendments that is expected to be published in late 2025. Analyses relying on these compliance studies should update the models with current market data where feasible to incorporate new building home type sizes, population data by climate zone, and space and water heating fuel choices by home type.

2021 IECC with Montana Amendments – Commercial

Background

Similar to the residential code, in the current code cycle Montana adopted the 2021 IECC for commercial buildings (with several Montana amendments made mid-cycle that went into effect September 21, 2024). Concurrently with IECC releases, DOE performs code comparison analyses to determine energy savings compared to the prior code cycle, and NEEA leverages this analysis to understand code impacts from unadjusted versions of the IECC.

With Montana's adoption of mid-cycle amendments to the 2021 IECC, NEEA found two changes to address regarding lighting and plug loads that were not part of the 2021 IECC base code. These are:

1. Removal of the secondary sidelit zone from the daylighting requirements section
2. Removal of the requirement for automated receptacle control in its entirety

NEEA proposes to use the DOE prototype models for each commercial building type and adjust outputs to account for the Montana amendments for the 2021 code cycle.

Report and Analysis Review

NEEA relied on two primary reports to determine the impact of the 2021 Montana Commercial code compared to the 2018 code. The first was PNNL's 2022 Energy and Energy Cost Savings Analysis of the 2021 IECC for Commercial Buildings report that compared savings to the previous 2018 IECC code. This report and the underlying prototype models form the basis for establishing energy consumption by climate zone for all provisions in the 2018 and 2021 IECC model codes, the building type weights (purchased by McGraw Hill), and an explanation of the methodology used to incorporate changes into the building prototype models.

The second report was PNNL's 2014 Standard 90.1-2013 Determination of Energy Savings: Quantitative Analysis, which further breaks down how code provisions were included in the DOE building prototype models (herein referred to as the 2014 Halverson report). This analysis helps illustrate how code provisions are translated to the DOE prototype models, which building prototypes are affected by certain code provisions, and what inputs can be adjusted if modifications are needed. Using these two reports, NEEA proposes the following methodology to determine code savings impacts:

1. Isolate the relevant lighting and plug load site energy data outputs from DOE's model 2018 and 2021 IECC analyses for each of DOE's 16 commercial building prototypes for climate zone 6B,
2. Use PNNL's 2022 Energy Savings report and the 2014 Halverson quantitative analysis to modify these outputs for each prototype as applicable (making assumptions as needed), and
3. Recalculate the site EUI for each prototype to reflect the modifications and compare with the 2018 IECC site EUI to calculate the Montana amended 2021 IECC savings.

To assess whether this approach would be possible, the review team analyzed the referenced reports and DOE prototype models, as well as the amendments made in Montana's 2021 IECC-C. The following are the sections of the 2021 IECC-C Montana code mid-cycle amendments that have the ability to impact commercial building energy use:

1. C402.5.1.2 Air barrier compliance is deleted and replaced with the following: "A continuous barrier for the opaque building envelope shall comply with the following: Buildings or portions of buildings, including group R and I occupancies, shall meet the provisions of Section C402.5.2 or C402.5.3 or R402.4.1.2 [402.4.1.2] & R402.4.1.3 [402.4.1.3]."
2. Subsection C405.2.4.2 Sidelit daylight zone is amended to remove requirement (3) in its entirety.
3. Subsection C405.11 Automatic receptacle control function is deleted in its entirety.
4. Subsection C405.12 Energy monitoring is deleted in its entirety.

The first amendment in the Montana code deals with air barrier compliance and adds options for air barrier testing and has little impact on energy savings as it primarily removes language intended for other climate zones.

The second amendment deals with daylighting zones and removes the requirement in Section C405.2.4.2 shown in Figure 7 below that includes secondary sidelit daylight zones.

> 3. The secondary sidelit daylight zone is directly adjacent to the primary sidelit daylight zone and shall extend laterally to 2.0 times the height from the floor to the top of the fenestration or to the nearest full height wall, whichever is less, and longitudinally from the edge of the fenestration to the nearest full height wall, or up to 0.5 times the height from the floor to the top of the fenestration, whichever is less, as indicated in Figure C405.2.4.2(1). The area of secondary sidelit zones shall not be considered in the calculation of the daylight zones in Section C402.4.1.1.

Figure 7. Excerpt from Section C405.2.4.2 in the 2021 IECC regarding sidelit daylight zone
Notes: Adapted from the 2021 IECC.

