July 11, 2024

REPORT #E24-013

Idaho, Montana, and Oregon Residential Energy Code Savings Analysis

Prepared For NEEA:
Kevin Rose, Lead Engineer, Codes

Prepared By:
Mark Frankel, Principal
Gia Mugford, Technical Analyst
Henry Odum, Engineering Manager
Zamora Lucas, Energy Modeler

Ecotope, Inc.
1917 First Avenue, Suite 300
Seattle WA 98101

Northwest Energy Efficiency Alliance
PHONE
503-688-5400
EMAIL
info@neea.org

TABLE OF CONTENTS

TABLE OF TABLES

EXECUTIVE SUMMARY

Ecotope has modeled the per-home energy savings realized by the most recently adopted residential energy codes in Idaho, Montana and Oregon homes. A representative distribution of prototype houses constructed under the code currently effective in each state was evaluated and compared with results for the same houses built under the previous version of the residential code in each state. The relevant codes and their net savings were as follows:

Table 1. State Energy Code History and Savings Estimate

State	Current Code	Previous Code	Whole Home Savings
Idaho	IECC 2018 with ID amendments	IECC 2015 with ID amendments	11.6%
Montana	IECC 2018 with MT amendments	IECC 2012 with MT amendments	2.5%
Oregon	2021 Oregon Residential Specialty Code	2017 Oregon Residential Specialty Code	-4.2%

Note: Following publication of this initial report, stakeholders identified a few potential errors and inconsistencies in the modeling inputs and assumptions used in the Oregon analysis, described in the Addendum to this report. The resulting updates in statewide annual electric (from 244 to 260 kWh) and gas (from -31 to -19 therms) savings caused statewide code-to-code savings of the 2021 ORSC with respect to the 2017 ORSC to increase from -4.2% to -2.0%.

The energy end uses modeled in the prototype houses were space heating, space cooling, ventilation, domestic water heating and lighting. Estimates, where necessary, are based on simulations and engineering models calibrated in previous field studies; no field work was conducted, nor measurements made for this current study. Plug loads, which are not currently regulated by code, are held constant between code years and are based on usage shown in recent studies of single-family and low-rise multifamily homes. Likewise, appliances unregulated by the residential codes are unchanged year over year. Assumptions of energy use and internal gains from these loads are based on research such as the Residential Building Stock Assessment (RBSA) metering study and recommendations used by the Regional Technical Forum in its resource potential studies.

The savings estimates in this study are driven in part by regional assumptions about fuel and system selections deployed across the population. Because these selections are independent of code requirements, the assumptions were kept the same between different code versions within each state. Structural changes to the additional measures options table in Oregon led to significant changes in system weighting between code versions in that state.

Multifamily structures constructed under the commercial code were not included in this analysis. Included were the proportion of low-rise multifamily constructed under the residential code in each state, representing small structures of less than four stories with minimal common areas.

This analysis did not make assumptions about compliance with each code; all homes are modeled as fully code compliant. These results are a paper-to-paper comparison, reflecting best estimates of energy performance based on the code requirements as written, not actual practice in the market. These results explicitly reflect the energy impacts of the changes in adopted code in each state. Recent construction practice studies in each state do indicate that the conditioning equipment and house air sealing current practices in each state exceed the efficiency minimums required by codes on average, so this study's results may overestimate the energy use for heating and cooling when compared with real-world performance.

INTRODUCTION

For more than 30 years, the Northwest has pursued state residential energy codes and building program improvements to create ever more efficient housing. Since its inception, the Northwest Energy Efficiency Alliance (NEEA) has played a pivotal role in aiding states to deliver more effective and efficient energy codes. NEEA contracted with Ecotope to quantify the energy use, energy savings and incremental costs for residential code improvements most recently adopted in Idaho, Montana and Oregon, using evaluation procedures aligned with previous protocols for estimating code stringency. Ecotope compared the previous and current residential energy code for single-family (including townhomes) and low-rise multifamily units of three stories or less constructed under the residential code.

The study objectives were to:

- Evaluate the stringency of requirements in each state's residential energy code compared with the 2018 International Energy Conservation Code (IECC).
- Calculate the code-compliant energy use per home under each state's current energy code and the preceding code.
- Calculate the incremental savings due to code improvements for each heating type and climate for single-family and low-rise residential multifamily units.
- Aggregate the savings estimates into a statewide estimate of overall code stringency impact.

The modeling software used for this project is SEEM[1] (Simplified Energy Enthalpy Model), which is used by the Regional Technical Forum and other regional stakeholders for modeling prototype homes in the Northwest. The Idaho and Montana analyses each weight 384 runs which describe the two code cycles, six climate locations, four heating systems, and eight prototype geometries for each states' analysis. The Oregon code analysis includes 640 SEEM simulations due to the additional prototype efficiency characteristics combinations needed to describe the efficiency associated with required additional measure options observed or assumed in each code adoption cycle.

[1] Ecotope, Inc., SEEM version 0.99d.

METHODS

Energy Use Calculations

Unit energy use is predicted by a combination of numerical simulations and engineering calculations. SEEM (version 0.99d), the residential energy-simulation program used for the analysis, is used to simulate heating, cooling and ventilation energy use. SEEM was developed for the Northwest Power and Conservation Council and NEEA and written by Larry Palmiter of Ecotope. It is the simulation engine used to provide heating and cooling energy savings estimates for the residential sector in the Northwest Power Plan, for the Performance Tested Comfort Systems (PTCS) incentive program, as well as for numerous other utility program offerings.

