Cost & Savings Estimates

ENERGY STAR
Single-Family New Homes,
Version 3.2 (Rev. 12)

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ENERGY STAR Single-Family New Homes, Version 3.2 (Rev. 12) Cost & Savings Estimates

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Section 1: Executive Summary

Overview

This document is intended to provide partners, utility sponsors, and program designers with an estimate of the incremental costs to build, and associated savings from, an ENERGY STAR certified single-family new home under Version 3.2 (Rev. 12) of the program in regions that have adopted the 2021 ICC codes (e.g., 2021 IECC, 2021 IRC).

Methodology

To complete this analysis, EPA evaluated sixteen typical homes across hot, mixed, and cold climates.

The architectural characteristics for each home were determined using the U.S. Department of Energy's Methodology for Evaluating Cost-Effectiveness of Residential Energy Code Changes[1]. Exhibit 1 shows the house parameters that were modeled consistently across all Climate Zones.

Exhibit 1: House Parameters Consistent Across Climate Zones

Parameter	Value
Number of Stories	Two
Conditioned Floor Area Per Floor (sq. ft.)	1,188
Total Conditioned Floor Area (sq. ft.)	2,376
Perimeter (ft)	54 x 22
Ceiling Height (ft)	8.5
Bedrooms	3
Window Area (% of Floor Area) & Distribution	15%, Even
Exterior Door Quantity & Total Area	2 Doors, 42 sq. ft.

Exhibit 2 shows parameters that were modeled with variations across Climate Zones. In Climate Zones 1 through 8, one home in each zone was configured with an electric heat pump and electric water heater, named Configuration A. A second home was configured with a gas furnace, electric air conditioner, and gas water heater, named Configuration B.

Exhibit 2: House Parameters Varied Across Climate Zones

<table>
<tr><th rowspan="2">CZ</th><th rowspan="2">Location</th><th rowspan="2">Foundation Type</th><th colspan="2">Space Heating, Cooling & Water Heating</th></tr>
<tr><th>Configuration A</th><th>Configuration B</th></tr>
<tr><td>1</td><td>Miami, FL</td><td rowspan="3">Slab</td><td rowspan="8">Electric Air-Source Heat Pump & Electric Water Heater</td><td rowspan="8">Gas Furnace, Electric AC, & Gas Water Heater</td></tr>
<tr><td>2</td><td>Houston, TX</td></tr>
<tr><td>3</td><td>Memphis, TN</td></tr>
<tr><td>4</td><td>Baltimore, MD</td><td rowspan="5">Unconditioned Basement</td></tr>
<tr><td>5</td><td>Chicago, IL</td></tr>
<tr><td>6</td><td>Burlington, VT</td></tr>
<tr><td>7</td><td>Duluth, MN</td></tr>
<tr><td>8</td><td>Fairbanks, AK</td></tr>
</table>

The energy efficiency features of the baseline homes were aligned with the 2021 IECC prescriptive path, except for the window and door performance in Climate Zone 1. In this location, the 2021 IECC defines a U-factor of 0.50. This level of performance is worse than what is likely to be available in the marketplace, so the improved window and door requirements of Climate Zone 2, a U-factor of 0.40, were modeled instead.

In addition, because no insulation installation grade is defined or required by code, all zones were modeled with Grade II insulation installation in walls and floors, and Grade I insulation installation in ceilings. This was based upon the predominant insulation grade, by assembly type, identified for single-family residential homes not indicated as 'above-code,' using data from the U.S. Department of Energy Residential Energy Code Field Studies[2].

Further, because no HVAC installation quality grade is defined or required by code, all zones were modeled with Grade III blower fan airflow, blower fan watt draw, and refrigerant charge as defined in ANSI / RESNET / ACCA / ICC 310-2020.

[1] https://www.energycodes.gov/sites/default/files/2021-07/residential_methodology_2015.pdf
[2] https://www.energycodes.gov/residential-energy-code-field-studies

Finally, the prescriptive path of the 2021 IECC requires builders to select one additional efficiency package from among five options. EPA selected the measure believed to be the most likely for builders to incorporate, which is the option to reduce energy use in service water heating. This option requires that the home include a 0.82 EF fossil fuel service, 2.0 EF electric service, or 0.4 solar fraction water heating system. Using the RESNET Energy Factor Conversion Equations, the fossil fuel and electric service efficiencies equate to 0.82 UEF and 2.15 UEF, respectively[3], effectively requiring the use of an instantaneous water heater or heat pump water heater. RESNET has reported that approximately a third of all homes that received an energy rating and were registered in 2020 already used such technology.

EPA believes the other four options for complying with the are less likely to be used throughout the country for a variety of reasons: the enhanced envelope performance option requires changes to the thermal enclosure; the improved air sealing and efficient ventilation system option requires the use of less commonly employed ERV/HRV technologies; the more efficient duct thermal distribution system option requires design practices that are currently only commonly used in homes without slab-on-grade foundations; and the more efficient HVAC equipment performance option requires equipment efficiencies that are not climate-specific (e.g., 96 AFUE furnaces in the south and 16 SEER AC in the north).

The energy efficiency features of the baseline homes are summarized in Exhibit 3.

Exhibit 3: Key Efficiency Features of Modeled 2021 IECC Baseline Homes

Climate Zone	1	2	3	4	4C & 5	6	7	8
Thermal Enclosure								
Ceiling Insulation	R-30	R-49		R-60				
Ceiling Insulation Grade	I							
Wall Insulation: Cavity	R-13		R-20					
Wall Insulation: Continuous	None			R-5				
Wall Insulation Grade	II							
Door U-factor	0.40		0.30					
Window U-factor	0.40		0.30					
Window SHGC	0.25			0.40				
Frame Floor Insulation	Not present			R-19	R-30		R-38	
Frame Floor Insulation Grade	Not present			II				
Slab Insulation & Depth	Uninsulated		R-10 2ft	Not present				
Infiltration and Mechanical Ventilation								
Infiltration (ACH50)	5		3					
Mechanical Vent. Type & Efficiency (CFM / W)	Supply Fan & 3.8				Exh. Fan & 2.8		HRV & 1.2	
HVAC								
Furnace & AC Efficiency (AFUE / SEER)	80 & 15				80 & 14			
Heat Pump Efficiency (HSPF / SEER)	8.8 & 15							
HVAC Grade: Airflow Deviation	-25%							
HVAC Grade: Watt Draw Efficiency (W / CFM)	0.58							
HVAC Grade: Refrigerant Grade	III							
Thermostat Type	Programmable							
Duct Leakage to Outside & Insulation	4 CFM / 100 sq. ft. of CFA & R-8							
Duct Location	75% Attic & 25% Cond.			50% Attic & 50% Basement				
Water Heating								
Gas: Efficiency (UEF) & Capacity (Gal.)	0.82 & 0 (Instantaneous)							
Electric: Efficiency (UEF) & Capacity (Gal.)	2.15 & 60							
Lighting & Appliances								
Lighting	100% Tier 1, Per ANSI / RESNET / ICC 301							
Refrigerator (kWh / yr)	491							
Dishwasher	NAECA Minimum Defaults, Per ANSI / RESNET / ICC 301							

[3] https://www.resnet.us/about/standards/resnet-ansi/

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The energy efficiency features of the ENERGY STAR certified homes were aligned with the National ERI Target Procedure, Version 3.2 (Rev. 12). Key features include a thermal enclosure system with insulation levels aligned with the 2021 IECC prescriptive compliance option, achieving Grade I insulation installation; windows and doors aligned with the latest ENERGY STAR Windows, Doors, and Skylights specification (Version 6.0); infiltration of 3 ACH50 in all locations; heat pump efficiency in all climates and air conditioner efficiency in warm and mixed climates aligned with the latest ENERGY STAR Central Air Conditioner and Heat Pump specification (Version 6.0); furnaces in mixed and cold climates generally aligned with the latest ENERGY STAR Furnace specification (Version 4.1), with all HVAC systems achieving Grade I for total duct leakage and Grade II installation for blower fan airflow and watt draw, per ANSI / RESNET / ACCA 310; 100% of ducts located in conditioned space; water heaters meeting or exceeding the minimum requirements for gas-fired instantaneous equipment and electric equipment defined in the latest ENERGY STAR Residential Water Heater specification (Version 4.0); a refrigerator meeting the requirements of the latest ENERGY STAR Consumer Refrigeration Products specification (Version 5.1); a dishwasher aligned with the ENERGY STAR defaults defined in ANSI / RESNET / ICC 301; and 100% Tier 2 lighting, as defined by ANSI / RESNET / ICC 301. These features are summarized in Exhibit 4 below, with improved features relative to the baseline home shaded green.

Exhibit 4: Key Efficiency Features of Modeled ENERGY STAR SFNH National Version 3.2 Homes

Climate Zone	1	2	3	4	4C & 5	6	7	8
Thermal Enclosure								
Ceiling Insulation	R-30	R-49		R-60				
Ceiling Insulation Grade	I							
Wall Insulation: Cavity	R-13		R-20					
Wall Insulation: Continuous	None			R-5				
Wall Insulation Grade	I							
Door U-factor	0.17							
Window U-factor	0.40		0.30		0.27			
Window SHGC	0.25			0.40				
Frame Floor Insulation	Not present			R-19	R-30		R-38	
Frame Floor Insulation Grade	Not present			I				
Slab Insulation & Depth	Uninsulated		R-10 2ft	Not present				
Infiltration and Mechanical Ventilation								
Infiltration (ACH50)	3		3					
Mechanical Vent. Type & Efficiency (CFM / W)	Supply Fan & 3.8				Exh. Fan & 2.8		HRV & 1.2	
HVAC								
Furnace & AC Efficiency (AFUE / SEER)	80 & 16			90&16	95 & 14			
Heat Pump Efficiency (HSPF / SEER)	9.2 & 16							
HVAC Grade: Airflow Deviation	-20%							
HVAC Grade: Watt Draw Efficiency (W / CFM)	0.52							
HVAC Grade: Refrigerant Grade	III							
Thermostat Type	Programmable							
Duct Leakage to Outside & Insulation	0 CFM / 100 sq. ft. of CFA & Not Present							
Duct Location	100% Conditioned Space							
Water Heating								
Gas: Efficiency (UEF) & Capacity (Gal.)	0.90 & 0 (Instantaneous)							
Electric: Efficiency (UEF) & Capacity (Gal.)	2.20 & 60							
Lighting & Appliances								
Lighting	100% Tier 2, Per ANSI / RESNET / ICC 301							
Refrigerator (kWh / yr)	450							
Dishwasher	ENERGY STAR Defaults, Per ANSI / RESNET / ICC 301							

To estimate energy savings, the baseline and ENERGY STAR certified home configurations were modeled in Ekotrope v4.0.2. Energy consumption was determined from the resulting Fuel Summary report. For reference, the reported ERI values were also recorded.

The resulting energy consumption for the baseline homes and ENERGY STAR certified homes were then converted to purchased energy costs using a 2019 national average rate of $0.1301 / kWh and $1.014 / therm, from the Energy Information Administration.[4,5] Finally, the purchased energy costs for the ENERGY STAR certified homes were subtracted from those of the baseline homes to determine savings.

The incremental costs of the features for each ENERGY STAR certified home were estimated next. This included both the mandatory measures required by the program (e.g., those in the National Rater Field Checklist), along with the measures that are not mandatory but are used to meet the ENERGY STAR ERI Target required by the program.

Results & Discussion

Exhibit 5 summarizes the annual purchased energy costs for each baseline and ENERGY STAR certified home. In addition, it summarizes the annual purchased energy savings and the total upgrade cost for each ENERGY STAR certified home, and the resulting monthly purchased energy savings, monthly mortgage upgrade cost, and net cash flow. The monthly mortgage upgrade cost was calculated assuming a 30-year fixed mortgage with a 5.0% interest rate.

Exhibit 5: ENERGY STAR National v3.2 Single-Family New Home vs 2021 IECC Home, Illustrative Cost & Savings Summary

#	CZ	Location	Found.	HVAC Equipment Type	2021 IECC	ENERGY STAR Version 3.2					
					Annual Purchased Energy Costs	Annual Purchased Energy Costs	Annual Purchased Energy Savings	Total Upgrade Cost	Monthly Purchased Energy Savings	Monthly Mortgage Upgrade Cost	Net Cash Flow
1	1	Miami, FL	Slab	Elec. Air-Source HP	$1,439	$1,232	$207 14%	$1,211	$17	$6	$11
2	1	Miami, FL	Slab	Gas Furn. / Elec. AC	$1,379	$1,168	$211 15%	$1,377	$18	$7	$10
3	2	Houston, TX	Slab	Elec. Air-Source HP	$1,636	$1,301	$335 20%	$1,463	$28	$8	$20
4	2	Houston, TX	Slab	Gas Furn. / Elec. AC	$1,404	$1,167	$237 17%	$1,629	$20	$9	$11
5	3	Memphis, TN	Slab	Elec. Air-Source HP	$1,733	$1,436	$297 17%	$1,010	$25	$5	$19
6	3	Memphis, TN	Slab	Gas Furn. / Elec. AC	$1,430	$1,215	$215 15%	$1,176	$18	$6	$12
7	4	Baltimore, MD	Bsmt.	Elec. Air-Source HP	$1,761	$1,440	$321 18%	$1,635	$27	$9	$18
8	4	Baltimore, MD	Bsmt.	Gas Furn. / Elec. AC	$1,374	$1,146	$227 17%	$1,935	$19	$10	$9
9	5	Chicago, IL	Bsmt.	Elec. Air-Source HP	$2,230	$1,746	$484 22%	$1,920	$40	$10	$30
10	5	Chicago, IL	Bsmt.	Gas Furn. / Elec. AC	$1,604	$1,261	$343 21%	$2,563	$29	$14	$15
11	6	Burlington, VT	Bsmt.	Elec. Air-Source HP	$2,450	$1,878	$571 23%	$1,668	$48	$9	$39
12	6	Burlington, VT	Bsmt.	Gas Furn. / Elec. AC	$1,715	$1,288	$427 25%	$2,815	$36	$15	$20
13	7	Duluth, MN	Bsmt.	Elec. Air-Source HP	$3,278	$2,427	$851 26%	$1,668	$71	$9	$62
14	7	Duluth, MN	Bsmt.	Gas Furn. / Elec. AC	$2,058	$1,473	$584 28%	$2,815	$49	$15	$34
15	8	Fairbanks, AK	Bsmt.	Elec. Air-Source HP	$5,262	$3,831	$1,431 27%	$1,668	$119	$9	$110
16	8	Fairbanks, AK	Bsmt.	Gas Furn. / Elec. AC	$2,581	$1,854	$727 28%	$2,815	$61	$15	$45

[4] Average retail price of electricity to ultimate customers; annual retail price, by sector, by state, by provider. https://www.eia.gov/electricity/data.php#sales

[5] Natural gas prices; residential price; annual. https://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PRS_DMcf_a.htm

For reference, the reported ERI values from Ekotrope, calculated according to ANSI / RESNET / ICC 301-2019 including Addenda A and B, are shown in Exhibit 6.

Exhibit 6: ERI Values of 2021 IECC and ENERGY STAR National v3.2 Single-Family New Homes

#	CZ	Location	Found.	HVAC Equipment Type	ERI Values	
					2021 IECC Home	ENERGY STAR v3.2 Home
1	1	Miami, FL	Slab	Elec. Air-Source HP	61	51
2	1	Miami, FL	Slab	Gas Furn. / