

# Performance Comparison among 2005, 2017, 2021, and 2023 Oregon Residential Specialty Codes and Department of Energy Zero Energy Ready Home National Program Requirements

Technical Report

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*Prepared for:*

Building Codes Division  
Oregon Department of Consumer and Business Services

*Prepared by:*

Energy Studies in Buildings Laboratory, University of Oregon

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# 1 Introduction

This work was supported by and completed at the request of the Oregon Department of Consumer and Business Services (DCBS) Building Codes Division. The main purpose of this study is to identify differences between the technical requirements between (1) the Department of Energy (DOE) Zero Energy Ready Homes (ZERH) Rev.06 National Program Requirements and the 2017 Oregon Residential Specialty Code (ORSC-2017), (2) the performance difference between the 2021 Oregon Residential Specialty Code (ORSC-2021) and ORSC-2017, (3) the performance difference between the 2023 Oregon Residential Specialty Code (ORSC-2023) and ORSC-2021, and (4) the performance difference between the 2005 Oregon Residential Specialty Code (ORSC-2005) and ORSC-2023 [1][2][3][4][5]. Two additional comparisons are included between ORSC-2021 and DOE ZERH and between ORSC-2023 and DOE ZERH since the performance values are readily available from the main goals of this project. This work is based on the ORSC-2017 models developed for a previous comparison of ORSC-2017 to the 2015 International Energy Conservation Code (IECC) [6], along with the most recent residential prototype models released by the Pacific Northwest National Laboratory (PNNL) via the U.S. Department of Energy (DOE).

# 2 Methodology

This work makes comparisons of identified relevant provision differences that are reflected in each code iteration and their respective energy models. This includes the four main comparisons mentioned in the introduction and listed here for posterity:

1. ORSC-2017 compared to DOE ZERH
2. ORSC-2021 compared to ORSC-2017
3. ORSC-2023 compared to ORSC-2021
4. ORSC-2023 compared to ORSC-2005

These comparisons are available in the set of spreadsheets available as part of Appendices A through D. The DOE residential prototype building models, as developed by PNNL as the basis for federal rulemaking, were modified to incorporate the requirements outlined by the DOE ZERH and each ORSC iteration. These models represent single-family residential baselines with HVAC system and foundation types most prevalent in the state of Oregon:

- Heat Pump system with slab-on-grade foundation

- Heat Pump system with crawlspace foundation
- Gas-fired furnace with slab-on-grade foundation
- Gas-fired furnace with crawlspace foundation

EnergyPlus v8.9 (March 23, 2018 NREL release) was used to match the original ORSC-2017 models. EnergyPlus v9.5 was used with the most recent set of DOE prototype building models to make use of the upgraded airflow network model for duct sealing calculations for ORSC-2023 and overall performance of ORSC-2005 except for service hot water to maintain simulation equivalence with ORSC-2023. Simulations are based on TMY3 weather data, with Portland, OR representing ASHRAE Climate Zone 4C and Redmond, OR representing ASHRAE Climate Zone 5B. Simulation results were processed to calculate Energy Use Intensity (EUI) (kBTU/ft<sup>2</sup>-yr) over the conditioned floor area and reported by climate zone, system type, and foundation type.

## 3 Provisions summary

### 3.1 ORSC-2017 compared to DOE ZERH

#### 3.1.1 *Envelope, ventilation, and air leakage*

The DOE ZERH envelope performance requirements follow those specified by IECC 2012 and IECC 2015, while fenestrations are expected to meet or exceed ENERGYSTAR requirements. As such, ORSC-2017 requires a slightly higher insulated envelope overall with R-21 above grade wall insulation compared to R-20 standard framing as specified by DOE ZERH. The exception is the window specification, where ORSC-2017 requires a U-factor of 0.30 and Solar Heat Gain Coefficient (SHGC) of 0.40 while DOE ZERH requires U-0.27 and SHGC of 0.30.

ORSC-2017 specifies a 5.0 ACH<sub>50</sub> air leakage rate with exhaust-only whole-house mechanical ventilation for climate zones 4C and 5B. DOE ZERH requires air leakage rates of 2.5 ACH<sub>50</sub> for climate zone 4C and 3.0 ACH<sub>50</sub> for climate zone 5B, along with balanced whole-house mechanical ventilation that includes heat exchange in both climate zones. ORSC-2017 specifies a higher fan airflow efficiency of 2.8W/cfm and 75cfm 24-hours/day for the whole-house mechanical ventilation system compared to 1.2W/cfm and 62cfm 24-hours/day required by DOE ZERH.

#### 3.1.2 *HVAC and service hot water*

For electric heat pump homes, DOE ZERH specifies a Seasonal Energy Efficiency Ratio (SEER) of 13 compared to 15 specified by ORSC-2017 Additional Measure A (ORSC-2017 Table N1101.1(2))[2]. DOE ZERH specifies a Heating Seasonal Performance Factor (HSPF) of 10 compared to 9.5 specified

by ORSC-2017 Additional Measure A. This yields a higher cooling coefficient of performance (COP) and lower heating COP for the ORSC-2017 electric heat pump baselines compared to the DOE ZERH models. The requirements for the gas-fired furnace homes are the same between ORSC-2017 Additional Measure A and DOE ZERH with an Annual Fuel Utilization Efficiency (AFUE) of 94% and 13 SEER for cooling. DOE ZERH requires 458 average annual auxiliary electrical energy consumption ( $E_{AE}$ ) for the furnace fan motor, while ORSC-2017 requires 438  $E_{AE}$ .