SEEM is also used extensively to support state building energy code revisions including, most recently, the revised 2018 Washington State Energy Code and 2021 Oregon Residential Specialty Code. The program combines building shell characteristics, thermostat settings, occupant behavior inputs, descriptions of heating and cooling systems, and duct distribution efficiency to develop an overall estimate of the energy requirements of a house. Additionally, engineering calculations calibrated by field studies are employed to determine the energy use for lighting and water heating.

The SEEM program consists of an hourly thermal simulation and an hourly moisture (humidity) simulation that interact with ducts, equipment, building shell and weather parameters to calculate the space conditioning requirements of the building. It is based on algorithms consistent with current American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Air-Conditioning, Heating, and Refrigeration Institute (AHRI), and International Organization for Standardization (ISO) calculation standards. The simulation generates outputs used in this analysis; they include building heat loss (UA), heating equipment input energy and cooling equipment input energy.

The weather files used in all savings simulations are typical meteorological year (TMY) weather files corresponding to the heating and cooling climate zones assigned to each Northwest county by the Regional Technical Forum (RTF).[2] These weather files are composite files of seasonal performance by month at regional weather stations spanning 30 years. These zones are well-aligned with the IECC climate zones, with IECC Zone 4 generally encompassing RTF Heating Zones 1 and 2, and IECC Zone 5 made up of counties assigned to RTF Heating Zone 3.

Table 2. Idaho Household Distribution across Regional Technical Forum Climate Zones

RTF Heating Zone	RTF Cooling Zone	Population of Households	% of ID HHs
1	3	265,022	46%
2	1	46,262	8%
2	2	165,026	29%
2	3	43,272	8%
3	1	52,560	9%

[2] http://www.nwcouncil.org/energy/rtf/zones/zonemapsx.htm.

Most households in Idaho are located in milder to moderate heating zones with cooling needs somewhat higher than Northwest average; 54% are in Cooling Zone 3. Only 9% of households are in the RTF's most severe Heating Zone 3.

Table 3. Montana Household Distribution across Regional Technical Forum Climate Zones

RTF Heating Zone	RTF Cooling Zone	Population of Households	% of MT HHs
2	1	12,578	7%
2	2	50,793	29%
3	1	88,055	50%
3	2	24,334	14%

64% of Montana households are located in the Northwest's most severe Heating Zone 3. Cooling demand is generally low for Montana homes.

Table 4. Oregon Household Distribution across Regional Technical Forum Climate Zones

RTF Heating Zone	RTF Cooling Zone	Population of Households	% of OR HHs
1	1	509,752	35%
1	2	778,386	54%
1	3	76,484	5%
2	1	88,525	6%

The majority of Oregon homes, 94%, are located in the Northwest's mildest heating zone. Cooling needs are moderate to mild, with just 5% located in Zone 3.

Engineering calculations calibrated by field studies were employed to determine the energy use for lighting and water heating. Lighting energy calculations were done using a lighting power density method corresponding to the level of regular and high efficacy lights required by the codes. This method assumes all lamps in the house operate 1.8 hours per day throughout the year. Water heating energy was calibrated to the equivalent of 22 gallons per day per occupant. Occupancy varies with house size and construction type (either single-family or multifamily). Gains associated with occupants, plugs, equipment and lighting are incorporated into the SEEM runs to account for their impacts on HVAC loads.

Importantly, this analysis compares the impacts of state-regulated loads on energy use. Regulated loads include space heating and cooling, water heating, lighting and ventilation. Loads not regulated by the code, including appliances and plug loads, are held constant in the analysis, and align with the values used in previous analyses of code stringency. Since they are not regulated and are held constant between the code versions, there will be no energy savings from unregulated loads due to code changes.

House Prototypes and Weights

A representative set of prototypical houses whose energy use can be estimated through simulation tools was identified for this study. The representative characteristics include climate location (by county), single- or multifamily occupancy, house size, ground contact type (slab, crawl or basement) and heating system type. These are standard analytical prototypes used by the Northwest Power and Conservation Council to develop and evaluate energy forecasts and conservation plans for the region's utilities. The same housing stock characteristics and distributions are used for both the previous and current code versions. Housing population climate distribution is drawn from the RTF's Climate Zone distribution data,[3] which can be mapped to households per county in each state. Using this distribution implies that new construction will occur at the same proportions as the existing housing stock. The proportion of single-family to multifamily construction is drawn from 2019 US census data on new housing starts[4] in each state.

Five distinct building prototypes were used in the SEEM simulations: a 1,344 ft^2 (square foot) ranch-style home, a 2,200 ft^2 split-level home, a 2,688 ft^2 home with a full conditioned basement, a large 5,000 ft^2 home with a full conditioned basement and a 952 ft^2 unit in an eight-unit townhouse structure. The 952 ft^2 prototype is a special case in this analysis that represents multifamily construction; this prototype represents a single residential unit within a small multifamily building. The state residential codes regulate multifamily structures three stories or less, which the 952 ft^2 prototype represents. This type of construction has many shared walls so the overall heating load per unit is less than for a single-family detached dwelling. The weights given to each prototype in each state were provided by NEEA for the analysis, and are included below.

Table 5. Prototype Weights

State	1,344 slab on grade	1,344 crawlspace	2,200 slab on grade	2,200 crawlspace	2,688 basement	5,000 basement	952 slab on grade	952 crawl space
Idaho	0.19	0.04	0.44	0.10	0.22	0.02	0.24	0.76
Montana	0.14	0.06	0.27	0.14	0.37	0.03	0.24	0.76
Oregon	0.17	0.04	0.49	0.18	0.08	0.04	0.24	0.76

[3] Regional Technical Forum, https://rtf.nwcouncil.org/work-products/supporting-documents/climate-zones/, accessed 11/22/2021.
[4] US Census Bureau, stateannual_201999.xls, https://www.census.gov/construction/bps/stateannual.html, accessed 11/22/2021.