The Montana amendment serves to restrict daylighting in sidelit zones to the primary area only. Doing so lessens the ability for the secondary sidelit daylight zone to take advantage of daylighting deeper within the space, which enables a building to offset lighting loads. Thus, removing this provision will impact the lighting energy use of prototype models.

As shown in Figure 8 below, the primary sidelit daylight zone is shown to be the area adjacent to windows up until the first full height wall. The secondary sidelit daylight zone is the area beyond that primary zone shown to be two times the height of the first sidelit zone.

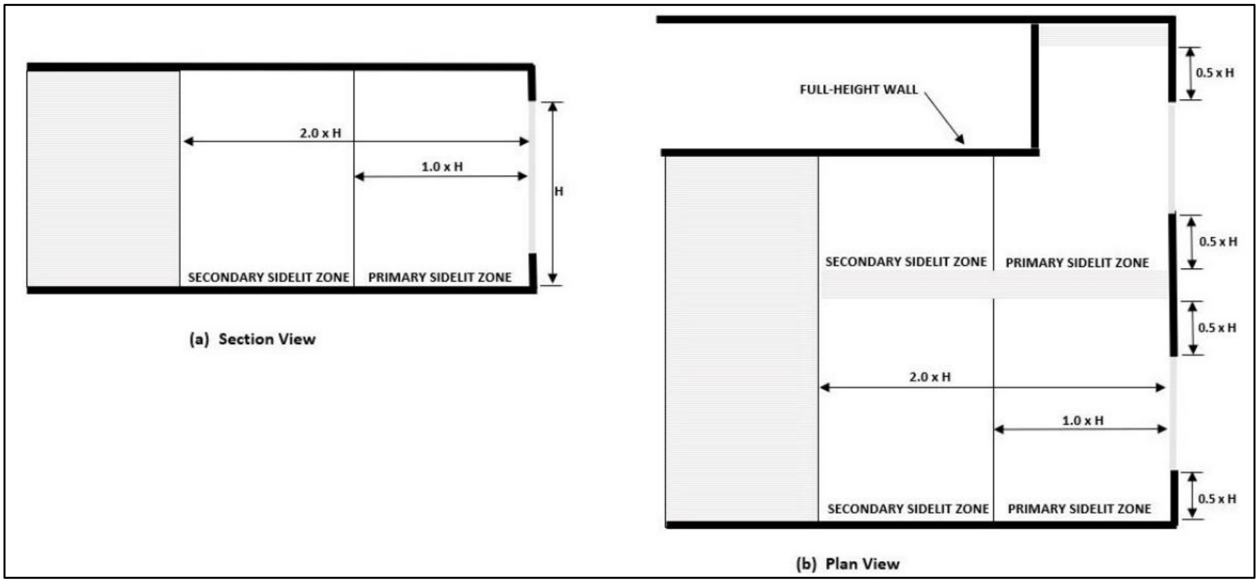


Figure 8. IECC method to determine sidelit daylight zone area

Notes: Adapted from the 2021 IECC.

While PNNL's 2022 Energy Savings report does not explain the methodology of how the prototype models integrate this provision, the models calculate consumption for each daylighting zone independently according to the 2014 Halverson report. Therefore, adjusting the applicable daylighting zones in the model will isolate the effect of the daylighting sidelit area. Note that this provision impacts only a subset of the prototype models as secondary sidelit daylighting controls do not apply to zones in prototype building models classified as retail spaces (Standalone Retail, Strip Mall) or dwelling units present in High-rise Apartment, Mid-rise Apartment, Small Hotel, and Large Hotel guestrooms.

The third amendment to remove the automated receptacle provision also impacts building energy use[6], though its impact on the overall model is more isolated. This provision in the 2021 IECC model code reduces plug load use by shutting power off to half the outlets in enclosed offices, conference rooms, breakrooms, classrooms, and several other specialty spaces.

As Montana amendments completely remove the automated receptacle requirement, the DOE prototype models must also adjust the energy use of receptacles to accurately capture energy savings impacts due to this provision. The 2022 PNNL Energy Savings report does not detail the savings associated with this particular code change, however the methodology of how it is incorporated in the model is explained in the 2014 Halverson report, as well as PNNL's 2011 report Achieving the 30% Goal: Energy Cost and Savings Analysis of ASHRAE Standard 90.1-2010. In that report, PNNL states that to calculate the impact due to automated receptacle controls, the building equipment operating schedules are modified in the DOE prototype models to approximate savings from reduced equipment "on" hours. The fraction in the schedule that plug equipment is "on" during occupied hours is reduced by the sum of the savings percentage for each space type identified as having savings (for example, conference room, private office, and classroom), multiplied by the proportion of building area that is associated with the corresponding space type. An example of the primary school prototype is shown in **Figure 9** below with the associated schedule reduction in receptacle control.