DOE ZERH requires an Energy Factor (EF) of 0.67 for gas-fired water heaters and an EF of 2.0 for electric water heaters, while ORSC-2017 requires an EF 0.62 and EF 0.95, respectively. This assumes a 40- to 50-gallon tank capacity.

### 3.1.3 *Lighting and equipment*

DOE ZERH interior and exterior lighting requirements specify that 80% of installed bulbs need to be LEDs and 20% can be fluorescent and/or compact fluorescent. ORSC-2017 interior lighting requirements specify that 96% of installed bulbs need to be LEDs and 4% can be fluorescent and/or compact fluorescent, while the exterior lighting requirements are 50% LEDs and 50% fluorescent and/or compact fluorescent. Equipment loads were kept constant across all models.

## 3.2 **ORSC-2021 compared to ORSC-2017**

### 3.2.1 *Envelope, ventilation, and air leakage*

The ORSC-2021 envelope performance requirements are identical to ORSC-2017, except for the window specifications where ORSC-2021 requires U-0.27 and SHGC 0.30, effectively making it equal with DOE ZERH, while ORSC-2017 requires U-0.30 and SHGC 0.40. ORSC-2021 Measure 1 and Measure 7 specify window areas of 71.2 ft<sup>2</sup> and 89.1 ft<sup>2</sup> per exterior wall, respectively. Additionally, ORSC-2021 exterior wall performance requires R-21 intermediate-framing walls, while ORSC-2017 requires R-21 standard-framing walls.

ORSC-2021 requires a 4.0 ACH<sub>50</sub> air leakage rate with balanced whole-house mechanical ventilation for climate zones 4C and 5B, while ORSC-2017 requires 5.0 ACH<sub>50</sub> for climate zones 4C and 5B. ORSC-2021 specifies a lower fan airflow efficiency of 1.6W/cfm and 62cfm 24-hours/day, while ORSC-2017 specifies 2.8W/cfm and 75cfm 24-hours/day. The ORSC-2021 fan airflow efficiency is slightly higher than the 1.2W/cfm specified by DOE ZERH.

### 3.2.2 HVAC and service hot water

The ORSC-2021 HVAC performance is based on ORSC-2021 Measure 1 and Measure 7. For gas-fired furnace homes Measure 1 requires AFUE 94% and Measure 7 requires AFUE 80%, while both specify 13 SEER for cooling. As per section 3.1.2, ORSC-2017 Additional Measure A specifies AFUE 94% and 13 SEER. For electric heat pump homes Measure 1 requires HSPF 10 and Measure 7 specifies HSPF 8.2, while both specify 14 SEER for cooling. As per section 3.1.2, ORSC-2017 specifies HSPF 9.5 and 15 SEER. Both standards require an  $E_{AE}$  of 227 for the furnace fan motor efficiency.

Water heater specifications are the same between ORSC-2021 and ORSC-2017 with EF 0.62 for gas and EF 0.95 for electric. This assumes a 40- to 50-gallon tank capacity.

### 3.2.3 Lighting and equipment

ORSC-2021 interior and exterior lighting requirements specify that 98% of installed bulbs need to be LEDs and 2% can be fluorescent and/or compact fluorescent, while ORSC-2017 requires a slightly lower ratio of 98% LEDs and 4% fluorescent and/or compact fluorescent for both interior and exterior lighting. Equipment loads were kept constant across all models.

## 3.3 ORSC-2023 compared to ORSC-2021

### 3.3.1 Envelope, ventilation, and air leakage

ORSC-2023 window area is increased to 89.1ft<sup>2</sup> per exterior wall with the discontinuation of the Additional Measure #7 from ORSC-2021. ORSC-2023 requires that new duct systems and air handling equipment and appliances be located fully within the thermal envelope. For the baseline models this requires an air duct leakage value of 0CFM @ 25Pa (leakage to outside and total), reduced from 95CFM leakage to outside and 107CFM total required by ORSC-2021. The ORSC-2023 air sealing requirement is also reduced to 3.5ACH @50Pa from 4.0ACH @50Pa. Ventilation requirements remain unchanged from ORSC-2021 to ORSC-2023.

### 3.3.2 HVAC and service hot water

In homes with gas-fired furnaces ORSC-2023 requires AFUE 94% for heating systems under Additional Measure #1, compared to AFUE 80% specified by ORSC-2021, while both specify 13 SEER for cooling systems. For homes with heat pump systems ORSC-2023 requires HSPF 10.0 for split heat pumps and 15 SEER for split cooling, while ORSC-2021 requires HSPF 8.2 and 14 SEER, respectively. Smart thermostat requirements were also added to ORSC-2023, while ORSC-2021 requires a programmable thermostat. ORSC-2023 requires air ducts to be located inside the

thermal envelope, while ORSC-2021 requires buried ductwork. Ventilation and furnace fan efficiency requirements remain unchanged from ORSC-2021 to ORSC-2023.

ORSC-2023 hot water system requirements improved slightly for gas water heaters to an EF of 0.64, from 0.62 in ORSC-2021, and decreased slightly for electric water heaters from an EF of 0.95 in ORSC-2021 to 0.93 in ORSC-2023.

### 3.3.3 *Lighting and equipment*

Lighting and equipment load requirements remain unchanged from ORSC-2021 to ORSC-2023.

## 3.4 **ORSC-2023 compared to ORSC-2005**

### 3.4.1 *Envelope, ventilation, and air leakage*

ORSC-2023 requires an underfloor insulation of R-30 compared to R-25 required by ORSC-2005. Window performance is also improved to U-0.27 and SHGC 0.30 in ORSC-2023, compared to U-0.40 and SHGC 0.40 required by ORSC-2005. And ceiling/roof insulation requirement is R-49 for ORSC-2023, compared to R-38 specified by ORSC-2005.

Air leakage requirements are improved significantly in ORSC-2023, which requires all duct systems and air handling equipment to be located within the thermal envelope, which results in air duct leakage of 0CFM @25Pa (total and leakage to outside). On the other hand, ORSC-2005 allows a total and leakage to outside of 285CFM @25Pa. ORSC-2023 air sealing allows 3.5ACH @50Pa while ORSC-2005 allows 8.0ACH @50Pa. ORSC-2023 also requires a balanced whole house ventilation system while ORSC-2005 requires exhaust only (intermittent bathroom fan).

### 3.4.2 *HVAC and service hot water*

In homes with gas-fired furnaces ORSC-2023 requires AFUE 94% for heating systems, compared to AFUE 78% specified by ORSC-2005, while both specify 13 SEER for cooling systems. For homes with heat pump systems ORSC-2023 requires HSPF 10.0 for split heat pumps and 15 SEER for split cooling, while ORSC-2005 requires HSPF 7.7 and 13 SEER, respectively. Smart thermostat is also required by ORSC-2023, while ORSC-2005 only requires a manual thermostat. ORSC-2023 ventilation fan energy requirement is 38.8W compared to 100W in ORSC-2005. ORSC-2023 requires 227 E<sub>AE</sub> for the furnace fan motor efficiency, while ORSC-2005 requires 766 and 868 E<sub>AE</sub> for climate zones 4C and 5B, respectively.

ORSC-2023 hot water system requirements for gas water heaters specify an EF of 0.64, while ORSC-2005 requires an EF of 0.57. And for electric water heaters ORSC-2023 requires an EF of 0.93 while ORSC-2005 requires an EF of 0.90.

### 3.4.3 Lighting and equipment

ORSC-2023 requires that 98% of installed interior and exterior bulbs be LEDs and 2% CFL, while ORSC-2005 allows 100% incandescent bulbs for interior and exterior.

## 4 Results summary

Annual Energy Use Intensity (EUI) performance, calculated using conditioned floor area, is shown for each model configuration and climate zone in Tables 1 through 6. ORSC-2017 is compared to DOE ZERH in Tables 1, 2, and 3. ORSC-2021 is compared to ORSC-2017 in Tables 4, 5, and 6. ORSC-2021 is compared to DOE ZERH in Tables 7, 8, and 9. ORSC-2023 is compared to ORSC-2021 in Tables 10, 11, and 12. ORSC-2023 is compared to ORSC-2005 in Tables 13, 14, and 15. And lastly ORSC-2023 is compared to DOE ZERH in Tables 16, 17, and 18. Tables 1, 4, and 7, 10, 13, and 16 include weighted averages for each combination of heating system type and foundation type in climate zone 4C, Tables 2, 5, 8, 11, 14, and 17 include the same in climate zone 5B, and Tables 3, 6, 9, 12, 15, and 18 include weighted averages of both climate zones combined. The ORSC weighting factors are based on the *Preliminary Energy Savings Analysis: 2018 IECC Residential Requirements* analysis by the Northwest Energy Efficiency Alliance (NEEA)[7]. The heating system weight factors are 86.4% for gas-fired furnace and 13.6% for electric heat pump. The foundation type weights are 74.5% for crawlspace and 25.5% for slab-on-grade. And the climate zone weights are 59.2% for climate zone 4C and 40.8% for climate zone 5B.

### 4.1 ORSC-2017 compared to DOE ZERH

The ORSC-2017 overall weighted EUI in climate zone 4C is 31.89 kBTU/ft<sup>2</sup>-yr with a +4.66 EUI or +17.1% difference compared to the DOE ZERH baselines as shown in Table 1. Under climate zone 5B the ORSC-2017 overall weighted EUI is 37.86 kBTU/ft<sup>2</sup>-yr with a +7.06 EUI or +22.9% difference compared to the DOE ZERH baselines as shown in Table 2. Combining across climate zones the ORSC-2017 overall weighted EUI is 34.32 kBTU/ft<sup>2</sup>-yr, constituting a difference of +5.64 EUI or +19.6% in comparison to the DOE ZERH baselines as shown in Table 3.