Four heating types were modeled for each prototype size above, based on the standard methodology used for the regional resource conservation analysis: gas furnace with no central air conditioning, gas furnace with central air conditioning, air source heat pump and electric zonal systems. For this analysis, the proportion of each system in each state's new construction was drawn from the Pacific Northwest National Laboratory's (PNNL's) recent studies of building practices under the 2017 (Oregon[5]) or 2018 (Idaho[6] and Montana[7]) codes. This same system distribution was then used in both code cycles compared in each state. The publication of PNNL's recent residential field studies in each state provides a rare and valuable opportunity to align SEEM prototypes with a recent evaluation of building practices under the previous code, and to compare actual practice to the stringency of measures in each states' codes. The heating type distributions are reported below.

Table 6. Heating System Weights

Heating System	Gas Furnace with Central Air Conditioning (GFAC)	Gas Furnace with No Air Conditioning (GFNC)	Air Source Heat Pump (ASHP)	Electric Zonal Heating (ZONL)
Idaho SF Distribution	0.56	0.26	0.09	0.09
Montana SF Distribution	0.54	0.32	0.07	0.07
Oregon SF Distribution	0.56	0.28	0.14	0.02
All States MF Distribution	0.20	0.12	0.05	0.63

Federal Standards and Unregulated Loads

Federal codes regulating equipment efficiency are not claimed as part of state code savings as they are not attributable to state codes. They are held steady at the values listed below in each code analysis:

Table 7. Federal Standards for House Equipment

House Equipment Rating	Current Federal Requirement
Furnace: Annual Fuel Utilization Efficiency (AFUE)	0.78
Heat: Heating Seasonal Performance Factor (HSPF)	8.20
Electric: Domestic Hot Water Uniform Energy Factor (DHW UEF)	0.96
Gas: Domestic Hot Water Uniform Energy Factor (DHW UEF)	0.67

Federal efficiency standards were most recently updated in 2017.[8]

[5] PNNL, Oregon Residential Field Study, August 2020.
[6] PNNL, Idaho Residential Energy Code Field Study, February 2019.
[7] PNNL, Montana Residential Energy Code Field Study, April 2019.
[8] National Archives and Records Administration, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32, accessed 11/22/2021.

The project team's analysis assumed an average water heater size of 55 gallons and used the Residential Energy Services Network (RESNET) spreadsheet calculator[9] to arrive at the efficiency values reported above.

As noted above, high efficacy lighting is assumed to mean compact fluorescent lamp (CFL) lamping until each state's code reaches the 90% or better requirement. Oregon reached the 90% requirement in the 2017 code, with the 2021 code requiring 100%. Montana reached 90% with the 2018 code adoption. At that point, transition to LED technology has been assumed, which leads to greater savings due to the lower wattage of LED lamps.

[9] Residential Energy Services Network, https://www.resnet.us/wp-content/uploads/RESNET-EF-Calculator-2017.xlsx, accessed 11/22/2021.

ANALYSIS

As stated above, this analysis is a comparison of the code-mandated performance of prototypical homes in predicted climate locations by energy modeling. The results reflect the impacts of state code changes between cycles if homes are built with 100% energy code compliance and if only federal minimum HVAC and DHW equipment is installed. (An exception is the Additional Measures provision of Oregon's code, under which builders can choose efficient equipment from an options list and thus claim credit for efficiency over the federal minimums.)

Code Impacts in Idaho

In 2018, Idaho improved the following components over the previous 2015 code: glazing, door insulation levels, basement wall insulation, air tightness requirements and lighting efficacy. When compared with the 2018 IECC, Idaho's in-force code meets the IECC 2018 performance standard for floors and slabs, below-grade walls, and duct insulation, and is more permissive for the remainder of the components. Idaho has added amendments to its code adoptions each cycle since 2012 and has rolled back many IECC updates in each cycle to IECC 2012 levels. Amendments are codified by the legislature in a negotiated rulemaking process, and the Idaho Building Code Board can make no amendments that are more restrictive than those published by the International Code Council.[10]

Table 8. Code Improvements in Idaho 2018

	Idaho 2018 Code	
	Change vs. Previous ID 2015 Code	**Compared with 2018 IECC**
Glazing	**Improved**	Worse
Door Insulation	**Improved**	Worse
Ceilings	No Change	Worse
Walls	No Change	Worse
Floors	No Change	Equal to
Basement Walls	**Improved**	Equal to
Basement Slab	No Change	Equal to
Air Sealing (ACH50)	**Improved**	Worse
Duct Insulation	No Change	Equal to
Lighting	**Improved**	Worse
Mechanical Ventilation	No Change	Worse

Table 9. Overall Code Impact for All Idaho Homes

State	**Current Code**	**Previous Code**	**Savings**
Idaho	IECC 2018 with ID amendments	IECC 2015 with ID amendments	11.6%

[10] Office of Energy Efficiency & Renewable Energy, https://www.energycodes.gov/status/states/idaho, accessed 11/22/2021.

The overall impact of the current code vs. the previous code across all homes in Idaho is an energy savings of 11.6%. This is the weighted result of 78% single-family homes and 22% multifamily homes.