Table 5.35. Primary School Prototype Example of Receptacle Control Schedule Reduction

	Open Office Area Fraction	Private Office Area Fraction	Computer Classroom Area Fraction	Occupancy Sensor Savings Estimate			Reduction to Plug Loads Schedule
				Open Office	Private Office	Classroom	
Occupied Hours	0.50%	3.00%	2.36%	21%	22%	32%	1.5%
Unoccupied Hours	0.50%	3.00%	2.36%	100%	100%	100%	5.9%

Figure 9. PNNL receptacle control reduction schedule example

Notes: Adapted from Achieving the 30% Goal: Energy Cost and Savings Analysis of ASHRAE Standard 90.1-2010 for the Department of Energy by PNNL, May 2011

Other prototype buildings that include spaces affected by the new receptacle control requirements are: Large Hotel, Small Hotel, Hospital, Medium Office, Large Office, Small Office, Standalone Retail, Full-service Restaurant, Secondary School, Outpatient Healthcare, and

[6] A 2013 Title 24 CASE study indicated up to 0.49kWh/sqft savings for small office buildings, and 0.61kWh/sqft for larger office buildings.

Warehouse. All affected building types would require adjustments to the control schedules to remove the impacts of this provision.

The final Montana amendment removes the provision to require energy monitoring for buildings 25,000 sqft or larger and has been a code provision in ASHRAE 90.1 since 2016. None of the reports cited above detail the modeling to demonstrate the savings from this provision.

Findings and Recommendations

Based on the amendments and sources noted above, several key assumptions made in NEEA's proposal to analyze the 2021 IECC-C with Montana amendments are noted below.

NEEA Assumption: The amendments to the secondary sidelit daylight zone and automated receptacle provisions are the only amendments that would materially impact commercial building energy use in Montana compared to the 2021 IECC model code.

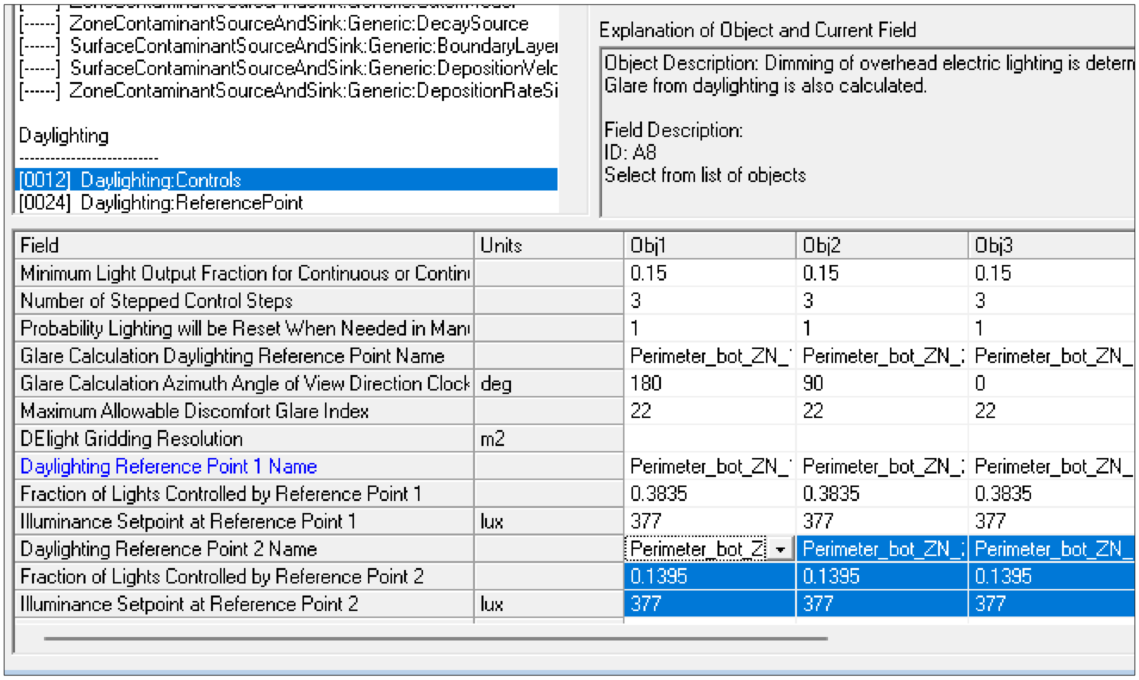
Review Finding: This assessment is valid. As noted above, the modification to air barriers in the Montana code deals with compliance and has little impact on energy savings. Additionally, although Montana amendments remove the verification component, modeling assumes 100% compliance in all codes and therefore this change would not be reflected in adjusted models. Therefore, it is not necessary to perform savings adjustments for this amendment.

Additionally, while the Montana amendment which removes building energy monitoring has the ability to save energy, the provision alone is unlikely to do so. In the proposal language for the 2021 IECC, the proponents of this measure cite a report on submetering (GSA 2011) savings. In that report, the authors note that metering (and, by extension, dashboards displaying energy consumption) do not save energy by themselves but rather serve to provide data to help inform future savings potential. The review did not uncover quantifiable adjustments made to the DOE model to capture this change and therefore do not see the need for NEEA to make further adjustments to remove it either.

Recommendation: None, this assumption is valid.

NEEA Assumption: NEEA can isolate the relevant lighting and plug load site energy data outputs from DOE's model 2018 and 2021 IECC analyses for each of DOE's 16 commercial building prototypes for Climate Zone 6B.

Review Finding: NEEA's proposed approach to adjust the models for secondary sidelit daylight zone impacts is valid. Adjusting the DOE prototype models to include or remove daylight zones appears straightforward for most prototypes within the energy model. As shown in Figure 10 below, changing the prototype model daylighting inputs (highlighted in blue) in each commercial building Input Data File (IDF) allows the model to be re-run using updated values for that zone.



Field	Units	Obj1	Obj2	Obj3
Minimum Light Output Fraction for Continuous or Contin		0.15	0.15	0.15
Number of Stepped Control Steps		3	3	3
Probability Lighting will be Reset When Needed in Man		1	1	1
Glare Calculation Daylighting Reference Point Name		Perimeter_bot_ZN_	Perimeter_bot_ZN_	Perimeter_bot_ZN_
Glare Calculation Azimuth Angle of View Direction Clock	deg	180	90	0
Maximum Allowable Discomfort Glare Index		22	22	22
DElight Gridding Resolution	m2			
Daylighting Reference Point 1 Name		Perimeter_bot_ZN_	Perimeter_bot_ZN_	Perimeter_bot_ZN_
Fraction of Lights Controlled by Reference Point 1		0.3835	0.3835	0.3835
Illuminance Setpoint at Reference Point 1	lux	377	377	377
Daylighting Reference Point 2 Name		Perimeter_bot_Z	Perimeter_bot_ZN_	Perimeter_bot_ZN_
Fraction of Lights Controlled by Reference Point 2		0.1395	0.1395	0.1395
Illuminance Setpoint at Reference Point 2	lux	377	377	377

Figure 10. Example Input Data File (IDF) adjustments to daylighting zone
Notes: Adapted from DOE Prototype model for the 2021 IECC.

Most 2018 prototype models did not have controls in the secondary sidelit daylight zone, with the exception of Primary and Secondary Schools and Warehouses. In those cases, determining the allocation of daylighting energy savings in the 2021 prototype models due to the secondary sidelit daylight provision requires the fraction of lighting controlled to be adjusted to match the same control fraction present in the 2018 prototype models. Those lighting control fractions in the primary and secondary sidelit zones are detailed in tables 5.20 and 5.21 in the 2014 Halverson 2014 report. A snippet of those tables is shown below in **Figure 11** which provides the fraction of the zone controlled by the secondary daylight sensor.