We feel it is fair to conclude that ORSC-2017 provisions fall significantly short of DOE ZERH, particularly considering the DOE ZERH glazing specifications, envelope tightness, mechanical

ventilation specifications, and more efficiency service hot water equipment. However, ORSC-2017 does still require higher cooling performance and interior lighting efficiency.

#### 4.2 ORSC-2021 compared to ORSC-2017

The ORSC-2021 overall weighted EUI in climate zone 4C is 30.02 kBTU/ft<sup>2</sup>-yr with a -1.86 EUI or -5.8% difference compared to the ORSC-2017 baselines as shown in Table 4. Under climate zone 5B the ORSC-2021 overall weighted EUI is 35.47 kBTU/ft<sup>2</sup>-yr with a -2.38 EUI or -6.3% difference compared to the ORSC-2017 baselines as shown in Table 5. Combining across climate zones the ORSC-2021 overall weighted EUI is 32.25 kBTU/ft<sup>2</sup>-yr, constituting a difference of -2.07 EUI or -6.0% in comparison to the ORSC-2017 baselines as shown in Table 6.

We feel it is fair to conclude that ORSC-2021 provisions show marked improvement over ORSC-2017 in all categories, while also considering the slight nuances of ORSC-2021 Measure 1 and Measure 7, as described in section 3.1.2 and 3.2.2.

#### 4.3 ORSC-2021 compared to DOE ZERH

The ORSC-2021 overall weighted EUI in climate zone 4C is 30.02 kBTU/ft<sup>2</sup>-yr with a +2.79 EUI or +10.3% difference compared to the DOE ZERH baselines as shown in Table 7. Under climate zone 5B the ORSC-2021 overall weighted EUI is 35.47 kBTU/ft<sup>2</sup>-yr with a +4.67 EUI or +15.2% difference compared to the DOE ZERH baselines as shown in Table 8. Combining across climate zones the ORSC-2021 overall weighted EUI is 32.25 kBTU/ft<sup>2</sup>-yr, constituting a difference of +3.56 EUI or +12.4% in comparison to the DOE ZERH baselines as shown in Table 9.

We feel it is fair to conclude that ORSC-2021 is underperforming compared to DOE ZERH overall, particularly with heating performance and service hot water equipment efficiency for both gas-fired and electric heat pump models. Likewise, while ORSC-2021 specifies balanced whole-house mechanical ventilation, heat recovery is not included. However, ORSC-2021 does show better performance with cooling, interior and exterior lighting, and furnace fan efficiency in comparison to DOE ZERH.

#### 4.4 ORSC-2023 compared to ORSC-2021

The ORSC-2023 overall weighted EUI in climate zone 4C is 26.68 kBTU/ft<sup>2</sup>-yr with a -3.35 EUI or -11.1% difference compared to the ORSC-2021 baselines as shown in Table 10. Under climate zone 5B the ORSC-2023 overall weighted EUI is 30.42 kBTU/ft<sup>2</sup>-yr with a -5.05 EUI or -14.2% difference compared to the ORSC-2021 baselines as shown in Table 11. Combined across climate zones the

ORSC-2023 overall weighted EUI is 28.21 kBTU/ft<sup>2</sup>-yr, constituting a difference of -4.04 EUI or -12.5% in comparison to the ORSC-2021 baselines as shown in Table 12.

We feel that ORSC-2023 has shown significant improvement over ORSC-2021 overall. While some of this improvement can be attributed to changes in HVAC and hot water systems efficiencies and controls, the most significant factor has been the requirement that all new ducts and air handling equipment be located within the building envelope.

#### 4.5 ORSC-2023 compared to ORSC-2005

The ORSC-2023 overall weighted EUI in climate zone 4C is 26.68 kBTU/ft<sup>2</sup>-yr with a -18.03 EUI or -40.3% difference compared to the ORSC-2005 baselines as shown in Table 13. Under climate zone 5B the ORSC-2023 overall weighted EUI is 30.42 kBTU/ft<sup>2</sup>-yr with a -25.13 EUI or -45.2% difference compared to the ORSC-2005 baselines as shown in Table 14. Combined across climate zones the ORSC-2023 overall weighted EUI is 28.21 kBTU/ft<sup>2</sup>-yr, constituting a difference of -20.93 EUI or -42.6% in comparison to the ORSC-2005 baselines as shown in Table 15.

It's clear that the ORSC-2023 has made significant strides in improving building performance since the 2005 code iteration. This comes from a combination of improvement that touch on envelope insulation and glazing performance, more stringent HVAC and hot water systems efficiencies and controls, more stringent ventilation requirements and improved equipment, and significantly more stringent air duct insulation and air sealing requirements.

