March 18, 2020

REPORT #E20-001

# Oregon Residential Specialty Code: Energy Efficiency Analysis


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**Glossary of Acronyms**

| | |
|---|---|
| AFUE | Annual Fuel Utilization Efficiency |
| ACH | Air Changes per Hour |
| COP | Coefficient of Performance |
| EF | Energy Factor |
| ERV | Energy Recovery Wheel |
| DHP | Ductless Heat Pump |
| DOEZER | Department of Energy Zero Energy Ready Home |
| HVAC | Heating, Ventilation and Air Conditioning |
| HFA | Heated Floor Area |
| HSPF | Heating Seasonal Performance Factor |
| HP | Heat Pump |
| IECC | International Energy Conservation Code |
| MELS | Miscellaneous Electric Load Use |
| NEEA | Northwest Energy Efficiency Alliance |
| NWPCC | Northwest Power and Conservation Council |
| ORSC | Oregon Residential Specialty Code |
| RTF | Regional Technical Forum |
| RBSA | Residential Building Stock Assessment |
| SEEM | Simplified Energy and Enthalpy Model |
| SEER | Seasonal Energy Efficiency Ratio |
| SHGC | Solar Heat Gain Coefficient |
| SRE | Sensible Heat Recovery Efficiency |
| SqFt | $ft^2$ |
| TMY | Typical Meteorological Year |
| UA | Building heat loss expressed as U-value times area |

**Acknowledgments**

This report was prepared by Ecotope, Inc. and Northwest Energy Efficiency Alliance (NEEA). The authors would like to thank the following experts and organizations for conducting insightful reviews and providing suggestions on the draft version of this report:

David Heslam, Earth Advantage,

Scott Leonard, Energy Trust of Oregon,

Members of Home Performance Council, Home Builders Association of Metropolitan Portland,

Mark Heizer, Oregon Building Code Division, and

Warren Cook, Blake Shelide, and Michael Freels, Oregon Department of Energy.

NEEA and Ecotope has modified the analysis and revised the draft report by incorporating the review comments, leading to the final report.

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**Executive Summary**

Oregon Executive Order (EO) 17-20, Section 4C requires newly constructed residential buildings to achieve equivalent performance levels with the 2017 U.S. Department of Energy (DOE) Zero Energy Ready (DOEZER) specification by 2023. To support this goal, Northwest Energy Efficiency Alliance (NEEA) has funded Ecotope to conduct an energy analysis for single-family homes and provide information to stakeholders to meet Executive Order 17-20. The study has the following goals:

- Provide a summary snapshot of the average annual energy consumption of the residential sector by establishing the 2017 Oregon Residential Specialty Code (ORSC) baseline energy use.
- Determine the difference in energy consumption between the 2017 ORSC baseline and the DOEZER Rev. 06 specification (the version of the specification published in 2017).
- Provide several combinations of measures to achieve DOEZER-equivalent energy savings by 2023.

To conduct the energy saving analysis, two single-family homes were modeled in Simplified Energy Enthalpy Model (SEEM)[1] and supplemented with engineering calculations. The prototypes, representing 67% of Oregon's single-family home population, included 2,200 $ft^2$ homes, one built over a crawlspace and one on a concrete slab. Each prototype home contains four heating systems (two gas-heated systems and two electric-heated systems). All studied homes further placed within two climate zones in Oregon. This totaled a suite of 16 prototype models included in each of two cases: 2017 ORSC and DOEZER.

The results in Table 1 show the annual energy consumption by end use for all prototypes after aggregating results by applying for the construction weighting factors. Inputs for both 2017 ORSC and DOEZER cases are outlined in Table 9.

Table 2 shows the difference in total energy use intensity for site energy consumption between the 2017 ORSC baseline and the DOEZER specification. It also presents the site energy saving target to meet the DOEZER efficiency level. In other words, the future Oregon Residential Specialty Code will need to deliver roughly 2.0 to 2.5 kBtu/sf annual site energy savings to be DOEZER equivalent.

[1] The field-validated hourly energy use model developed by Ecotope and used by the Regional Technical Forum, Northwest Power and Conservation Council and NEEA.

**Table 1. Annual Energy Consumption by End Use**

| Case | Home Type | Heating | Cooling (kWh) | Fan (kWh) | Water Heating | Lighting (kWh) | MELs (kWh) | Total Electric (kWh) | Total Gas (Therm) |
|---|---|---|---|---|---|---|---|---|---|
| **2017 ORSC (Option 5A)** | DHP | 3,477 (kWh) | 380 | 89 | 2,927 (kWh) | 766 | 4,000 | 11,639 | - |
| | Central HP | 3,101 (kWh) | 595 | 312 | 2,927 (kWh) | 766 | 4,000 | 11,701 | - |
| | Gas Furnace with AC | 339 (therm) | 705 | 436 | 153 (therm) | 766 | 4,000 | 5,907 | 492 |
| | Gas Furnace with no AC | 340 (therm) | 0 | 360 | 153 (therm) | 766 | 4,000 | 5,126 | 493 |
| **DOEZER (Rev. 06)** | DHP | 3,117 (kWh) | 302 | 484 | 1,390 (kWh) | 1,041 | 3,820 | 10,154 | - |
| | Central HP | 2,626 (kWh) | 508 | 673 | 1,390 (kWh) | 1,041 | 3,820 | 10,058 | - |
| | Gas Furnace with AC | 293 (therm) | 529 | 783 | 142 (therm) | 1,041 | 3,820 | 6,173 | 435 |
| | Gas Furnace with no AC | 295 (therm) | 0 | 719 | 142 (therm) | 1,041 | 3,820 | 5,580 | 437 |

Note:
1. DHP (ductless heat pump with electric zonal heating); Central HP (central air source heat pump); AC (air conditioner); MELs (miscellaneous electric loads)
2. Option 5A refers to the additional measures required in 2017 ORSC Table N1101.1(2).

**Table 2. Annual Energy Use Intensity (EUI) Comparison, Site Energy (kBtu/sf)**

| Home Type | 2017 ORSC (Option 5A) | ZER (Rev. 06) | ZER-equivalent Saving Target |
|---|---|---|---|
| DHP | 18.1 | 15.8 | 2.3 |
| Central HP | 18.2 | 15.6 | 2.5 |
| **All Electric Total** | **18.1** | **15.7** | **2.5** |
| Gas Furnace with AC | 31.5 | 29.3 | 2.2 |
| Gas Furnace with no AC | 30.3 | 28.5 | 1.8 |
| **Gas Heat Total** | **31.1** | **29.1** | **2.0** |

To facilitate exploration of several combinations of measures to meet DOEZER-equivalent saving goal, several measures (e.g., Super Windows, Air Tightness, Zero Energy Ready Wall, and others) were designed to be unique so that more than one could be chosen without duplication of the measure design. Once measures were developed, a "least first cost" and a "max energy savings" selection of measures were selected and modeled. The goal was to ensure the savings in 2023 (i.e., "Select 4 Energy Measure") were roughly equal to the DOEZER specification. Annual EUI Savings of

the measure packages are summarized in Table 3 – these are savings over those of a current 2017 ORSC-compliant home.

**Table 3. Summary of Energy Savings Compared to a 2017 ORSC Baseline**

| Measure Inputs | Home Type | Total Site EUI (kBTU/sf) | EUI Savings |
|---|---|---|---|
| **2017 ORSC Baseline (Option 5A)** | | | |
| See **Table 9** | All Elec | 18.1 | --- |
| See **Table 9** | Gas Heat | 31.1 | --- |
| **DOEZER Rev. 06** | | | |
| See **Table 9** | All Elec | 15.7 | 2.5 |
| See **Table 9** | Gas Heat | 29.1 | 2.0 |
| **"Select 3 Energy Measures" – See Appendix A** | | | |
| **Least First Cost** | | | |
| X1: DHP 9.5 OR Central HP 10 HSPF<br>W1: 2.0 UEF Water Heater<br>A: U-0.045 Wall | All Elec | 15.3 | 2.8 |
| X1: 90% AFUE Furnace<br>Y: Ducts Inside<br>A: U-0.045 Wall | Gas Heat | 29.6 | 1.5 |
| **Max Energy Savings** | | | |
| X1: DHP 9.5 HSPF OR Central HP 10 HSPF<br>W1: 2.0 UEF Electric Water Heater<br>A: U-0.045 Wall | All Elec | 15.3 | 2.8 |
| X1: 90% AFUE Furnace<br>W1: 0.85 UEF Gas Water Heater<br>A: U-0.045 Wall | Gas Heat | 29.5 | 1.6 |
| **"Select 4 Energy Measures" – See Appendix A** | | | |
| **Least First Cost** | | | |
| X1: DHP 9.5 HSPF OR Central HP 10 HSPF<br>W2: 2.9 UEF Electric Water Heater (2 credit measure)<br>A: U-0.045 Wall | All Elec | 14.7 | 3.4 |
| X1: 90% AFUE Furnace<br>W1: 0.85 UEF Gas Water Heater<br>Y: Ducts Inside<br>A: U-0.045 Wall | Gas Heat | 28.1 | 3.0 |
| **Max Energy Savings** | | | |
| X1: DHP 9.5 HSPF<br>W2: 2.9 UEF Water Heater (2 credit measure)<br>A: U-0.045 Wall<br>OR<br>X2: Central HP 12 HSPF<br>W1: 2.0 UEF Water Heater<br>A: U-0.045 Wall | All Elec | 14.5 | 3.6 |
| X1: 90% AFUE Furnace<br>W2: 1.2 UEF Water Heater (2 credit measure)<br>A: U-0.045 Wall | Gas Heat | 27.7 | 3.4 |