Compared with the previous code, the current Idaho code is responsible for overall electric savings of 8%. Electric savings are a combination of impacts of lighting improvements in all homes, cooling savings from improved envelope components where AC is present, and heating in electrically heated homes, which represent only 3% of single-family homes but 68% of multifamily units. Additionally, Idaho has moved from a requirement of 50% high efficacy lamps to 75%.

Table 10. Electric Energy Usage and Savings in Idaho

Code	SF Energy Use kWh/home	MF Energy Use kWh/home	Weighted Energy Use kWh/home
ID15	9,726	10,716	9,945
ID18	8,980	9,657	9,129
Savings	747	1,060	816
Pct Savings	7.7%	9.9%	8.2%

Gas savings from the previous code to the current code are 13% across all Idaho homes. This reflects the impact of code mandated insulation/window improvements and air tightness improvements on gas heated homes. This analysis assumes 97% of single-family homes in Idaho are heated with gas and 78% of new homes constructed are single-family, so these homes dominate the overall state performance.

Table 11. Gas Energy Usage and Savings in Idaho

Code	SF Energy Use therms/home	MF Energy Use therms/home	Weighted Energy Use therms/home
ID15	838	139	684
ID18	727	121	593
Savings	111	18	90
Pct Savings	13.2%	13.0%	13.2%

To investigate the isolated savings impact of air sealing, the study team ran the Idaho analysis holding the Air Change per Hour at 50 Pascals (ACH50) measure steady at 5ACH50 in both 2015 and 2018. Claiming no benefit for increased air tightness in Idaho reduced the statewide overall savings from about 11% to 8%; therefore, approximately one-fourth of the statewide efficiency improvement is attributable to the improved air sealing requirement. Given current air sealing practices in Idaho, this code measure will likely not impact energy use in the real world. Overall, while the latest Idaho code adoption has improved many measures, it is still underperforming when compared with the 2018 IECC.

Code Impacts in Montana

Montana elected not to adopt a new code in 2015, so is now moving from the 2012 IECC (with amendments) to the 2018 IECC with amendments. Amendments are adopted by a vote of the Montana Building Codes Council based on public input regarding each version of the IECC.[11] The items that improved with the 2018 code over the previous 2012 code were glazing, door insulation levels, lighting efficacy and ventilation efficiency. For the 2018 code, Montana did not amend slab insulation requirements in the coldest climates to improve them over the IECC requirement as it had done for the 2012 code, so performance on this measure worsened in the new code. Montana's in-force code meets the IECC 2018 performance for all measures except door insulation levels.

Table 12. Code Improvements in Montana 2018

	Montana 2018	
	Change vs. MT 2012 Code	**Compared with 2018 IECC**
Glazing	**Improved**	Equal to
Door Insulation	**Improved**	Worse
Ceilings	No Change	Equal to
Walls	No Change	Equal to
Floors	No Change	Equal to
Basement Walls	No Change	Equal to
Basement Slab	Worsened	Equal to
Air Sealing (ACH50)	No Change	Equal to
Duct Insulation	No Change	Equal to
Lighting	**Improved**	Equal to
Mechanical Ventilation	**Improved**	Equal to

Table 13. Overall Code Impact for All Montana Homes

State	**Current Code**	**Previous Code**	**Savings**
Montana	IECC 2018 with MT amendments	IECC 2012 with MT amendments	2.5%

The current Montana code creates total savings across all homes of 2.5% compared with the previous code, and overall electric savings of 8%. Montana has adopted the IECC 2018 measure of 90% high efficacy lamps; the previous requirement was 75%. At this level, the study team has assumed that builders will move from CFL lamping to LED fixtures to obtain the diversity of fixture types they need to install. This increases the amount of lighting savings as LEDs are two to three times more efficient than CFLs.

[11] Office of Energy Efficiency & Renewable Energy, https://www.energycodes.gov/status/states/montana, accessed 11/22/2021.

Table 14. Electric Energy Usage and Savings in Montana

Code	SF Energy Use kWh/home	MF Energy Use kWh/home	Combined Energy Use kWh/home
MT12	9,030	10,527	9,442
MT18	8,180	10,022	8,687
Savings	850	505	755
Pct Savings	9.4%	4.8%	8.0%

As a result of a 2018 code rollback in the required insulation level of slabs in milder climates, Montana results show negative gas savings compared with the previous code. Montana amendments to the 2012 IECC required four feet of perimeter insulation in all climates; these requirements were not carried over to the 2018 adoption, so slab perimeters in the milder Zone 5b climate can now be furnished with only two feet of perimeter insulation. This reduction in required insulation increases heat loss in homes with slab construction, which are the majority of new construction in Montana. The model assumes that 90% of new construction occurs in Zone 5b, and that over 60% of homes have slabs. Despite this rollback of slab insulation requirements, this provision is still aligned with IECC 2018 stringency.

Table 15. Gas Energy Usage and Savings in Montana

Code	SF Energy Use therms/home	MF Energy Use therms/home	Combined Energy Use therms/home
MT12	827	139	638
MT18	830	136	639
Savings	-3	2	-2
Pct Savings	-0.4%	1.6%	-0.3%

In Montana, the low proportion of multifamily homes with slab insulation (only 50% of the units have ground contact in the model), and a higher proportion of the total envelope taken up by more efficient windows, together contribute to a higher savings rate for multifamily homes compared with single-family homes.

Code Impacts in Oregon

Oregon maintains its own code process, the Oregon Residential Specialty Code (ORSC), which includes a chapter on residential energy efficiency. Two efficiency items improved in the 2021 code compared with the previous 2017 code were glazing and lighting efficacy. As noted earlier in this section, Oregon code requires a series of prescriptive measures and that builders choose efficiency options from a list of additional measures. This efficiency requirement became more permissive in the 2021 code, which requires the inclusion of only one option rather than the two options required in the previous code. The reduction to only one required efficiency measure has a negative impact on building performance that is not outweighed by improvements to the prescriptive requirements in this code cycle. When compared with the 2018 IECC, Oregon's in-force code meets or exceeds IECC 2018 performance for all measures except door and wall insulation levels and the air sealing requirement.

Table 16. Code Improvements in Oregon 2021

	Oregon	
	Change vs. ORSC 2017	**Compared with 2018 IECC**
Glazing	**Improved**	**Better Than**
Door Insulation	No Change	Worse
Ceilings	No Change	Equal to
Walls	No Change	Worse
Floors	No Change	Equal to
Basement Walls	No Change	Equal to
Basement Slab	No Change	**Better Than**
Air Sealing (ACH50)	No Change	Worse
Duct Insulation	No Change	Equal to
Lighting	**Improved**	**Better Than**
Mechanical Ventilation	No Change	Equal to

Note: Following publication of this initial report, stakeholders identified a few potential errors and inconsistencies in the modeling inputs and assumptions used in the Oregon analysis. Upon further investigation, NEEA concluded that two of the inputs (duct R-value and fan efficiency) warranted revision while two other inputs (above-grade wall R-value and door U-Factor) were modeled correctly despite incorrect entries for these items appearing in the report narrative. Consequently, the 2021 ORSC energy modeling was rerun with the corrected values. ***Updated Oregon savings are described in the Addendum at the end of this report.***

Additional Measure Requirements in the Oregon Residential Specialty Code (ORSC)

In the 2017 and 2021 code cycles, Oregon energy code requires that builders select additional measures to install from a list provided in Table N1101.1(2) of each code version. The 2017 code included two additional required measures: an envelope enhancement measure and a conservation (building equipment-related) measure. The 2021 code requires only one of those two measures, either an envelope enhancement *or* a conservation measure.

Selected Additional Measures for the 2017 Oregon ORSC

Oregon's options pathways introduce some uncertainty into the analysis since different additional measures result in different building energy use characteristics. PNNL conducted a study on behalf of the U.S. Department of Energy in 2019, characterizing rates of compliance with the 2017 Oregon code in 162 surveyed houses.[12] One goal of this study was to determine which additional measures were adopted most frequently to achieve code compliance. The study was able to determine the additional measures selected with reasonable confidence in 34 cases (see Table 3.20 of the PNNL study).[13]

Ecotope used these findings as a guideline to characterize the rate of adoption of each additional measure. The three most commonly adopted measure combinations in the PNNL study represented 75% of the cases observed. The remaining identified combinations of the two measures in the study each represented 5% or less of the cohort and were excluded from the weightings below. The findings of the PNNL study were translated into the following weightings of additional measure option combinations for the 2017 code analysis:

Most common measure option combination, at 29% (Combination A5 in Table 17):

- Option A: High Efficiency HVAC System, and
- Option 5: Air Sealing/Ducts checklist

Second-most common, at 26% (Combination A2 in Table 17):

- Option A: High Efficiency HVAC System, and
- Option 2: Upgraded package 1: R23 wall, R38 floor over crawl, U 0.28 windows

Third-most common, at 20% (Combination A6 in Table 17):

- Option A: High Efficiency HVAC System, and
- Option 6: low UA (modeled by a reduction in window area to 12% of floor area, which yields an approximate 8.3% reduction in UA)

These proportions were renormalized to 100% to arrive at the model weights used to calculate overall performance under the 2017 code. These combinations represent the three code path options modeled for 2017.

Table 17. 2017 Oregon Additional Measures Path Weights

Measure Path by Run Name in SEEM models	Adjusted Weight
OR17B: Combination A5 (air sealing)	0.39
OR17C: Combination A2 (envelope)	0.35
OR17A: Combination A6 (low UA)	0.26

[12] PNNL, Oregon Residential Field Study, August 2020.
[13] PNNL, Oregon Residential Field Study, August 2020.

Selected Additional Measures for the Oregon 2021 ORSC

Houses built under the 2021 Oregon code have not yet been characterized, so the additional measures used must be imputed based on expected practice. This study uses the PNNL Oregon code compliance study in combination with recommendations from the Oregon Building Codes Division to estimate deployment of code alternates in this study. The Oregon Building Codes Division assumes as baseline that builders meet the requirement with a reduction of required window area to 12% of floor area.

> *"BCD has suggested that the baseline strategy for meeting code should utilize Option 7, which adopts a reduced window area requirement (12% of floor area)…."*[14]

The PNNL study reported that 29% of Oregon homes exceeded 2017 code as part of an elective above-code program such as the Oregon Energy Performance Score (EPS). This suggests that a portion of builders will adopt more aggressive performance strategies, rather than least-cost code compliance strategies. The study team therefore assumed that this percentage of 2021 homes would likewise adopt a compliance pathway that achieves higher efficiency, even if it is not the least-cost compliance pathway. For the 29% of new homes predicted to seek maximized efficiency, the team assumed the adoption of additional measures indicated as common in the PNNL study of 2017 code-built homes—i.e., builders will continue to build in a similar manner. The most prevalent and impactful efficiency measure in Oregon new construction is installation of efficient HVAC systems.