#### 4.6 ORSC-2023 compared to DOE ZERH

The ORSC-2023 overall weighted EUI in climate zone 4C is 26.68 kBTU/ft<sup>2</sup>-yr with a -0.55 EUI or -2.0% difference compared to the DOE ZERH baselines as shown in Table 16. Under climate zone 5B the ORSC-2023 overall weighted EUI is 30.42 kBTU/ft<sup>2</sup>-yr with a -0.38 EUI or -1.2% difference compared to the DOE ZERH baselines as shown in Table 17. Combined across climate zones the ORSC-2023 overall weighted EUI is 28.21 kBTU/ft<sup>2</sup>-yr, constituting a difference of -0.48 EUI or -1.7% in comparison to the DOE ZERH baselines as shown in Table 18.

We feel it is fair to conclude that ORSC-2023 is on par with DOE ZERH performance overall. As with ORSC-2021, there are some trade-offs between ORSC-2023 and DOE ZERH. For example, DOE ZERH requires higher efficiency for water heaters and heat recovery as part of a whole-house ventilation system, along with more stringent air sealing. On the other hand, ORSC-2023 requires higher efficiencies for split cooling, furnace and ventilation fans, and lighting; along with the

requirement for all ducting and air handling equipment to be located within the thermal envelope. All these factors seem to be balancing out in a way that brings ORSC-2023 and DOE ZERH to relatively equal footing.

Table 1 Results summary: ORSC-2017 vs. DOE ZERH-Rev.06 for climate zone 4C

Climate Zone 4C	EUI (kBtu/ft <sup>2</sup> -year)			
Building Type	DOE ZERH	ORSC-2017	Difference	%Difference
Heat Pump system with slab-on-grade foundation	21.3	<b>25.0</b>	+3.8	+17.7%
Heat Pump system with crawlspace foundation	21.8	<b>25.4</b>	+3.7	+16.9%
Gas-fired furnace with slab-on-grade foundation	29.5	<b>34.7</b>	+5.2	+17.5%
Gas-fired furnace with crawlspace foundation	30.1	<b>35.1</b>	+5.1	+16.8%

<b>Overall Weighted EUI</b>	<b>27.23</b>	<b>31.89</b>	<b>+4.66</b>	<b>+17.1%</b>
Change compared to DOE ZERH		<b>+17.1%</b>		

Table 2 Results summary: ORSC-2017 vs. DOE ZERH-Rev.06 for climate zone 5B

Climate Zone 5B	EUI (kBtu/ft <sup>2</sup> -year)			
Building Type	DOE ZERH	ORSC-2017	Difference	%Difference
Heat Pump system with slab-on-grade foundation	23.9	<b>29.6</b>	+5.7	+23.9%
Heat Pump system with crawlspace foundation	24.4	<b>30.0</b>	+5.6	+22.8%
Gas-fired furnace with slab-on-grade foundation	33.6	<b>41.4</b>	+7.8	+23.2%
Gas-fired furnace with crawlspace foundation	34.0	<b>41.7</b>	+7.7	+22.6%

<b>Overall Weighted EUI</b>	<b>30.80</b>	<b>37.86</b>	<b>+7.06</b>	<b>+22.9%</b>
Change compared to DOE ZERH		<b>+22.9%</b>		

Table 3 Results summary: ORSC-2017 vs. DOE ZERH-Rev.06 for climate zones 4C & 5B (weighted averages)

Climate Zone 4C + 5B	EUI (kBtu/ft <sup>2</sup> -year)			
Building Type	DOE ZERH	ORSC-2017	Difference	%Difference
Heat Pump system with slab-on-grade foundation	22.3	<b>26.9</b>	+4.6	+20.4%
Heat Pump system with crawlspace foundation	22.8	<b>27.3</b>	+4.4	+19.4%
Gas-fired furnace with slab-on-grade foundation	31.2	<b>37.4</b>	+6.2	+20.0%
Gas-fired furnace with crawlspace foundation	31.7	<b>37.8</b>	+6.1	+19.3%

<b>Overall Weighted EUI</b>	<b>28.69</b>	<b>34.32</b>	<b>+5.64</b>	<b>+19.6%</b>
Change compared to DOE ZERH		<b>+19.6%</b>		

Table 4 Results summary: ORSC-2021 vs. ORSC-2017 for climate zone 4C

<b>Climate Zone 4C</b>	EUI (kBtu/ft <sup>2</sup> -year)			
<b>Building Type</b>	ORSC-2017	<b>ORSC-2021</b>	Difference	%Difference
Heat Pump system with slab-on-grade foundation	25.0	<b>24.2</b>	-0.9	-3.4%
Heat Pump system with crawlspace foundation	25.4	<b>24.6</b>	-0.9	-3.3%
Gas-fired furnace with slab-on-grade foundation	34.7	<b>32.4</b>	-2.3	-6.7%
Gas-fired furnace with crawlspace foundation	35.1	<b>32.8</b>	-2.3	-6.6%

<b>Overall Weighted EUI</b>	<b>31.89</b>	<b>30.02</b>	<b>-1.86</b>	<b>-5.8%</b>
Change compared to ORSC-2017		<b>-5.8%</b>		