Table 5.20. Fraction of Lighting Power Controlled by Daylighting Sensors in Zones in Prototype building Models

Prototype building/Zone	Fraction of Zone Controlled by Primary Sidelighted Area Sensor	Fraction of Zone Controlled by Secondary Sidelighted Area Sensor	Target Illuminance (lux)
Small Hotel			
Front Lounge Flr1	0.29	0.29	300
MeetingRoomFlr1	0.28	0.28	375
FrontOfficeFlr1	0.26	0.26	375
LaundryRoomFlr1	0.26	0.26	300
Large Hotel			
LobbyFlr1	0.07	0.07	300
Café	0.39	0.39	300
Dining_Flr6	0.20	0.20	300
Banquet_Flr6	0.20	0.20	300
Warehouse			
Office	0.29	0.10	375
Quick-service Restaurant			
Dining	0.38	0.38	300
Full-service Restaurant			
Dining	0.25	0.25	300
Primary School			
Corner_Class_1_Pod_1_ZN_1_FLR_1	0.56	0.20	500
Mult_Class_1_Pod_1_ZN_1_FLR_1	0.28	0.28	500
Mult_Class_2_Pod_3_ZN_1_FLR_1	0.28	0.28	500
Computer_Class_ZN_1_FLR_1	0.28	0.28	500
Lobby_ZN_1_FLR_1	0.28	0.28	300
Offices_ZN_1_FLR_1	0.24	0.18	375
Cafeteria_ZN_1_FLR_1	0.34	0.16	300
Library_Media_Center_ZN_1_FLR_1	0.26	0.18	500

Table 5.21. Fraction of Each Perimeter Zone under Daylighting Control in Office Prototype buildings

Assumption	Small Office	Medium Office	Large Office
Total primary sidelighted area as a fraction of perimeter Zone Area	0.56	0.56	0.57
Total secondary sidelighted area as a fraction of perimeter zone area	0.21	0.44	0.43
Fraction of primary sidelighted area that can be daylighted	0.43	0.68	0.68
Fraction of secondary sidelighted area that can be daylighted	0.14	0.32	0.32
Fraction of perimeter zone controlled by sensor 1 (primary sidelighted area)	0.24	0.38	0.39
Fraction of perimeter zone controlled by sensor 2 (secondary sidelighted area)	0.03	0.14	0.14

Figure 11. Daylighting Control Fractions from Tables 5.20 and 5.21 of the 2014 Halverson report

A simpler approach is to use the DOE modeling HTML output files. These outputs list electricity consumption for all end-uses and contain a reference to the secondary sidelit daylight zone with the corresponding lighting loads, as well as the watts of lighting controlled for each zone in the building. With the exception of the three models noted above, all remaining 2018 prototype models indicate zero watts in the DAYLREFPT2 zones (which matches the IDF inputs), indicating no secondary sidelit daylight zone savings are being accounted for. In the 2021 prototype models however, lighting controlled watts are present for the secondary reference point (DAYLREFPT2) as shown by the example given in Table 6 below.

Table 6. Lighting wattage and fraction controlled for daylighting zones in Medium Office

Reference Point	Zone	Fraction Controlled	Lighting Installed in Zone [W]	Lighting Controlled [W]
PERIMETER_BOT_ZN_1_DAYLREFPT1	PERIMETER_BOT_ZN_1	0.38	1229.96	471.69
PERIMETER_BOT_ZN_1_DAYLREFPT2	PERIMETER_BOT_ZN_1	0.14	1229.96	171.58
PERIMETER_BOT_ZN_2_DAYLREFPT1	PERIMETER_BOT_ZN_2	0.38	778.67	298.62
PERIMETER_BOT_ZN_2_DAYLREFPT2	PERIMETER_BOT_ZN_2	0.14	778.67	108.62
PERIMETER_BOT_ZN_3_DAYLREFPT1	PERIMETER_BOT_ZN_3	0.38	1229.96	471.69
PERIMETER_BOT_ZN_3_DAYLREFPT2	PERIMETER_BOT_ZN_3	0.14	1229.96	171.58
PERIMETER_BOT_ZN_4_DAYLREFPT1	PERIMETER_BOT_ZN_4	0.38	778.62	298.6
PERIMETER_BOT_ZN_4_DAYLREFPT2	PERIMETER_BOT_ZN_4	0.14	778.62	108.62

As such, summing the total wattage controlled by DAYLREFPT2 from the 2021 model for each building prototype generates the total savings impacts due to this code change.

A similar finding holds true for automated receptacles provision, where PNNL modifies occupancy rates of zones within the IDF to estimate energy savings impacts due to this code provision. The 2014 Halverson report details the occupancy adjustments needed to capture automated receptacle control as shown in **Figure 12** below.

Table 5.19. Reduction Factors for Baseline and Advanced Models

	Standard 90.1-2010		Standard 90.1-2013	
Prototype	Occupied Hours Reduction Fraction	Unoccupied Hours Reduction Fraction	Occupied Hours Reduction Fraction	Unoccupied Hours Reduction Fraction
Large Hotel	0.9604	0.7938	0.9524	0.7652
Small Hotel - Private Office[(a)]	0.9258	-	0.9258	-
Small Hotel - Break Room	1.0000	1.0000	0.9584	0.7228
Small Hotel - Conference Room	1.0000	1.0000	0.8873	0.6625
Fast Food Restaurant	0.9989	0.9951	0.9989	0.9951
Retail Strip Mall	0.9963	0.9831	0.9963	0.9831
High-rise Apartment	0.9258	0.6625	0.9258	0.6625
Mid-rise Apartment	0.9258	0.6625	0.9258	0.6625
Hospital	0.9773	0.8849	0.9740	0.8732
Large Office	0.9515	0.7444	0.9491	0.7369
Medium Office	0.9604	0.7938	0.9531	0.7692
Retail Standalone	0.9983	0.9919	0.9972	0.9869
Sit Down Restaurant	0.9992	0.9963	0.9989	0.9943
Small Office	0.9694	0.8515	0.9595	0.8190
Warehouse	0.9694	0.8515	0.9595	0.8190
Primary School	0.9952	0.9816	0.9306	0.7797
Secondary School	0.9983	0.9919	0.9512	0.8446
Outpatient HealthCare	0.9926	0.9664	0.9905	0.9555

(a) The private office space in Small Hotel is a 24-hour occupied space. It does not have unoccupied hours.

Figure 12. Reduction factors for baseline and advanced models

Notes: Adapted from Standard 90.1-2013 Determination of Energy Savings: Quantitative Analysis report for DOE by PNNL, August, 2014

This change is modeled as an occupancy adjustment to loads and is integrated in with other occupancy-based controls features within the model. While NEEA could extract these occupancy factors from the IDF for each prototype model, it is unclear where exactly in the file to make this adjustment.

Instead, a simpler method is to again use the PNNL prototype model HTML file outputs and rely on the end-use category table that references plug loads. This table specifies the same consumption value for both 2015 and 2018 IECC model runs but indicates a lower value in the 2021 IECC model runs. As plug loads were the only change to this end-use between code cycles, the consumption from this end-use is therefore likely equivalent to the automated receptacles provision. The table lists the consumption estimates for the various end-uses within the prototype model, and MiscPlug is shown in Table 7 below to have a value of 584.69 GJ, whereas this same end-use had a value of 641.3 GJ in prior code versions.

Table 7. MiscPlug energy use for 2021 IECC DOE prototype model

End-Use	Subcategory	Electricity [GJ]
Heating	General	263.1
Cooling	General	94.39
Interior Lighting	LightsWired	203.56
Exterior Lighting	General	50.8
Interior Equipment	MiscPlug	584.69
	ElevatorLift	120.1
	ElevatorLightsFan	0.64
Exterior Equipment	Transformer	11.66
Fans	General	95.09
Pumps	General	0.02
Heat Rejection	General	0
Humidification	General	0
Heat Recovery	General	0
Water Systems	General	0
	WaterUse	0
	Water Heater	0
Refrigeration	General	0
Generators	General	0

Recommendation: NEEA's assumption is correct in that accounting for energy savings impacts attributed to daylighting in the secondary sidelit daylighting zone is possible by using the prototype model IDFs. Through testing we discovered that lighting end-uses in the model output file were not reliable for calculating differences from this provision. This is due to how the model assigns lighting energy for each space and the full load hours of lighting use based on the daylighting strategy employed. Changing the output file does not change the hours of lighting use in the space, resulting in inaccurate consumption estimates when relying solely on the DAYLREFPT2 output values. Furthermore, removing the reference point from the IDF and re-running the model is more comprehensive as it accounts for any heating and cooling interactions due to the lighting load throughout the year.