Adopting this assumption leaves two code path models for 2021 code: the lowest-cost reduction of window area to 12% of floor area (Option 7 in Table 18) and the efficient HVAC measure (Option 1a in Table 18). Given the assumptions listed above for the 2017 and 2021 code paths, the resulting code path weights are as follows:

Table 18. 2021 Oregon Additional Measures Path Weights

Measure Path by Run Name in SEEM models	**Weight**
OR21A =Option 7 (12% window area)	0.71
OR21D = Option 1a (HVAC)	0.29

Table 19. Overall Code Impact for All Oregon Homes

State	**Current Code**	**Previous Code**	**Savings**
Oregon*	2021 Oregon Residential Specialty Code	2017 Oregon Residential Specialty Code	-4.2%

****Updated Oregon savings are described in the Addendum at the end of this report.***

[14] Ecotope, Inc., report for NEEA: *Oregon Residential Specialty Code: 2005 Baseline and Code Roadmap to Achieve the 2030 Goal*. February 12, 2021.

In Oregon, total weighted savings from previous code to current code across all homes are -4.2%, while overall electric savings are 3.9%. Electric savings are a combination of the impacts of lighting improvements in all homes, cooling savings where AC is present, and heating savings in electrically heated homes. Oregon has moved from a requirement of 90% high efficacy lamps in the previous code to 100% in the current code. LED lamping throughout is assumed for both code cycles.

Table 20. Electric Energy Usage and Savings in Oregon

Code	SF Energy Use kWh/home	MF Energy Use kWh/home	Combined Energy Use kWh/home
ORSC17	7,084	5,486	6,333
ORSC21	6,899	5,176	6,089
Savings	185	310	244
Pct Savings	2.6%	5.7%	3.9%

The negative gas savings of -9.5% across all homes in Oregon is attributable to the previous-code requirement of two additional measures that included improved equipment efficiency to only one required measure, which does not always include improved equipment efficiency. The 2017 code required one measure that impacted the efficiency of installed equipment, and compliance studies indicate that builders have historically met this requirement with a more efficient gas furnace. Under the 2017 Oregon code, the 2019 PNNL field study found that 75% of homes selected the equipment efficiency option of improved HVAC as one of the two required measures, and that about 80% of homes installed gas furnaces.

The 2021 code does not require an improved equipment measure; builders may instead choose to implement improvements in other building elements such as envelope or air tightness. Notably, an analysis of code improvements as adopted will assume the federal minimum furnace efficiency for homes in which builders do not choose the efficient HVAC option of an AFUE of 0.78. In practice, Oregon's recent compliance study found that the average gas furnace AFUE was 0.95. It is difficult to predict how market practice will change with the new more permissive code, but furnace performance is unlikely to decline to the federal minimum. Therefore, while the updated energy code is nominally less stringent, the overall impact on energy performance may not be as extreme as this constrained code comparison analysis suggests.

Table 21. Gas Energy Usage and Savings in Oregon

Code	SF Energy Use therms/home	MF Energy Use therms/home	Combined Energy Use therms/home
ORSC17	465	167	325
ORSC21	512	181	356
Savings	-47	-13	-31
Pct Savings	-10.1%	-7.9%	-9.5%

FINDINGS

Energy Use and Savings Findings

Table 22 summarizes the electric, gas and combined savings per unit in each state by fuel type. Each state has made lighting efficiency improvements and glazing performance improvements which help reduce electricity use. In Idaho, code improvements over the previous code have had considerable impact, but the air sealing measure may have little real-world impact as current practice already exceeds the code requirement. Similarly in Oregon, the gas furnace equipment typically found in new construction homes greatly exceeds the federal minimum standard, so real-world performance of these houses may not reflect this code-only comparison, which assumes baseline furnaces meet only minimum standards.

Table 22. Per-Unit Energy Savings by State

State	Electric (kWh/yr)	Natural Gas (therm/yr)	Combined (kBtu/yr)	Combined Savings (%)
Idaho	816	90	3464	11.6%
Montana	755	-2	708	2.5%
Oregon*	244	-31	-665	-4.2%

Updated Oregon savings are described in the Addendum at the end of this report.

CONCLUSIONS

Code impacts that correlate with the real world can be difficult to accurately model. This analysis provides a basis from which to approximate impact: the effects of code cycle improvements as written in Idaho, Montana and Oregon. Real-world compliance will not be 100%, and recent compliance studies in each state indicate that equipment installed often outperforms the federal minimums, which lag common practice regionwide. The impacts of each state's most recent code revisions are discussed below.

Montana shows a small combined energy savings improvement of 2.5%, largely due to electric savings. Savings in energy use due to envelope improvements in this code cycle have been overwhelmed by the more permissive slab insulation requirements, a component that has a large impact on house heat loss in cold climates. The impacts in Montana are moderate, but a comparison with the 2018 IECC shows that Montana has come into closer alignment with the current national standard in this cycle. If slab insulation had not regressed from four feet to two feet at the slab perimeter, results of the analysis would show a stronger code-over-code performance improvement.

Idaho shows notable combined energy savings of 11.6%, attributable to lighting savings as well as to improvements in envelope components. Idaho continues to lag the 2018 IECC requirements due to rollbacks of efficiency measures in adopted Idaho amendments but has made progress with this cycle.

Approximately one-fourth of this improvement appears attributable to the improved air sealing requirement. Idaho's previous and current air sealing practices already exceed even the new tighter requirement as tested in Idaho's recent PNNL study, so these savings may not be seen in the real world. The PNNL field study in Idaho shows that 38 of 63 houses tested (60%) had an ACH50 of 4 or better, which was the average value found and is considered a well-sealed house. The current 2018 IECC requires an ACH50 of 5. Idaho has rolled this requirement back from IECC requirements with amendments in each code cycle, to 7ACH50 in 2015 and 5ACH50 in 2018. All Idaho houses tested by PNNL met the 2015 requirement of 7ACH50 or less; just eight houses (13%) tested greater than 5ACH50. When compared with observed air tightness in recently constructed homes reported in the PNNL Idaho study, both the current and previous codes are more permissive than the average value observed. Real-world savings from increased air tightness code requirements will be minimal if houses are already exceeding the requirements.

Oregon shows negative combined energy savings of -4.2% due largely to the differences in efficiency between code minimum and code alternate requirements for HVAC equipment. While the real-world impact of looser equipment standards is hard to predict, reducing the number of required additional efficiency measures from two to one will likely result in some loss in overall efficiency, particularly given that little efficiency gain occurred in the prescriptive code measures between the 2017 and 2021 codes.

The analysis as performed includes several sources of uncertainty. A key one is that the code impact evaluation must predict future construction. Oregon analysis is especially complicated by the additional option measures in each code cycle, 24 possible house configurations in 2017, and eight in 2021. While estimating the most commonly selected options for the 2017 code is possible using data from the recent PNNL study in Oregon, the impact of the 2021 code's removal of compulsory efficiency options for house equipment requires assumptions about builders' behaviors. The least-expensive option for complying with the new Oregon code requirements represents an overall decline in code impact compared with previous requirements, so the extent to which builders are motivated to minimize cost will have a significant impact on effective code stringency.

Actual equipment installed may vary, especially given that equipment in the market has up to now exceeded the minimum federal standards. In reality, much more efficient equipment is being specified in the market, so house heating and cooling energy performance may often be better than the code minimum-based modeling indicates. Modeling furnace performance per the in-force federal minimum standards will overpredict heating energy use in all states, when compared with actual equipment being installed in new construction as reported in PNNL's recent building practices reports. Consequently, the impact from measures that reduce heating load between code cycles may appear larger than real-world results.

Modeling air tightness per the written code will overestimate energy savings for this code cycle in Idaho, and it will overpredict house conditioning energy needs due to air changes in both Idaho and Montana.

As long as rules are more permissive than practice, modeled code comparisons can only roughly approximate real-world performance. This is especially true of federal equipment efficiency standards, which significantly lag Northwest practice. Continuing to track builder practices in the field is an important method of gauging the effectiveness of efficiency measures adopted in each code. Compliance studies can then be used as a tool to direct future amendments to the residential energy code to bring it in line with actual regional practice.

Table 23. Savings by House Prototype and Zone in Idaho

				Electric Savings (kWh/yr) per house					Gas Savings (therm/yr) per house			
	Year Code	Heating	Home	SF	SF	MF	MF		SF	SF	MF	MF
State	Effective	System	CZ	5	6	5	6		5	6	5	6
ID	2018 - 2015	GFNC		541	517	271	266		116	79	58	45
ID	2018 - 2015	GFAC		616	522	329	281		118	81	57	44
ID	2018 - 2015	ASHP		1,639	1,261	793	687		0	0	0	0
ID	2018 - 2015	ZONL		2,888	2,310	1,458	1,248		0	0	0	0

Table 24. Savings by House Prototype and Zone in Montana

				Electric Savings (kWh/yr) per house					Gas Savings (therm/yr) per house			
	Year Code	Heating	Home	SF	SF	MF	MF		SF	SF	MF	MF
State	Effective	System	CZ	5	6	5	6		5	6	5	6
MT	2018 - 2012	GFNC		818	831	410	414		-15	3	5	8
MT	2018 - 2012	GFAC		854	854	413	417		-14	3	5	8
MT	2018 - 2012	ASHP		746	906	471	504		0	0	0	0
MT	2018 - 2012	ZONL		510	872	512	569		0	0	0	0

Table 25. Savings by House Prototype and Zone in Oregon

				Electric Savings (kWh/yr) per house					Gas Savings (therm/yr) per house			
	Year Code	Heating	Home	SF	SF	MF	MF		SF	SF	MF	MF
State	Effective	System	CZ	5	6	5	6		5	6	5	6
OR	2021 - 2017	GFNC		492	491	409	409		-62	-74	-18	-22
OR	2021 - 2017	GFAC		153	188	299	303		-50	-63	-14	-19
OR	2021 - 2017	ASHP		428	447	386	387		0	0	0	0
OR	2021 - 2017	ZONL		-4,914	-5,896	-1,265	-1,645		0	0	0	0

ADDENDUM

Updated Determination Analysis: Energy Impact of New Residential Energy Codes in Oregon

Prepared for:

Tess Studley, NEEA

Kevin Rose, NEEA

Prepared by:

Mark Frankel

Gia Mugford

Paul Kintner (No longer at Ecotope)

Henry Odum

Zamora Lucas

December 19, 2023

TABLE OF CONTENTS — ADDENDUM

TABLE OF TABLES — ADDENDUM

EXECUTIVE SUMMARY

This Addendum is a revision and update of the Oregon-related elements and section of the 2022 report that precedes this Addendum. Further description of the updates is provided in the following Introduction section.

Ecotope modeled the per-home energy savings realized by the 2021 ORSC. A representative distribution of prototype houses constructed under the 2021 ORSC was evaluated and compared with results for the same houses built under the 2017 ORSC.

In the updated analysis, changes were made to 2021 ORSC models only. The first change was duct insulation values going from R-8 to 95% at R-23.5 and 5% at R-8. The second change was the fan efficiency going from 2.8 w/cfm to 1.6 w/cfm. The resulting updates in statewide annual electric and gas savings caused statewide code-to-code savings of the 2021 ORSC with respect to the 2017 ORSC to increase from -4.2% to -2.0%.