Table 5 Results summary: ORSC-2021 vs. ORSC-2017 for climate zone 5B

<b>Climate Zone 5B</b>	EUI (kBtu/ft <sup>2</sup> -year)			
<b>Building Type</b>	ORSC-2017	<b>ORSC-2021</b>	Difference	%Difference
Heat Pump system with slab-on-grade foundation	29.6	<b>28.3</b>	-1.4	-4.6%
Heat Pump system with crawlspace foundation	30.0	<b>28.6</b>	-1.3	-4.5%
Gas-fired furnace with slab-on-grade foundation	41.4	<b>38.5</b>	-2.9	-7.0%
Gas-fired furnace with crawlspace foundation	41.7	<b>38.9</b>	-2.9	-6.8%

<b>Overall Weighted EUI</b>	<b>37.86</b>	<b>35.47</b>	<b>-2.38</b>	<b>-6.3%</b>
Change compared to ORSC-2017		<b>-6.3%</b>		

Table 6 Results summary: ORSC-2021 vs. ORSC-2017 for climate zones 4C & 5B (weighted averages)

<b>Climate Zone 4C + 5B</b>	EUI (kBtu/ft <sup>2</sup> -year)			
<b>Building Type</b>	ORSC-2017	<b>ORSC-2021</b>	Difference	%Difference
Heat Pump system with slab-on-grade foundation	26.9	<b>25.8</b>	-1.1	-3.9%
Heat Pump system with crawlspace foundation	27.3	<b>26.2</b>	-1.0	-3.8%
Gas-fired furnace with slab-on-grade foundation	37.4	<b>34.9</b>	-2.6	-6.8%
Gas-fired furnace with crawlspace foundation	37.8	<b>35.3</b>	-2.5	-6.7%

<b>Overall Weighted EUI</b>	<b>34.32</b>	<b>32.25</b>	<b>-2.07</b>	<b>-6.0%</b>
Change compared to ORSC-2017		<b>-6.0%</b>		

Table 7 Results summary: ORSC-2021 vs. DOE ZERH-Rev.06 for climate zone 4C

Climate Zone 4C	EUI (kBtu/ft <sup>2</sup> -year)			
Building Type	DOE ZERH	ORSC-2021	Difference	%Difference
Heat Pump system with slab-on-grade foundation	21.3	<b>24.2</b>	+2.9	+13.6%
Heat Pump system with crawlspace foundation	21.8	<b>24.6</b>	+2.8	+13.0%
Gas-fired furnace with slab-on-grade foundation	29.5	<b>32.4</b>	+2.8	+9.6%
Gas-fired furnace with crawlspace foundation	30.1	<b>32.8</b>	+2.7	+9.1%

<b>Overall Weighted EUI</b>	<b>27.23</b>	<b>30.02</b>	<b>+2.79</b>	<b>+10.3%</b>
Change compared to DOE ZERH		<b>+10.3%</b>		

Table 8 Results summary: ORSC-2021 vs. DOE ZERH-Rev.06 for climate zone 5B

Climate Zone 5B	EUI (kBtu/ft <sup>2</sup> -year)			
Building Type	DOE ZERH	ORSC-2021	Difference	%Difference
Heat Pump system with slab-on-grade foundation	23.9	<b>28.3</b>	+4.4	+18.2%
Heat Pump system with crawlspace foundation	24.4	<b>28.6</b>	+4.2	+17.3%
Gas-fired furnace with slab-on-grade foundation	33.6	<b>38.5</b>	+4.9	+14.6%
Gas-fired furnace with crawlspace foundation	34.0	<b>38.9</b>	+4.8	+14.2%

<b>Overall Weighted EUI</b>	<b>30.80</b>	<b>35.47</b>	<b>+4.67</b>	<b>+15.2%</b>
Change compared to DOE ZERH		<b>+15.2%</b>		

Table 9 Results summary: ORSC-2021 vs. DOE ZERH-Rev.06 for climate zones 4C & 5B (weighted averages)

Climate Zone 4C + 5B	EUI (kBtu/ft <sup>2</sup> -year)			
Building Type	DOE ZERH	ORSC-2021	Difference	%Difference
Heat Pump system with slab-on-grade foundation	22.3	<b>25.8</b>	+3.5	+15.7%
Heat Pump system with crawlspace foundation	22.8	<b>26.2</b>	+3.4	+14.9%
Gas-fired furnace with slab-on-grade foundation	31.2	<b>34.9</b>	+3.7	+11.8%
Gas-fired furnace with crawlspace foundation	31.7	<b>35.3</b>	+3.6	+11.3%

<b>Overall Weighted EUI</b>	<b>28.69</b>	<b>32.25</b>	<b>+3.56</b>	<b>+12.4%</b>
Change compared to DOE ZERH		<b>+12.4%</b>		

Table 10 Results summary: ORSC-2023 vs. ORSC-2021 for climate zone 4C

<b>Climate Zone 4C</b>	EUI (kBtu/ft <sup>2</sup> -year)			
<b>Building Type</b>	ORSC-2021	<b>ORSC-2023</b>	Difference	%Difference
Heat Pump system with slab-on-grade foundation	24.2	<b>22.5</b>	-1.7	-7.0%
Heat Pump system with crawlspace foundation	24.6	<b>23.1</b>	-1.4	-5.8%
Gas-fired furnace with slab-on-grade foundation	32.4	<b>27.9</b>	-4.4	-13.7%
Gas-fired furnace with crawlspace foundation	32.8	<b>28.8</b>	-4.0	-12.3%

<b>Overall Weighted EUI</b>	<b>30.02</b>	<b>26.68</b>	<b>-3.35</b>	<b>-11.1%</b>
Change compared to ORSC-2021		<b>-11.1%</b>		

Table 11 Results summary: ORSC-2023 vs. ORSC-2021 for climate zone 5B

<b>Climate Zone 5B</b>	EUI (kBtu/ft <sup>2</sup> -year)			
<b>Building Type</b>	ORSC-2021	<b>ORSC-2023</b>	Difference	%Difference
Heat Pump system with slab-on-grade foundation	28.3	<b>25.1</b>	-3.2	-11.3%
Heat Pump system with crawlspace foundation	28.6	<b>26.1</b>	-2.6	-9.0%
Gas-fired furnace with slab-on-grade foundation	38.5	<b>32.0</b>	-6.5	-16.9%
Gas-fired furnace with crawlspace foundation	38.9	<b>33.0</b>	-5.8	-15.0%

<b>Overall Weighted EUI</b>	<b>35.47</b>	<b>30.42</b>	<b>-5.05</b>	<b>-14.2%</b>
Change compared to ORSC-2021		<b>-14.2%</b>		

Table 12 Results summary: ORSC-2023 vs. ORSC-2021 for climate zones 4C & 5B (weighted averages)

<b>Climate Zone 4C + 5B</b>	EUI (kBtu/ft <sup>2</sup> -year)			
<b>Building Type</b>	ORSC-2021	<b>ORSC-2023</b>	Difference	%Difference
Heat Pump system with slab-on-grade foundation	25.8	<b>23.5</b>	-2.3	-8.9%
Heat Pump system with crawlspace foundation	26.2	<b>24.3</b>	-1.9	-7.2%
Gas-fired furnace with slab-on-grade foundation	34.9	<b>29.6</b>	-5.3	-15.2%
Gas-fired furnace with crawlspace foundation	35.3	<b>30.5</b>	-4.8	-13.5%

<b>Overall Weighted EUI</b>	<b>32.25</b>	<b>28.21</b>	<b>-4.04</b>	<b>-12.5%</b>
Change compared to ORSC-2021		<b>-12.5%</b>		

Table 13 Results summary: ORSC-2023 vs. ORSC-2005 for climate zone 4C

<b>Climate Zone 4C</b>	EUI (kBtu/ft <sup>2</sup> -year)			
<b>Building Type</b>	ORSC-2005	<b>ORSC-2023</b>	Difference	%Difference
Heat Pump system with slab-on-grade foundation	33.0	<b>22.5</b>	-10.6	-32.0%
Heat Pump system with crawlspace foundation	31.6	<b>23.1</b>	-8.5	-26.8%
Gas-fired furnace with slab-on-grade foundation	52.0	<b>27.9</b>	-24.0	-46.3%
Gas-fired furnace with crawlspace foundation	49.7	<b>28.8</b>	-20.9	-42.1%

<b>Overall Weighted EUI</b>	<b>44.71</b>	<b>26.68</b>	<b>-18.03</b>	<b>-40.3%</b>
Change compared to ORSC-2005		<b>-40.3%</b>		

Table 14 Results summary: ORSC-2023 vs. ORSC-2005 for climate zone 5B

<b>Climate Zone 5B</b>	EUI (kBtu/ft <sup>2</sup> -year)			
<b>Building Type</b>	ORSC-2005	<b>ORSC-2023</b>	Difference	%Difference
Heat Pump system with slab-on-grade foundation	44.2	<b>25.1</b>	-19.1	-43.2%
Heat Pump system with crawlspace foundation	40.3	<b>26.1</b>	-14.3	-35.4%
Gas-fired furnace with slab-on-grade foundation	64.3	<b>32.0</b>	-32.3	-50.2%
Gas-fired furnace with crawlspace foundation	60.6	<b>33.0</b>	-27.6	-45.5%

<b>Overall Weighted EUI</b>	<b>55.55</b>	<b>30.42</b>	<b>-25.13</b>	<b>-45.2%</b>
Change compared to ORSC-2005		<b>-45.2%</b>		

Table 15 Results summary: ORSC-2023 vs. ORSC-2005 for climate zones 4C & 5B (weighted averages)

<b>Climate Zone 4C + 5B</b>	EUI (kBtu/ft <sup>2</sup> -year)			
<b>Building Type</b>	ORSC-2005	<b>ORSC-2023</b>	Difference	%Difference
Heat Pump system with slab-on-grade foundation	37.6	<b>23.5</b>	-14.1	-37.4%
Heat Pump system with crawlspace foundation	35.2	<b>24.3</b>	-10.8	-30.8%
Gas-fired furnace with slab-on-grade foundation	57.0	<b>29.6</b>	-27.4	-48.1%
Gas-fired furnace with crawlspace foundation	54.1	<b>30.5</b>	-23.6	-43.6%

<b>Overall Weighted EUI</b>	<b>49.13</b>	<b>28.21</b>	<b>-20.93</b>	<b>-42.6%</b>
Change compared to ORSC-2005		<b>-42.6%</b>		

Table 16 Results summary: ORSC-2023 vs. DOE ZERH-Rev.06 for climate zone 4C

Climate Zone 4C	EUI (kBtu/ft <sup>2</sup> -year)			
Building Type	DOE ZERH	ORSC-2023	Difference	%Difference
Heat Pump system with slab-on-grade foundation	21.3	<b>22.5</b>	1.2	5.7%
Heat Pump system with crawlspace foundation	21.8	<b>23.1</b>	1.4	6.4%
Gas-fired furnace with slab-on-grade foundation	29.5	<b>27.9</b>	-1.6	-5.5%
Gas-fired furnace with crawlspace foundation	30.1	<b>28.8</b>	-1.3	-4.3%

<b>Overall Weighted EUI</b>	<b>27.23</b>	<b>26.68</b>	<b>-0.55</b>	<b>-2.0%</b>
Change compared to DOE ZERH		<b>-2.0%</b>		

Table 17 Results summary: ORSC-2023 vs. DOE ZERH-Rev.06 for climate zone 5B

Climate Zone 5B	EUI (kBtu/ft <sup>2</sup> -year)			
Building Type	DOE ZERH	ORSC-2023	Difference	%Difference
Heat Pump system with slab-on-grade foundation	23.9	<b>25.1</b>	1.2	4.9%
Heat Pump system with crawlspace foundation	24.4	<b>26.1</b>	1.7	6.8%
Gas-fired furnace with slab-on-grade foundation	33.6	<b>32.0</b>	-1.6	-4.8%
Gas-fired furnace with crawlspace foundation	34.0	<b>33.0</b>	-1.0	-3.0%

<b>Overall Weighted EUI</b>	<b>30.80</b>	<b>30.42</b>	<b>-0.38</b>	<b>-1.2%</b>
Change compared to DOE ZERH		<b>-1.2%</b>		

Table 18 Results summary: ORSC-2023 vs. DOE ZERH-Rev.06 for climate zones 4C & 5B (weighted averages)

Climate Zone 4C + 5B	EUI (kBtu/ft <sup>2</sup> -year)			
Building Type	DOE ZERH	ORSC-2023	Difference	%Difference
Heat Pump system with slab-on-grade foundation	22.3	<b>23.5</b>	1.2	5.4%
Heat Pump system with crawlspace foundation	22.8	<b>24.3</b>	1.5	6.5%
Gas-fired furnace with slab-on-grade foundation	31.2	<b>29.6</b>	-1.6	-5.2%
Gas-fired furnace with crawlspace foundation	31.7	<b>30.5</b>	-1.2	-3.8%

<b>Overall Weighted EUI</b>	<b>28.69</b>	<b>28.21</b>	<b>-0.48</b>	<b>-1.7%</b>
Change compared to DOE ZERH		<b>-1.7%</b>		

## 5 References

1. Department of Energy. (2017). DOE Zero Energy Ready Home National Program Requirements (Rev.06). <https://www.energy.gov/eere/buildings/downloads/doe-zero-energy-ready-home-national-program-requirements-rev-06>
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## 6 Appendix Materials

The following supplementary materials are in the process of being developed to document the comparison of DOE ZERH and ORSC-2017, ORSC-2021 and ORSC-2017, ORSC-2023 and ORSC-2021, and ORSC-2023 and ORSC-2005:

1. **Appendix A – Envelope and Air Leakage** spreadsheet detailing the construction and material changes.  
*(AppendixA\_Envelope\_AirLeakage.xlsx)*
2. **Appendix B – Lighting and Equipment** spreadsheet contains the lighting and equipment objects and efficiencies.  
*(AppendixB\_Lighting\_Equipment.xlsx)*
3. **Appendix C – HVAC and Service Hot Water** spreadsheet contains the building system and service hot water objects and efficiencies.  
*(AppendixC\_HVAC\_SHW.xlsx)*
4. **Appendix D – EUI Results** spreadsheet contains the processed simulation results for Climate Zones 4C and 5B, with a weighted average.  
*(AppendixD\_EUI\_Results\_ORSC-2017\_DOE-ZERH-Rev.06.xlsx)*  
*(AppendixD\_EUI\_Results\_ORSC-2021\_ORSC-2017.xlsx)*  
*(AppendixD\_EUI\_Results\_ORSC-2021\_DOE-ZERH-Rev.06.xlsx)*  
*(AppendixD\_EUI\_Results\_ORSC-2023\_ORSC-2021.xlsx)*  
*(AppendixD\_EUI\_Results\_ORSC-2023\_ORSC-2005.xlsx)*  
*(AppendixD\_EUI\_Results\_ORSC-2023\_DOE-ZERH-Rev.06.xlsx)*