To estimate the consumption impacts due to removing the secondary sidelit daylighting provision, we set the DAYLREFPT2 value to zero in prototype models which had no previous daylighting in those zones and re-ran each 2021 prototype model using EnergyPlus v22.1. As noted above, for most prototype models, the DAYLREFPT2 value was zero in the 2015 and 2018 IECC models, indicating that energy consumption appearing in the 2021 prototype models is due to the presence of controls in the secondary sidelit daylight zone. For Primary School, Secondary School, and Warehouse prototype models, the methodology is the same as noted above, however an extra step is taken due to the presence of daylighting in these DAYLREFPT2 zones in prior codes. For these zones, the fraction of lighting controlled in the 2018 IECC model is subtracted from the fraction of lighting controlled in the 2021 model, leaving the difference in control fraction between the two code cycles. This difference is then added to the 2021 IECC daylighting control fraction to account for changes due to increased daylighting control in these zones from the secondary sidelit daylighting provision. The results from the modified EnergyPlus model are added to the base 2021 model to account for the added energy use due to the removal of this daylighting provision.

Removal of the automated receptacle end-use is straightforward as it is simply the difference in the MiscPlug end-use in each code cycle. Similar to the secondary sidelit daylighting provision analysis, IECC HTML output files were first loaded into Excel for the 2015, 2018, and 2021 IECC codes. The MiscPlug consumption in each prototype model was then tallied for each prototype model across code cycles. The 2015 IECC prototype outputs confirmed that MiscPlug consumption estimates did not change between 2015 and 2018 IECC versions, indicating that changes in the 2021 IECC were due to the automated receptacle provision. Taking the difference between the MiscPlug estimates in the 2018 and 2021 models yields the savings impacts due to the removal of this provision.

The consumption differences between the 2021 IECC and the amended Montana 2021 Code are shown in Table 8 below for each provision. As these energy saving provisions were removed through the Montana amendment process, consumption values appear higher compared to the 2021 IECC to indicate the increase in consumption.

Table 8. End-Use Consumption Estimates - 2021 IECC compared to Montana 2021 Code

	2021 MT Code Amendment Provision Applicability		IECC 2021 Energy Consumption		MT 2021 Energy Consumption (w/Amendments)	
Building Type	**Automated Receptacle**	**Secondary Sidelit Zone**	**MiscPlug (kWh/yr)**	**Lights Wired (kWh/yr)**	**MiscPlug (kWh/yr)**	**Lights Wired (kWh/yr)**
Apartment High Rise	**No**	**No**	N/A	N/A	N/A	N/A
Apartment Mid Rise	**No**	**No**	N/A	N/A	N/A	N/A
Hospital	**Yes**	**Yes**	1,517,903	877,458	1,566,306	877,767
Hotel Large	**Yes**	**Yes**	264,558	167,406	266,544	170,739
Hotel Small	**Yes**	**Yes**	86,403	55,486	87,311	58,117
Office Large	**Yes**	**Yes**	1,481,936	563,478	1,631,108	581,100
Office Medium	**Yes**	**Yes**	162,414	56,544	178,139	59,494
Office Small	**Yes**	**Yes**	13,417	7,278	14,667	7,353
Outpatient Healthcare	**Yes**	**Yes**	330,594	96,617	333,778	98,519
Restaurant Fast Food	**No**	**Yes**	N/A	5725	N/A	6,264
Restaurant Sit Down	**Yes**	**Yes**	0	11,442	0	13,036
Retail Standalone	**Yes**	**No**	53,972	N/A	54,211	N/A
Retail Strip Mall	**No**	**No**	N/A	N/A	N/A	N/A
School Primary	**Yes**	**Yes**	263,206	103,669	304,628	104,850
School Secondary	**Yes**	**Yes**	533,072	292,958	589,553	309,897
Warehouse	**Yes**	**Yes**	37,919	35,697	38,692	35,750

Notes: An N/A in the table indicates that one or both provisions did not apply to that building prototype model, even though the MiscPlug and Secondary Sidelit consumption estimates may differ between the 2018 and 2021 code cycles. As such there are no savings impacts for those building types.

The final savings impacts for these two provisions, both as gross savings and savings per ft^2 using DOE prototype model building sizes are shown in Table 9 below.