Table A-1. State Code History and Savings Estimate

State	Current Code	Previous Code	Whole Home Savings
Oregon (Jan 2022)	2021 Oregon Residential Specialty Code	2017 Oregon Residential Specialty Code	-4.2%
Oregon – Updated (Dec 2023)	2021 Oregon Residential Specialty Code	2017 Oregon Residential Specialty Code	-2.0%

INTRODUCTION

This updated report is a revision and update of the Oregon-related elements of the 2022 report that precedes this Addendum, entitled *Determination Analyses: Energy Impact of New Residential Energy Codes in Idaho, Montana and Oregon.* After finalization of this report, stakeholders identified a few potential errors and inconsistencies in the modeling inputs and assumptions used in the Oregon analysis. Upon further investigation, NEEA concluded that two of the inputs (duct R-value and fan efficiency) warranted revision while two other inputs (above-grade wall R-value and door U-Factor) were modeled correctly despite incorrect entries for these items appearing in the report narrative. Consequently, the 2021 ORSC energy modeling was rerun with the corrected values.

A detailed **Introduction** of the full analysis can be found in the original report.

METHODS

Details on the methods for both the initial and updated Oregon savings analyses can be found in the earlier **Methods** section of this report.

ANALYSIS

Details on the analysis for both the initial and updated Oregon savings can be found in the earlier Analysis section, from **Code Impacts in Oregon** through **Selected Additional Measures for the Oregon 2021 ORSC**.

In the updated analysis, changes were made to 2021 ORSC models only. The first change was duct insulation values going from R-8 to 95% at R-23.5 and 5% at R-8. The second change was the fan efficiency going from 2.8 w/cfm to 1.6 w/cfm.

FINDINGS

The following findings supplant those described for Oregon in the earlier **Findings** section in this report.

Energy Use and Savings Findings

Based on the updated analysis summarized in this Addendum, total weighted savings in Oregon across all homes is -2.0%.

Table A-2. Annual Dwelling Unit Savings in Oregon

Oregon Savings Comparison	Electric (kWh/yr)	Natural Gas (therm/yr)	Combined (kBtu/yr)	Combined Savings (%)
Oregon (Original: January 2022)	244	-31	-665	-4.2%
Oregon (Updated: December 2023)	260	-19	-311	-2.0%

Electric savings overall are 4.1%. Electric savings are a combination of the impacts of lighting improvements in all homes, cooling savings where AC is present, and heating in electrically heated homes in Climate Zone 5. Oregon has moved from a requirement of 90% high efficacy lamps to 100%. LED lamping throughout is assumed for both code cycles.

Table A-3. Electric Energy Usage and Savings in Oregon

Code	SF Energy Use (kWh/home)	MF Energy Use (kWh/unit)	Combined Energy Use (kWh/home)
ORSC17	7,084	5,486	6,333
ORSC21	6,780	5,276	6,074
Savings	304	209	260
Pct Savings	4.3%	3.8%	4.1%

Gas savings across all homes in Oregon are -6.0%. The negative gas savings are attributable to the impact of moving from two required additional measures under the previous code, which almost always included improved equipment efficiency, to only one required measure, which may not always include improved equipment efficiency.

Table A-4. Gas Energy Usage and Savings in Oregon

Code	SF Energy Use (therms/home)	MF Energy Use (therms/unit)	Combined Energy Use (therms/home)
ORSC17	465	167	325
ORSC21	491	179	344
Savings	-26	-12	-19
Pct Savings	-5.6%	-7.2%	-6.0%

It is important to note that this analysis of code improvements, as adopted, assumes the federal minimum furnace efficiency for homes in which builders do not choose the efficient HVAC option: an AFUE of 0.78. In practice, Oregon's recent compliance study found that the average gas furnace AFUE was 0.95.

Table A-5 provides a breakdown of these electric and gas savings by home type, climate zone, and heating system. Note that each entry is a weighted average of multiple prototype configurations.

Table A-5. Annual Savings by House Prototype and Zone in Oregon

				Electric Savings (kWh/yr) per house				Gas Savings (therm/yr) per house			
	Year Code	Heating	Home	SF	SF	MF	MF	SF	SF	MF	MF
State	Effective	System	CZ	4	5	4	5	4	5	4	5
OR	2021 - 2017	GFNC		573	566	305	305	-32	-42	-16	-20
OR	2021 - 2017	GFAC		258	298	197	202	-29	-36	-13	-17
OR	2021 - 2017	ASHP		667	841	294	307	0	0	0	0
OR	2021 - 2017	ZONL		-4,871	-5,853	-1,370	-1,751	0	0	0	0

CONCLUSIONS

Correlating code impacts with real-world effects can be difficult to accurately model. This analysis provides a basis from which to approximate impact: the effects of code cycle improvements as written in Oregon. In the real world, compliance will not be 100% and recent compliance studies indicate that equipment installed often outperforms the federal minimums, which lags common practice regionwide.

The December 2023 updated analysis for Oregon shows negative savings of -2.0% due largely to the differences in efficiency between code minimum and code alternate requirements for HVAC equipment. While the real-world impact of looser equipment standards is hard to predict, reducing the number of required additional efficiency measures from two to one is highly likely to result in some loss in overall efficiency, particularly given the limited efficiency gains in the prescriptive measures of the code between the 2017 and 2021 codes.

Additional conclusions generalizable to all states in the initial analysis can be found in the original **Conclusions** section.