Results show that three measures for electric-heated homes and four measures for gas-heated homes under a future Oregon Residential Specialty Code are needed to achieve DOEZER equivalence. While this study explored a selected combination of defined measures, there are many other possible combinations of these measures. Providing a small group of non-overlapping measures allows the builder more flexibility on achieving DOEZER equivalence. The study provides a framework and data for future Oregon Residential Specialty Code development to meet the Executive Order.

## 1. Introduction

Oregon Executive Order (EO) 17-20, Section 4C requires newly constructed residential buildings to achieve equivalent performance levels with the 2017 U.S. Department of Energy (DOE) Zero Energy Ready (DOEZER) specification by 2023. To support this goal, Northwest Energy Efficiency Alliance (NEEA) has funded Ecotope to conduct an energy analysis for single-family homes and provide information to stakeholders to meet Executive Order 17-20. The study has the following goals:

- Provide a summary snapshot of the average annual energy consumption of the residential sector by establishing the 2017 Oregon Residential Specialty Code (ORSC) baseline energy use.
- Determine the difference in energy consumption between the 2017 ORSC baseline and the DOEZER Rev. 06 specification (the version of the specification published in 2017).
- Provide several combinations of measures to achieve DOEZER-equivalent energy savings by 2023.

In order to develop a representative picture of Oregon's new construction single-family homes, the energy modeling methodology was developed to follow guidelines used by the Northwest Power and Conservation Council (NWPCC), Regional Technical Forum (RTF), and the Washington State Building Code Council (SBCC). Section 2 in this report documents the methodology and detailed analysis inputs and modeling assumptions.

Findings from the analysis in the study suggest a need to increase the number of required measures from Table 1101.1(2) Additional Measures[2] in the current 2017 ORSC to achieve energy efficiency performance level equivalent to DOEZER. Envelope measures were developed such that the reductions in total shell heat loss rate (U-value * area of component) was within 5% of each other. HVAC and water heating equipment measures were developed to achieve 10-20% energy savings of each other. All the measures were evaluated for their relative savings over the minimum requirements of 2017 ORSC before any options were chosen. This provides a way of considering several different combinations of measures that achieved DOEZER equivalence. It also helps establish percentage savings over the minimum code and excludes variability in the results by screening the options out. Results and conclusions are included in Section 3 and 4, respectively. Future residential code framework and measures can be found in Appendix A. The NWPCC Heating and Cooling Climate Zone maps are provided in Appendix B and Summary of Measure by Measure modeled savings results are provided in Appendix C.

The study establishes the baseline for 2017 Oregon Residential Specialty Code energy use and determines the difference in the energy consumption between 2017 ORSC baseline and the DOEZER Rev. 06 specification without overlapping 2017 ORSC requirements. Where requirements of the local code overlap with the DOEZER requirements and exceed DOEZER are referred as overlapping requirements in this study. The feedback received from the peer reviews indicate that Oregon Zero Energy Ready Residential Code uses the DOEZER Rev. 06 minimum requirements and the current 2017 ORSC is not used to set the DOEZER Rev. 06 prescriptive requirements. In responding to the comments, NEEA and Ecotope conducted an additional scenario analysis and the results are provided in Appendix D to assist stakeholders understand the impacts from this alternative analysis.

[2] https://codes.iccsafe.org/content/chapter/10141/

## 2. Methodology

The modeling process and selection of residential prototypes remained consistent with the framework developed by the Regional Technical Forum (RTF) and the Northwest Power and Conservation Council (NWPCC) for energy forecasting for the region's utilities. This study focused on single-family detached homes and modeled two housing types. By focusing on the most common residential prototypes and modeling them within the state's two most populous climate zones, a representative picture of annual energy use can be characterized within Oregon's single-family sector.

Energy use was predicted by a combination of numerical simulations and engineering calculations. Simplified Energy Enthalpy Model (SEEM)[3] was used to simulate heating, cooling, and ventilation energy use. SEEM 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 energy requirements for a house. Additionally, engineering calculations calibrated by field studies were employed to determine the energy use of other end uses such as lighting, water heating, appliances, and miscellaneous electric loads (MELs). Since MELs are the only unregulated load in a single-family home, this value was kept constant across all modeling runs and incorporates gas and electric cooking (represented in equivalent kWh usage). Minor credit has been claimed for Energy Star appliances for refrigerators, dryers and washing machine in the DOEZER runs using the Regional Technical Forum (RTF) workbooks.[4]

[3] https://rtf.nwcouncil.org/simplified-energy-enthalpy-model-seem

[4] https://rtf.nwcouncil.org/standard-information-workbook

## 2.1. Input Assumptions

The following inputs and weightings remained constant throughout the modeling study. This provided a consistent basis upon which individual conservation measures, packages of measures, and code/DOEZER-compliant runs were built.

### 2.1.1. Prototype and Heating System Selection

In summary, two building prototypes were modeled (with four heating systems each) and placed within two climate zones. This totaled 16 simulation runs for each individual measure or condition analyzed. The diversity of climate zones and heating system types captured the variation in typical home energy use, instead of a like-for-like analysis which would have focused solely on a single house selection. The two prototypes were 2,200 $ft^2$ detached single-family homes, one placed over a crawlspace and the other on a concrete slab. These two prototypes represent 67% of Oregon's single-family home population. Table 4 describes the building characteristics of these two prototypes and their corresponding weighting factors.

Based on the standard methodology used by the RTF, each of the two prototypes was simulated with the following four heating systems: gas furnace with no central air conditioning , gas furnace with central air conditioning, central heat pump (HP), and ductless heat pump with electric zonal heating. Weights for the base heating systems of single-family prototypes were sourced from a combination of the RLW reports,[5] the RBSA phone survey, and the RBSA field study.[6] Table 5 presents the weights for these four heating systems.

**Table 4. Prototype Characteristics of Selected Single-family Homes**

| Characteristics | 2200c | 2200s |
|---|---|---|
| Foundation | Crawl | Slab |
| Units | 1 | 1 |
| Floors | 1.5 | 1.5 |
| Glazing (% HFA) * | 16.6% | 16.6% |
| Occupants per Unit | 2.75 | 2.75 |
| Prototype Weight | 0.73 | 0.27 |

*HFA: Heated Floor Area

**Table 5. Heating System Weights**

| **Heating System** | **Gas Furnace with Central Air Conditioning** | **Gas Furnace with no Air Conditioning** | **Central Heat Pump** | **DHP with Electric Zonal Heating** |
|---|---|---|---|---|
| **Weights** | 0.535 | 0.290 | 0.119 | 0.056 |

[5] NEEA (2007). Single-Family Residential New Construction Characteristics and Practices Study. RLW Analytics

[6] NEEA (2012). 2011 Residential Building Stock Assessment: Single-Family Characteristics and Energy Use. Ecotope

### 2.1.2. Climate Zone Weighting

The weather files used in this study were composite typical meteorological year (TMY) weather files corresponding to the heating and cooling climate zones used by the NWPCC. These climate zone designations correlated closely to the 2015 IECC-defined Climate Zone map. However, the NWPCC climate zones had the benefit of providing a holistic picture of single-family energy use in Oregon by breaking out climate weightings by the state's population. Table 6 lists the climate zone weights for the entire state. This analysis modeled two climate zones (Heating Zone 1 and Cooling Zones 1 & 2), capturing 81% of Oregon's population. See Appendix B for climate zone maps.

**Table 6. Climate Zone Weights of Oregon Counties (Based on 2000 Census Data)**

| Climate Zone | Population | Weight |
|---|---|---|
| **Heating 1 & Cooling 1*** | 1,578,168 | 48% |
| **Heating 1 & Cooling 2*** | 1,085,867 | 33% |
| **Heating 1 & Cooling 3** | 369,335 | 11% |
| **Heating 2 & Cooling 1** | 170,348 | 5% |
| **Heating 2 & Cooling 2** | 97,883 | 3% |
| **Heating 3 & Cooling 1** | 14,553 | 0% |
| **Total** | 3,316,154 | 100% |

*Selected climate zones for this analysis

### 2.1.3. Federal Minimum Equipment Efficiencies

An important consideration in developing code-compliant savings is understanding the federal minimum equipment efficiencies upon which energy savings are calculated. Table 7 summarizes the equipment efficiencies set in place on January 1, 2018. While it is anticipated that federal efficiencies will increase in the future, these values were left unchanged in order to focus this exercise solely on the proposed code impacts.

**Table 7. List of Equipment Federal Minimum Efficiency Assumptions**

| Equipment | Federal Minimum Efficiency |
|---|---|
| Air Conditioner | 13 SEER |
| Central Heat Pump[7] | 8.2 HSPF 14 SEER |
| Gas Furnace[7] | 80% AFUE |
| Electric Water Heater | 0.95 EF |
| Gas Water Heater | 0.62 EF |

[7] Central Gas Furnace or Heat Pump are modeled to cycle on and off to meet heating and cooling load only. Savings from any fan efficiency measure such as an ECM motor is not captured in this study. ECM motor is typically used in central furnace to ventilate the house when there is no heating and cooling load allowing the furnace fan to ramp down to minimum speed for ventilation. Such a measure will have no impact on the savings as our study assumes that ventilation is brought through whole house HRV or bath fans.

## 2.2. Comparison of 2017 ORSC and DOEZER Rev. 06

Building upon the input assumptions summarized in Section 2.1, modeling runs were developed in compliance with the 2017 Oregon Residential Specialty Code (ORSC) and DOE Zero Energy Ready Home (DOEZER) Rev. 06 specifications. The 16 simulation runs for each specification were weighted down to two representative values (gas and electric heating source), and the difference in modeled annual energy consumption set the basis for the development of the Oregon Residential Code Measures. All runs were fully compliant with each respective specification.

To pass the current 2017 ORSC, builders must choose two measures from Table N1101.1(2) Additional Measures; this leads to a considerable amount of variation when attempting to model a "typical" new home in Oregon. As such, all prescriptive requirements of the ORSC were included in the analysis and two measures were selected under Table N1101.1(2) of the 2017 ORSC. Two selected additional measures were Option 5 (Air sealing home and ducts) and Option A (High efficiency HVAC system).[8]

Table 8 summarizes the assumed measures for each heating system. In general, it was assumed that mastic was applied to ductwork and that an equipment measure was selected. Since the 2017 ORSC has no mandatory requirement for duct air-sealing, the study referenced shows that typical leakage of untested residential ductwork is 12%.[9] Sealing ductwork with mastic (Measure 5 from Table N1101.1(2)) assumed that the overall leakage would drop in half to roughly 6%. This remains consistent with previous code impact studies by NEEA.[10]

**Table 8. Selected Measures from Table N1101.1(2) for the 2017 ORSC Baseline Models**

| Heating System Type | Additional Measure #1 (Air Sealing Home and Ducts) | Additional Measure #2 (High Efficiency HVAC Systems) |
|---|---|---|
| Gas Furnace, no AC | Option 5: All req'd & ducts sealed | Option A: Furnace AFUE 94% |
| Gas Furnace, with AC | Option 5: All req'd & ducts sealed | Option A: Furnace AFUE 94% |
| Central Heat Pump (HP) | Option 5: All req'd & ducts sealed | Option A: Heat Pump HSPF 9.5, SEER 15 |
| Ductless Heat Pump with Electric Resistance Heating | Option 5: All req'd & air handlers inside envelope (ductless heat pump) | Option C: DHP, HSPF 10 |

Prescriptive compliance path in DOEZER Rev. 06 specification limits builders to a single path of compliance for any given heating system. Therefore, the development of the simulation runs was relatively straightforward. A summary of all inputs used to characterize a fully-compliant 2017 ORSC and DOEZER Rev. 06 home is listed in Table 9.

[8] In early 2020 NEEA conducted a field study for newly constructed homes in Oregon using DOE's methodology. The preliminary field data shows for most of new homes in Oregon, Option A (high efficiency HVAC system) were used by builders and Option 1 (High efficiency walls) and Option 5 (Air sealing home and ducts) were equally used to meet the code requirements. For this study, we selected Option 5A as the popular additional measures, with the field data to support this selection. We expect the field study data and report will be published by May or June 2020 when the project team complete the data analysis and finish the report.

[9] CIEE (2002). Residential HVAC and Distribution Research Implementation. Lawrence Berkeley National Laboratory

[10] NEEA (2018). 2017 Oregon Residential Specialty Code Energy Efficiency: Impact Assessment. Ecotope

DOEZER Rev.06 specifications listed in Table 9 do not capture overlapping 2017 ORSC requirements. Where requirements of the local code overlap with the DOEZER requirements and exceed DOEZER are referred as overlapping requirements in this study. In the DOZER specifications, the insulation required in above grade walls is R-20; the U value for the doors is 0.30; cooling efficiency for Heat Pump is SEER 13; and lighting requirement is for 80% high efficacy lamps. In all these areas the 2017 ORSC exceeds the DOEZER minimum requirements. However, the feedback received from the peer reviews indicate that Oregon Zero Energy Ready Residential Code uses the DOEZER Rev. 06 minimum requirements and the current 2017 ORSC is not used to set the DOEZER Rev. 06 prescriptive requirements. In responding to the comments, NEEA and Ecotope conducted an additional scenario analysis and the results are provided in Appendix D to assist stakeholders understand the impacts from this alternative analysis.

**Table 9. Comparison of 2017 ORSC Baseline and DOEZER Rev. 06 Modeling Inputs**

| Component | 2017 ORSC Baseline (with two additional measures from Table N1101.1(2)) | DOEZER Rev. 06 (without any overlapping ORSC code requirements) |
|---|---|---|
| **Envelope** | | |
| **Above Grade Wall** | 2x6 int. w/ R-21 batts | 2x6 int. w/ R-20 batts |
| **Glazing** | U-0.30, SHGC-0.40 | U-0.27, SHGC-0.30 |
| **Roof** | R-49 | R-49 |
| **Floor Over Unheated** | R-30 | R-30 |
| **Slab-on-Grade** | R-15 for 2 ft | R-10 for 2 ft |
| **Doors** | U-0.20 | U-0.30 |
| **Airtightness** | 5 ACH50 | 2.5 ACH50 (Zone 4C)<br>2.0 ACH50 (Zone 5B) |
| **Heating and Cooling (System Type)** | | |
| **Gas Furnace, no AC (Heat Only)** | Heat: 94% AFUE | Heat: 94% AFUE |
| **Gas Furnace, with AC (Heat+Cool)** | Heat: 94% AFUE<br>Cool: 13 SEER | Heat: 94% AFUE<br>Cool: 13 SEER |
| **DHP w/ Electric resistance heating (Heat+Cool)** | Heat: 10 HSPF<br>Cool: 13 SEER[1] | Heat: 10 HSPF<br>Cool: 13 SEER |
| **Central Heat Pump (Heat+Cool)** | Heat: 9.5 HSPF<br>Cool: 15 SEER | Heat: 10 HSPF<br>Cool: 13 SEER |
| **Ventilation, Ducts & Controls** | | |
| **Ventilation[2]** | Exhaust fan, 2.8 cfm/W, 75 cfm<br>Schedule: Cycle 8 hr/day | ERV, 60% SRE, 1.2 cfm/W, 65 cfm<br>Schedule: 24 hr/day |
| **Duct Location** | Ducts located outside conditioned space, R-8 insulation, 6% system airflow leakage to exterior | Ducts and equipment located within conditioned space, 1% system airflow leakage to exterior[3] |
| **Thermostat** | 7-Day Programmable | 7-Day Programmable |
| **Domestic Hot Water (Fuel Source)[4]** | | |
| **Gas** | 0.62 EF | 0.67 EF |
| **Electric** | 0.95 EF | 2.0 EF |
| **Water Consumption[5]** | Gallons/day = 23 +11*(#occupants-1) | Gallons/day = 23 +11*(#occupants-1) |
| **Lighting, Appliances & Plugs** | | |
| **Lighting Efficacy and Runtime[5]** | 95% high efficacy[6] 1.8 hr/day | 80% high efficacy 1.8 hr/day |
| **Appliances** | Federal Minimum | EnergyStar |
| **Plugs** | Unregulated Load, 1,600kWh/yr | Unregulated Load, 1,600kWh/yr |