Table 9. **End-Use Savings Estimates - 2021 IECC compared to Montana 2021 Code**

	2021 MT Code Amendment Provision Applicability		Energy Savings (2021 IECC - MT 2021)		Energy Savings per ft² (2021 IECC - MT 2021)	
Building Type	**Automated Receptacle**	**Secondary Sidelit Zone**	**MiscPlug (kWh/yr)**	**Secondary Sidelit Zone (kWh/yr)**	**MiscPlug ($kWh/yr/ft^2$)**	**Secondary Sidelit Zone ($kWh/yr/ft^2$)**
Apartment High Rise	**No**	**No**	N/A	N/A	N/A	N/A
Apartment Mid Rise	**No**	**No**	N/A	N/A	N/A	N/A
Hospital	**Yes**	**Yes**	-48,403	-308	-0.20	0.00
Hotel Large	**Yes**	**Yes**	-1,986	-3,333	-0.02	-0.03
Hotel Small	**Yes**	**Yes**	-908	-2,631	-0.02	-0.07
Office Large	**Yes**	**Yes**	-149,172	-17,622	-0.30	-0.04
Office Medium	**Yes**	**Yes**	-15,725	-2,950	-0.29	-0.06
Office Small	**Yes**	**Yes**	-1,250	-75	-0.23	-0.01
Outpatient Healthcare	**Yes**	**Yes**	-3,183	-1,903	-0.08	-0.05
Restaurant Fast Food	**No**	**Yes**	N/A	-539	N/A	-0.22
Restaurant Sit Down	**Yes**	**Yes**	0	-1,594	0.00	-0.29
Retail Standalone	**Yes**	**No**	-239	N/A	-0.01	N/A
Retail Strip Mall	**No**	**No**	N/A	N/A	N/A	N/A
School Primary	**Yes**	**Yes**	-41,422	-1,181	-0.56	-0.02
School Secondary	**Yes**	**Yes**	-56,481	-16,939	-0.27	-0.08
Warehouse	**Yes**	**Yes**	-772	-53	-0.01	0.00

Notes: An N/A in the table indicates that one or both provisions did not apply to that building prototype model, even though the MiscPlug and Secondary Sidelit consumption estimates may differ between the 2018 and 2021 code cycles. As such there are no savings impacts for those building types.

Finally, the cumulative savings impacts on total site energy use for both the automated receptacle and secondary sidelit zone provision are shown in **Error! Reference source not found.** below.

Table 10. **Total Site Savings Estimates - 2021 IECC compared to Montana 2021 Code**

	2021 MT Code Amendment Provision Applicability		Energy Savings (2021 IECC - MT 2021)	Energy Savings per ft^2 (2021 IECC - MT 2021)
Building Type	**Automated Receptacle**	**Secondary Sidelit Zone**	**Total Site Energy Savings (kWh/yr)**	**Total Site Energy Savings (kWh/yr/ft^2)**
Apartment High Rise	**No**	**No**	N/A	N/A
Apartment Mid Rise	**No**	**No**	N/A	N/A
Hospital	**Yes**	**Yes**	-48,672	-0.20
Hotel Large	**Yes**	**Yes**	-5,242	-0.04
Hotel Small	**Yes**	**Yes**	-3,411	-0.09
Office Large	**Yes**	**Yes**	-164,503	-0.33
Office Medium	**Yes**	**Yes**	-18,153	-0.34
Office Small	**Yes**	**Yes**	-1,322	-0.24
Outpatient Healthcare	**Yes**	**Yes**	-5,022	-0.12
Restaurant Fast Food	**No**	**Yes**	-206	-0.08
Restaurant Sit Down	**Yes**	**Yes**	-883	-0.16
Retail Standalone	**Yes**	**No**	-239	-0.01
Retail Strip Mall	**No**	**No**	N/A	N/A
School Primary	**Yes**	**Yes**	-42,386	-0.57
School Secondary	**Yes**	**Yes**	-68,936	-0.33
Warehouse	**Yes**	**Yes**	-803	-0.02

Notes: An N/A in the table indicates that one or both provisions did not apply to that building prototype model, even though the MiscPlug and Secondary Sidelit consumption estimates may differ between the 2018 and 2021 code cycles. As such there are no savings impacts for those building types. Additionally, total site savings may differ from the end-use savings in Table 9 because the model captures additional interactive heating and cooling impacts due to the removal of daylighting controls.

Future Gaps to Address

Future code changes may potentially become more complex and integrated with whole building energy use. There is an increased probability of error when modifying IDFs for each prototype to attempt and isolate amended code provisions. NEEA should develop a review and adjustment framework for modifying IDF or output files to reliably account for state-level adjustments in future code cycles.

Additionally, as there are 16 prototype models for Climate Zone 6B, it may be beneficial to determine which commercial building types are most prevalent in the target area before spending resources to modify all prototype models. This would reduce the time and cost burden to modify models each code cycle from the standard DOE prototypes, especially if future amendments remove provisions which have significant interactive effects on the buildings.