1. No specification in Oregon code for DHP SEER rating; assume DHP cooling efficiency is same as DOEZER.
2. Ventilation requirements are met by the combination of passive infiltration rates and mechanical fan flow. Per ASHRAE 62.2-2010-Addendum n: Mechanical ventilation is not required at 5 ACH50, therefore an intermittent exhaust fan is modeled. Mechanical ventilation at a rate of 65cfm (constant) is required for a 2,200 ft$^2$ home with tested 2 ACH50 infiltration.
3. Allows a total of 10ft of ductwork to be located outside the heated envelope per DOEZER Rev.06 endnote #16.
4. Gas-heated homes are assumed to have gas water heating, and electric heated homes are assumed to have electric water heating. 50-gallon tank.
5. NEEA (2012). 2011 Residential Building Stock Assessment: Single-family Characteristics and Energy Use.
6. Section N1107.2 exception of the 2017 ORSC allows up to two permanently installed lighting fixtures as non-high efficiency. The modeled home is assumed to have 40 installed fixtures.

## 2.3. Future Oregon Residential Code Measures

The future Oregon Residential Specialty Code is intended to achieve DOEZER Rev. 06 energy savings by 2023. We propose savings be achieved within two code development cycles, including 2020 and 2023. As per Oregon's 2020 residential code adoption plan[11], Oregon Building Code Division will be adopting Oregon Zero Energy Ready Residential Code (OZERRC) and is anticipated to be effective Oct 1, 2020. A residential code development study such as this offers the benefit of leading to a more robust energy code that provides the targeted energy savings while giving builders options in complying with code. Table 10 below lists the proposed code measures analyzed in this study. See Appendix A for the suggested code framework and measures.

To facilitate exploration of several combinations of measures to meet DOEZER-equivalent saving goal, several measures (e.g., Super Windows, Air Tightness, Zero Energy Ready Wall, and others) were designed to be unique so that more than one could be chosen without duplication of the measure design. These were evaluated for their relative savings over the minimum requirements of 2017 ORSC (i.e., before any options were chosen). This provides a way of considering several different combinations of measures that achieved DOEZER savings equivalence. It also helps establish percentage savings over the minimum code and excludes variability in the results by screening the options out.

The proposed measures fall under two categories: load reduction (envelope measures) and mechanical equipment and system efficiencies. For load reduction measures, a simple UA calculation was completed for the 2,200 $ft^2$ slab and crawlspace prototypes. Each envelope measure was developed to reduce the heating load by roughly 6%.

Each HVAC measure was adjusted to provide similar levels of energy savings within the proposed framework; however, the diversity of housing types, climate zones, and system types led to greater variations in the modeled savings. All HVAC measures were developed using the same basic input assumptions as those summarized in Section 2.1.

Figure 1 and Figure 2 display the relative savings of all proposed measures, and detailed measure-by-measure savings are shown in Table 13 in Appendix C. The measure-specific savings are modeled off a 2017 ORSC home *without* any measures selected from Table N1101.1(2), and thus assume federal minimum efficiency equipment for the four heating system types modeled. For select equipment measures, two "tiers" in efficiency were created to honor highly efficient equipment (beyond the federal minimum efficiencies). These are simply referred to as "Tier 1" and "Tier 2" equipment efficiency levels, as shown in Table 10.

[11] https://www.oregon.gov/bcd/codes-stand/code-adoption/Pages/2020-orsc-adoption.aspx

**Table 10. Proposed Code Measures**

| | | |
|---|---|---|
| **Envelope Measures** | | |
| A | Super-Efficient Wall | Wall U ≤ 0.045 (2x6 in. wood R-21 cavity insulation + R-5 continuous) |
| B | Super Window | Window U ≤ 0.24, SHGC 0.27<br>Skylight U ≤ 0.43 |
| C | Roofs & Floors | Flat Roof U ≤ 0.017 (R-60 w/ partial raised heel)<br>Vaulted Ceiling U ≤ 0.017 (10" Structural Insulated Panel (SIP))<br>Floor over Crawlspace U ≤ 0.025 (R-38 batts in floor joists)<br>Slab on Grade R-10 continuous rigid |
| D | Air Sealing* | ACH50 ≤ 2.0<br>* Must be paired with HVAC measure for balanced mechanical ventilation |
| E | Glazing Limit | Glazing area (frame opening) is less than 12% of floor area |
| F | UA Rated** | Third Party Rater Verified UA Value<br>1 Credit - 6% lower heat loss than code baseline<br>2 Credit - 12% lower heat loss than code baseline<br>3 Credit - 18% lower heat loss than code baseline |
| **HVAC Measures** | | |
| V | Heat Recovery Ventilation (HRV)* | Balanced Mechanical Ventilation<br>**Tier 1** / **Tier 2**<br>Sensible Recovery Efficiency: 60% / 80%<br>Fan Power (W/cfm): 1.2 / 1.5 |
| W | Water Heating | Minimum Efficiency Values<br>**Tier 1** / **Tier 2**<br>Electric Water Heater: 2.0 / 2.9 UEF<br>Gas Water Heater: 0.85 / 1.2 UEF |
| X | HVAC System | Minimum Efficiency Values<br>**Tier 1** / **Tier 2**<br>DHP w/Zonal ER***: 9.5 / 11.4 HSPF<br>Gas Furnace: 90% / 95% AFUE<br>Air Source Heat Pump: 10 / 12 HSPF<br>Ground Source Heat Pump: 3.0 / 4.0 COP |
| Y | Ducts Inside**** | All ducts are located inside conditioned space |

* Measures D and V must be paired together: "Air Sealing and Ventilated Right"
** May not be used with any other Envelope measure
*** Zonal ER shall not exceed 1.0 Watts/ft$^2$ of conditioned floor area
****Exception: Up to 10' of total duct length is permitted to be outside of the home's thermal and air barrier boundary OR a ductless heating system is used

**Figure 1. Energy Saving Potentials from Proposed Measures (for Envelope and Ventilation Measures)**

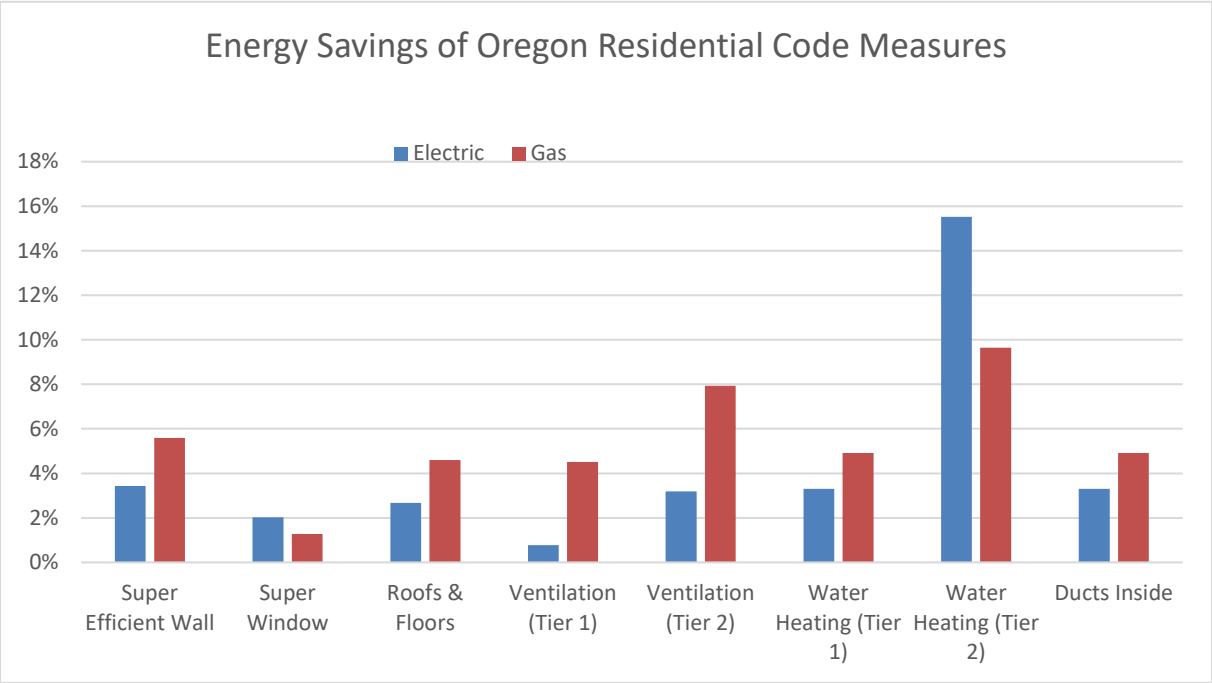
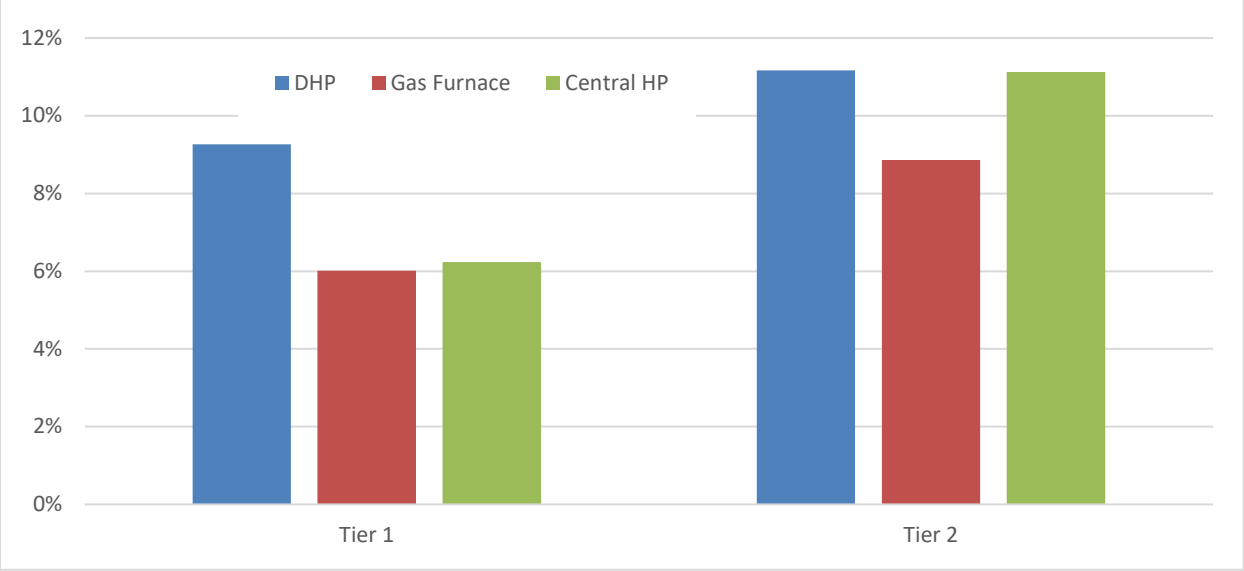



**Figure 2. Energy Saving Potentials from Proposed HVAC Measures**



## 3. Results and Saving Estimates

Once the measures were developed, the future Oregon Residential Code was modeled under the years 2020 (Select 3 Energy Measures) and 2023 (Select 4 Energy Measures). These combinations of measures are intended to demonstrate the effectiveness of the future Oregon Residential Code compared to the DOEZER specification. The annual site energy savings shown in Table 11 and Table 12 are *compared to a fully compliant 2017 ORSC home.* All weighting factors related to prototypes, climate zone, and heating fuel type (electric versus natural gas) have been included in these results.

**Table 11. Future Oregon Residential Code Savings: "Least First Cost"**

| Measure Inputs | Home Type | Total EUI (kBtu/sf) | EUI Savings (over 2017 ORSC) |
|---|---|---|---|
| **DOEZER Rev. 06** | | | |
| See **Table 9** | All Elec | 15.7 | 2.5 |
| See **Table 9** | Gas Heat | 29.1 | 2.0 |
| **2020 Code: Select 3 Energy Measures – See Appendix A** | | | |
| **Least First Cost** | | | |
| X1: DHP 9.5 OR Central HP 10 HSPF<br>W1: 2.0 UEF Water Heater<br>A: U-0.045 Wall | All Elec | 15.3 | 2.8 |
| X1: 90% AFUE Furnace<br>Y: Ducts Inside<br>A: U-0.045 Wall | Gas Heat | 29.6 | 1.5 |
| **2023 Code: Select 4 Energy Measures – See Appendix A** | | | |
| **Least First Cost** | | | |
| X1: DHP 9.5 OR Central HP 10 HSPF<br>W2: 2.9 UEF Water Heater (2 credit measure)<br>A: U-0.045 wall | All Elec | 14.7 | 3.4 |
| X1: 90% AFUE Furnace<br>W1: 0.85 UEF Water Heater<br>Y: Ducts Inside<br>A: U-0.045 Wall | Gas Heat | 28.1 | 3.0 |

As shown, DOEZER equivalence is met when three measures are selected for electric-heated homes and four measures are selected for gas-heated homes under the proposed Oregon code, implying that the proposed code format could be set to require select 4 measures in future. Since gas-heated homes represent 82.5% of Oregon homes (RLW 2007), the proposed future cycle of codes could be geared towards achieving the necessary savings for predominate heating fuel type since it represents the majority of state's energy use.

**Table 12. Future Oregon Residential Code Savings: "Max Energy Savings"**

| Measure Inputs | Home Type | Total EUI (kBtu/sf) | EUI Savings (over 2017 ORSC) |
|---|---|---|---|
| **DOEZER Rev. 06** | | | |
| See **Table 9** | All Elec | 15.7 | 2.5 |
| See **Table 9** | Gas Heat | 29.1 | 2.0 |
| **2020 Code: Select 3 Energy Measures** | | | |
| **Max Energy Savings** | | | |
| X1: DHP 9.5 HSPF OR ASHP 10<br>W1: 2.0 UEF Water Heater<br>A: U-0.045 Wall | All Elec | 15.3 | 2.8 |
| X1: 90% AFUE Furnace<br>W1: 0.85 UEF Water Heater<br>A: U-0.045 Wall | Gas Heat | 29.5 | 1.6 |
| **2023 Code: Select 4 Energy Measures** | | | |
| **Max Energy Savings** | | | |
| X1: DHP 9.5<br>W2: 2.9 UEF Water Heater (2 credit measure)<br>A: U-0.045 Wall<br>OR<br>X2: ASHP 12<br>W1: 2.0 UEF Water Heater<br>A: U-0.045 Wall | All Elec | 14.5 | 3.6 |
| X1: 90% AFUE Furnace<br>W2: 1.2 UEF Water Heater (2 credit measure)<br>A: U-0.045 Wall | Gas Heat | 27.7 | 3.4 |

## 4. Conclusions

The Oregon Residential Specialty Code Energy Efficiency Analysis establishes the baseline for 2017 Oregon Residential Specialty Code energy use and determines the difference in the energy consumption between 2017 ORSC baseline and the DOEZER Rev. 06 specification. The study also explores several combinations of measures to meet DOEZER-equivalent savings goals. These were evaluated for their relative savings over the minimum requirements of the 2017 ORSC.

Once measures were developed, "least first cost" and "max energy savings" selections of measures were chosen and modeled. The goal was to ensure that the EUI savings in 2020 or 2023 Code (i.e., "Select 4 Energy Measure" path) were roughly equal to the DOEZER Rev. 06 specification.

While this study explored a selected combination of defined measures, many other possible measures, and combinations of these measures, could be defined. Providing a small group of non-overlapping measures allows the builder more flexibility for achieving DOEZER Rev. 06 equivalence. The study provides a framework and data for future Oregon residential energy code development to meet Oregon Executive Order 17-20.

## 5. References


Baylon, D., Larson, B, Logsdon, M, Davis B. September 28, 2014. *Residential Building Stock Assessment: Metering Study*. Portland OR: Northwest Energy Efficiency Alliance. Retrieved from https://neea.org/img/documents/residential-building-stock-assessment-metering-study.pdf

Baylon, D., Storm P., Geraghty K., Davis B. September 18, 2012. *2011 Residential Building Stock Assessment: Single-Family Characteristics and Energy Use*. Portland OR: Northwest Energy Efficiency Alliance. Retrieved from https://neea.org/img/documents/residential-building-stock-assessment-single-family-characteristics-and-energy-use.pdf

U.S. Department of Energy., April 2017. DOE Zero Energy Ready Home Program Requirements (Rev. 06). Retrieved from https://www.energy.gov/sites/prod/files/2017/04/f34/DOE%20Zero%20Energy%20Ready%20Home%20National%20Program%20Requirements%20Rev06%20-%20Final_0.pdf

Storm, P., Hannas B., Baylon D. October 17, 2016. *2017 Oregon Residential Specialty Code Energy Efficiency: Impact Assessment.* Portland OR: Northwest Energy Efficiency Alliance. Retrieved from https://neea.org/img/documents/WSEC_ResCodeImpact_2012-2015_Memo_2019-04-03.pdf

Larson, B. et al. March 2, 2015. *Heat Pump Water Heater Model Validation Study*. (Report No. E15-306) Portland, OR: Northwest Energy Efficiency Alliance. Retrieved from https://neea.org/img/uploads/heat-pump-water-heater-saving-validation-study.pdf

RLW Analytics. March 27, 2007a. *Single-Family Residential New Construction Characteristics and Practices Study*. Portland, OR: Northwest Energy Efficiency Alliance. Retrieved from https://neea.org/img/uploads/RESIDENTIANEWCONSTRUCTION5CC78C1BD226.pdf

SEEM: https://rtf.nwcouncil.org/simplified-energy-enthalpy-model-seem

Sherman, M., Walker, I. May 2002. *Residential HVAC and Distribution Research Implementation.* Berkeley, CA: California Institute for Energy Efficiency.

## Appendix A: Future Oregon Residential Code Framework and Measures

### Oregon Energy Code Concept

This table shows a progression from 2017 to 2023 in two roughly equivalent performance steps

| 2017 (Existing) | 2020 | 2023 (DOEZER equivalent) |
|---|---|---|
| Select 2 from 2017 measure list | Select 3 Energy Measures* | Select 4 Energy Measures* |

Measures should be roughly equal in energy savings for typical home
Measures should not be mutually exclusive so that more than one can be chosen
* At least one measure shall be a shell measure (A-F) and one shall be an HVAC measure (V-Z)

**Reasons for choosing a progressive number of measures:**

| | |
|---|---|
| 1 | Measures do not need to change with each code cycle. Builders and officials get familiar with the measures, and know what they will need to do in the future. |
| 2 | Envelope measures are simple and limited making compliance checking easy<br>If a builder wants to do something else, they can use a UA trade-off calculation provided by a HERS rater or Utility Program that uses HERS program |

**Measure Names**

Shell Measures

| | |
|---|---|
| A | Super Efficient Wall |
| B | Super Window |
| C | Roof & Floors |
| D | Air Sealing* |
| E | Glazing Limit |
| F | UA Rated** |

HVAC Measures

| | |
|---|---|
| V | Heat Recovery Ventilation* |
| W | Water Heating |
| X | HVAC System |
| Y | Ducts Inside**** |
| S | Solar |
| | |

**Examples**

| Path | What's it mean? | # of Measures | Code Compliance |
|---|---|---|---|
| AW2 | House has a super efficient wall and a 2nd tier efficiency water heater | 3 | 2020 |
| BVS | House has super windows, heat recovery ventilator, and solar panels | 3 | 2020 |
| CX2 | House has extra insulation in walls, roof and floors plus a 2nd tier efficiency measure space heating and cooling system | 3 | 2020 |
| DYX2 | House was tested with blower door to have an air leakage <2.0 and has balanced ventilation system with an HRV and a 2nd Tier efficiency space heating and cooling system | 4 | 2023 |
| ABCY | House has super efficient wall, upgraded floor and roof insulation, super windows and a 1st tier efficiency water heater | 4 | 2023 |

| Envelope Measures | | | | | |
|---|---|---|---|---|---|
| A | Super Efficient Wall | Wall U ≤ 0.045 Btuh/hr-F (2x6 int wood w/ R-21batts + R-4ci) | | | |
| B | Super Window | Window U ≤ 0.24 Btuh/hr-F<br>Skylight U ≤ 0.43 Btuh/hr-F | | | |
| C | Roof & Floors | Flat Roof U ≤ 0.017 Btuh/hr-F (R-60 w/ partial raised heel)<br>Vaulted Ceiling U ≤ .017 Btuh/hr-F (10" Structural Insulated Panel (SIP))<br>Floor over Crawlspace U ≤ 0.025 Btuh/hr-F (R-38 batts in floor joists)<br>Slab on Grade R-10 continous rigid | | | |
| D | Air Sealing* | ACH50 ≤ 2.0<br>* Must be paired with HVAC measure for controlled ventilation | | | |
| E | Glazing Limit | Glazing area (frame opening) is less than 12% of floor area | | | |
| F | UA Rated** | Third Party Rater Verifies UA Value | | | |
| | | 1 | 6% lower heat loss than code baseline | | |
| | | 2 | 12% lower heat loss than code baseline | | |
| | | 3 | 18% lower heat loss than code baseline | | |

| HVAC Measures | | | | | |
|---|---|---|---|---|---|
| V | Heat Recovery Ventilation* | Balanced Ventilation | | | |
| | | | Tier 1 | Tier 2 | |
| | | Sensible Recovery Efficiency | 60% | 80% | |
| | | Fan Power | 1.2 | 1.5 | W/cfm |
| W | Water Heating | Minimum Efficiency values | | | |
| | | | Tier 1 | Tier 2 | |
| | | Electric Water Heater | 2.0 | 2.9 | UEF |
| | | Gas Water Heater | 0.85 | 1.2 | UEF |
| X | HVAC System | Minimum Efficiency values | | | |
| | | | Tier 1 | Tier 2 | |
| | | DHP w/Zonal ER*** | 9.5 | 11.4 | HSPF |
| | | Gas Furnace | 0.9 | 0.95 | AFUE |
| | | Air Source Heat Pump | 10 | 12 | HSPF |
| | | Ground Source Heat Pump | 3.0 | 4.0 | COP |
| Y | Ducts Inside**** | All ducts are located inside conditioned space | | | |

* Measures D and V must be paired together "Air Tight and Ventilated Right"
** may not be used with any other Envelope measure
*** zonal ER shall not exceed 1.0 Watts/ft2 of conditioned floor area
**** Exception: Up to 10' of total duct length is permitted to be outside of the home's thermal and air barrier boundary OR a ductless heating system is used

## Appendix B: Heating and Cooling Climate Zones (NWPCC)

### Figure 3. NWPCC Heating Climate Zone Map of Oregon

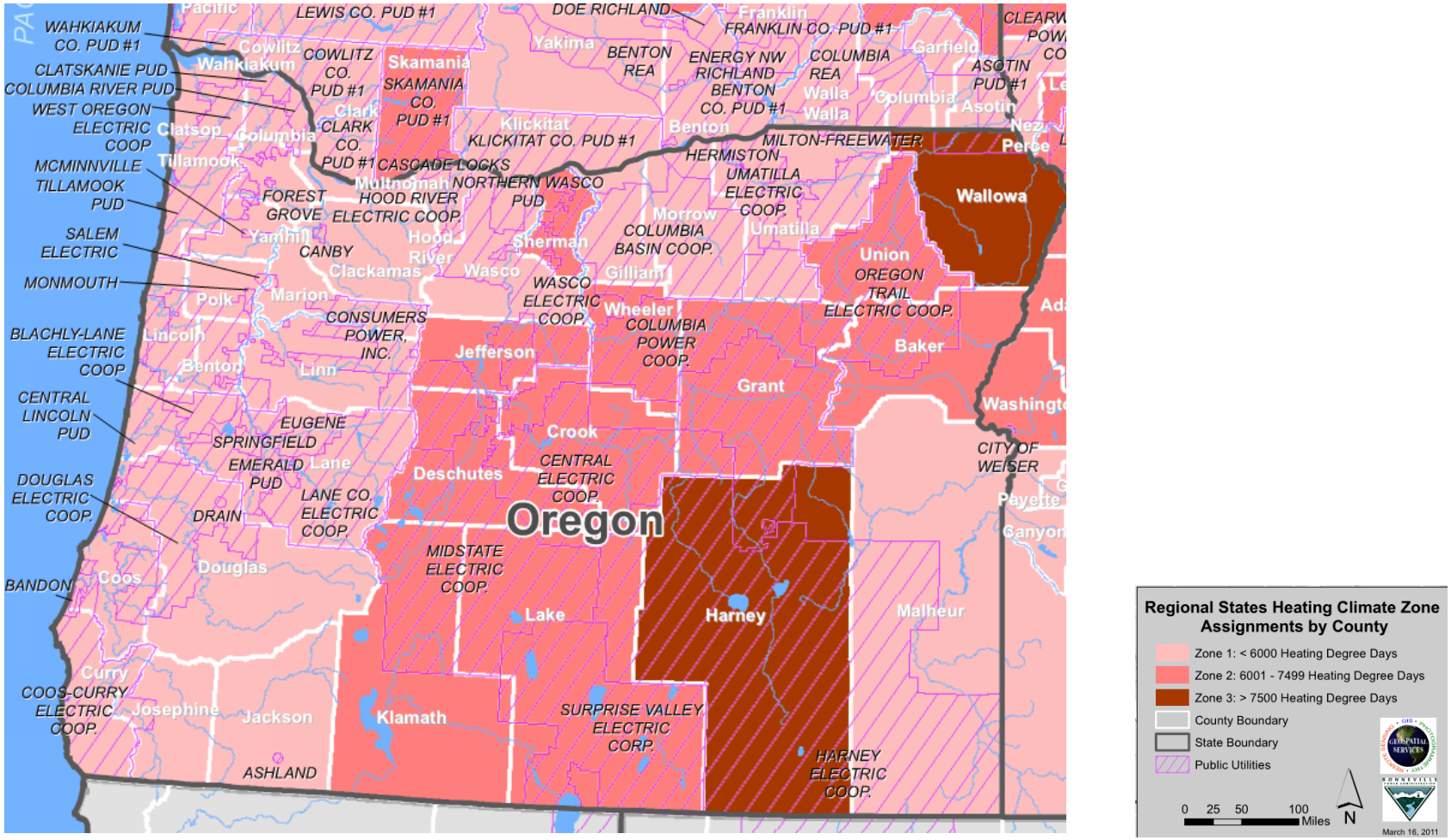
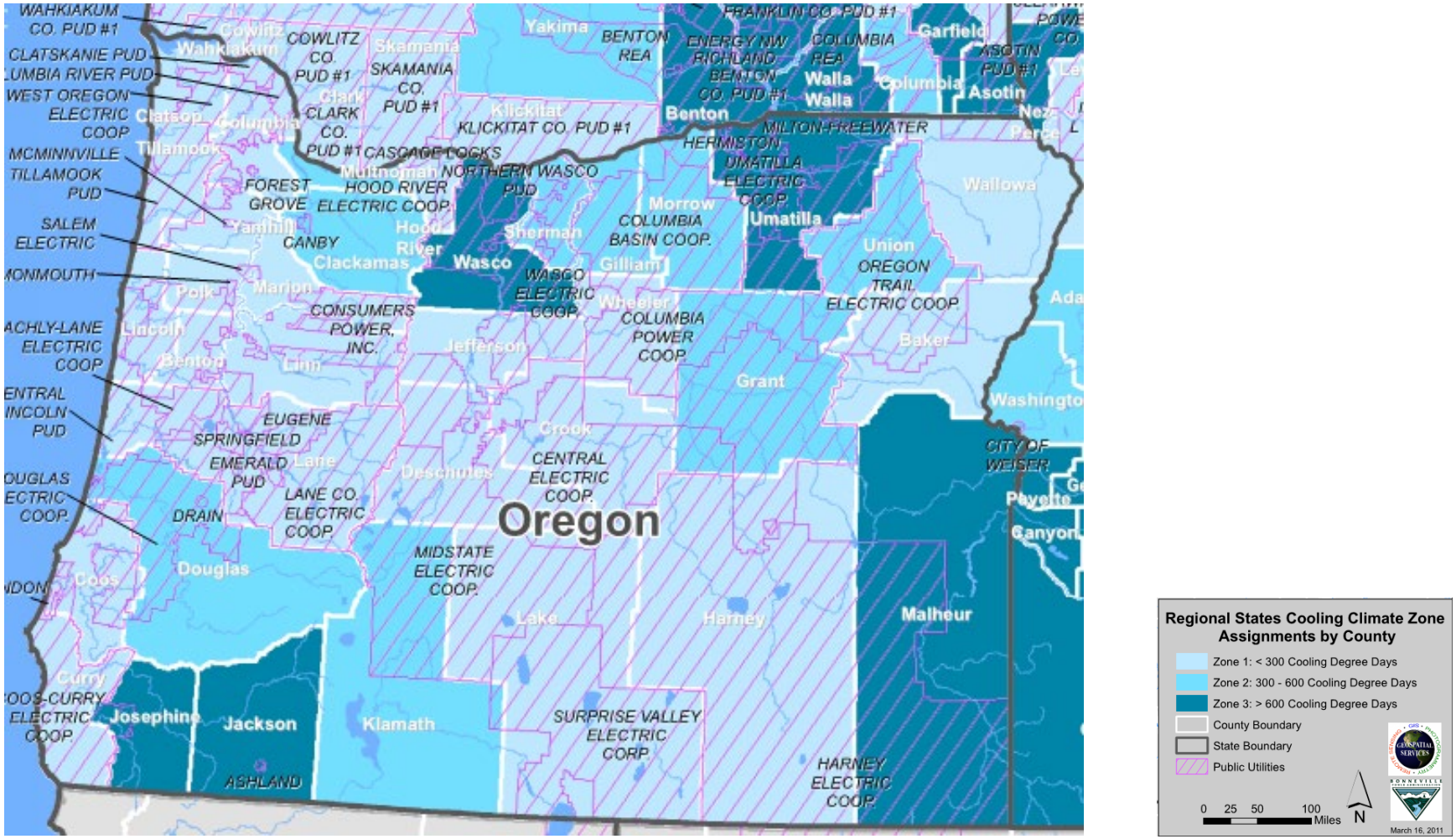


**Figure 4. NWPCC Cooling Climate Zone Map of Oregon**



## Appendix C: Measure-by-measure – Modeled Savings Results

### Table 13. Measure-by-Measure Savings of the Proposed Oregon Residential Code

| Measure | Heating System | Weighted Heating, kWh | Heating % Saving | Weighted Cooling, kWh | Cooling % Saving | Water Heating, kWh | Water Heating % Saving | Total Electric, kWh | Total Electric % Saving | | Total Therm* | Total Therm % Saving |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A: Super-Efficient Wall** | Electric | 3588 | 10.1% | 576 | -0.1% | 2927 | | 12249 | 3.4% | | | |
| | Gas | 379 (therm) | 9.9% | 484 | -0.1% | 153 (therm) | | 5644 | 0.6% | | 532 | 7.3% |
| **B: Super Window** | Electric | 3900 | 2.3% | 417 | 27.6% | 2927 | | 12427 | 2.0% | | | |
| | Gas | 416 (therm) | 1.2% | 350 | 27.7% | 153 (therm) | | 5540 | 2.4% | | 569 | 0.9% |
| **C: Roofs & Floors** | Electric | 3665 | 8.2% | 590 | -2.5% | 2927 | | 12346 | 2.7% | | | |
| | Gas | 386 (therm) | 8.3% | 496 | -2.5% | 153 (therm) | | 5661 | 0.3% | | 539 | 6.1% |
| **D+V: Ventilation Ventilation** | 1: Electric | 3532 | 11.5% | 573 | 0.4% | 2927 | | 12586 | 0.8% | | | |
| | 1: Gas | 374 (therm) | 11.1% | 479 | 0.9% | 153 (therm) | | 6031 | -6.2% | | 527 | 8.1% |
| | 2: Electric | 3326 | 16.7% | 586 | -1.7% | 2927 | | 12280 | 3.2% | | | |
| | 2: Gas | 351 (therm) | 16.5% | 489 | -1.2% | 153 (therm) | | 5927 | -4.4% | | 504 | 12.1% |
| **Y: Ducts Inside** | Electric | 3655 | 8.5% | 533 | 7.4% | 2927 | | 12266 | 3.3% | | | |
| | Gas | 385 (therm) | 8.5% | 452 | 6.6% | 153 (therm) | | 5616 | 1.1% | | 538 | 6.2% |
| **W: Water Heating** | 1: Elec (E) | 3993 | | 576 | | 1390 | 52.5% | 11147 | 12.1% | | | |
| | 1: Gas (G) | 421 (therm) | | 484 | | 119 (therm) | 22.2% | 5678 | | | 540 | 5.9% |
| | 2: Elec (E) | 3993 | | 576 | | 959 | 67.2% | 10716 | 15.5% | | | |
| | 2: Gas (G) | 421 (therm) | | 484 | | 79 (therm) | 48.4% | 5678 | | | 500 | 12.9% |
| **X: Space Heating & Cooling** | XASHP1 | 3334 | 8.8% | 476 | 30.8% | 2927 | | 11830 | 6.2% | | | |
| | XASHP2 | 2860 | 21.8% | 317 | 53.9% | 2927 | | 11213 | 11.1% | | | |
| | XDHP1 | 3477 | 26.1% | 380 | -12.5% | 2927 | | 11639 | 9.3% | | | |
| | XDHP2 | 3220 | 31.6% | 380 | -12.5% | 2927 | | 11395 | 11.2% | | | |
| | XFUR90 | 374 (therm) | 11.1% | | | 153 (therm) | | 5969 | 6.2% | | 527 | 8.1% |
| | XFUR95 | 354 (therm) | 15.8% | | | 153 (therm) | | 19770 | 9.0% | | 507 | 11.6% |

*Total Energy (kWh equiv) includes natural gas (Therm) energy use

**Table 14. Detailed Energy Use for Packages of Measures Under the Proposed Oregon Residential Code**

| Code | # of Selected Measures | Heating System | Weighted Heating | Weighted Cooling (kWh) | Water Heating | Lights, Vent, Plugs, Appl (kWh) | Total Electric (kWh) | Total Electric % Saving | Total Therms | Total Therm % Saving |
|---|---|---|---|---|---|---|---|---|---|---|
| **Least First Cost Packages** | | | | | | | | | | |
| **XDHP1-W1E-A** | 3 | Elec (DHP) | 3133 kWh | 380 | 1390 kWh | 4854 | 9757 | 16.2% | --- | --- |
| **XDHP1-W2E-A** | 4 | Elec (DHP) | 3133 kWh | 380 | 959 kWh | 4854 | 9326 | 19.9% | --- | --- |
| **XFUR90-A-Y** | 3 | Gas | 308 therm | 453 | 153 therm | 5132 | 5585 | 1.6% | 461 | 6.3% |
| **XFUR90-W1G-A-Y** | 4 | Gas | 308 therm | 453 | 119 therm | 5132 | 5585 | 1.6% | 427 | 13.2% |
| **XASHP1-W1E-A** | 3 | Elec Central HP | 3018kWh | 477 | 1390 kWh | 5071 | 9956 | 14.9% | --- | --- |
| **XASHP1-W2E-A** | 4 | Elec Central HP | 3018 kWh | 477 | 959 kWh | 5071 | 9525 | 18.6% | --- | --- |
| **Maximum Energy Savings Packages** | | | | | | | | | | |
| **XDHP1-W1E-A** | 3 | Elec (DHP) | 3133 kWh | 380 | 1390 kWh | 4854 | 9757 | 16.2% | --- | --- |
| **XDHP1-W2E-A** | 4 | Elec (DHP) | 3133 kWh | 380 | 959 kWh | 4854 | 9326 | 19.9% | --- | --- |
| **XFUR90-W1G-A** | 3 | Gas | 337 therm | 484 | 119 therm | 5160 | 5644 | 0.6% | 456 | 7.4% |
| **XFUR90-W2G-A** | 4 | Gas | 337 therm | 484 | 79 therm | 5160 | 5644 | 0.6% | 416 | 15.5% |
| **XASHP1-W1E-A** | 3 | Elec Central HP | 3018 kWh | 477 | 1390 kWh | 5071 | 9956 | 14.9% | --- | |
| **XASHP2-W1E-A** | 4 | Elec Central HP | 2608 kWh | 319 | 1390 kWh | 5084 | 9401 | 19.7% | --- | |

## Appendix D: Alternate Analysis of DOEZER Rev6 (Including all exceeding ORSC Requirements)

### Table 15 Comparison of 2017 ORSC Baseline and DOEZER Rev. 06 Modeling Inputs (Including all exceeding and overlapping ORSC Requirements)

| Component | 2017 ORSC Baseline (with two measures from Table N1101.1(2)) | DOEZER Rev. 06 *(with all overlapping ORSC code requirements)* |
|---|---|---|
| **Envelope** | | |
| **Above Grade Wall** | 2x6 int. w/ R-21 batts | ***2x6 int. w/ R-21 batts*** |
| **Glazing** | U-0.30, SHGC-0.40 | U-0.27, SHGC-0.30 |
| **Roof** | R-49 | R-49 |
| **Floor Over Unheated** | R-30 | R-30 |
| **Slab-on-Grade** | R-15 for 2 ft | ***R-15 for 2 ft*** |
| **Doors** | U-0.20 | ***U-0.20*** |
| **Air-tightness** | 5 ACH50 | 2.5 ACH50 (Zone 4C)<br>2.0 ACH50 (Zone 5B) |
| **Heating and Cooling (System Type)** | | |
| **Gas Furnace (Heat Only)** | Heat: 94% AFUE | Heat: 94% AFUE |
| **Gas Furnace w/ AC (Heat+Cool)** | Heat: 94% AFUE<br>Cool: 13 SEER | Heat: 94% AFUE<br>Cool: 13 SEER |
| **DHP w/ Electric Baseboards (Heat+Cool)** | Heat: 10 HSPF<br>Cool: 15 SEER | Heat: 10 HSPF<br>***Cool: 15 SEER*** |
| **Central Heat Pump (Heat+Cool)** | Heat: 9.5 HSPF<br>Cool: 15 SEER | Heat: 10 HSPF<br>Cool: 15 SEER |
| **Ventilation, Ducts & Controls** | | |
| **Ventilation‡** | Exhaust fan, 2.8 cfm/W, 75 cfm<br>Schedule: Cycle 8 hr/day | ERV, 60%SRE, 1.2 cfm/W, 65 cfm<br>Schedule: 24 hr/day |
| **Duct Location** | Ducts located outside conditioned space, R-8 insulation, 6% system airflow leakage to exterior | Ducts and equipment in located within conditioned space, 1% system airflow leakage to exterior |
| **Thermostat** | 7-Day Programmable | 7-Day Programmable |
| **Domestic Hot Water (Fuel Source)** | | |
| **Gas** | 0.62 EF | 0.67 EF |
| **Electric** | 0.95 EF | 2.0 EF |
| **Water Consumption** | Gallons/day = 23 +11*(#occupants-1) | Gallons/day = 23 +11*(#occupants-1) |
| **Lighting, Appliances & Plugs** | | |
| **Lighting Efficacy and Runtime** | 95% high efficacy 1.8 hr/day | ***95% high efficacy*** 1.8 hr/day |
| **Appliances** | Federal Minimum | EnergyStar |
| **Plugs** | Unregulated Load, 1,600kWh/yr | Unregulated Load, 1,600kWh/yr |

**Table 16 Comparison of 2017 ORSC Baseline and DOEZER Rev. 06 Annual Energy Consumption (Including all exceeding and overlapping ORSC Requirements)**

| Measure Inputs | Home Type | Total Site EUI (kBTU/sf) | EUI Savings |
|---|---|---|---|
| **2017 ORSC Baseline (Option 5A)** | | | |
| See Table **15** | All Elec | 18.1 | --- |
| See Table **15** | Gas Heat | 31.1 | --- |
| **DOEZER Rev. 06** | | | |
| See Table **15** | All Elec | 15.0 | 3.1 |
| See Table **15** | Gas Heat | 28.3 | 2.8 |

## Observations and Conclusions

The analysis above lists the site energy savings target to meet DOEZER equivalency (including all exceeding and overlapping ORSC requirements). These include updating the insulation for above grade walls from R-20 to R-21; upgrading u value for the doors from 0.30 to 0.20; cooling efficiency for the Heat Pump from SEER 13 to SEER 15; and updating the requirement of high efficacy lamps from 80% to 95%. The future Oregon Residential Specialty Code will need to deliver roughly 2.8 to 3.1 kBtu/sf annual site EUI savings to be DOEZER equivalent. The analysis shows that both electric homes and the gas heated homes will need to select 4 energy measures to meet the DOEZER equivalency. Depending on how DOEZER specifications are interpreted, the number of measures selected can vary depending on the home fuel source to meet the DOEZER equivalency.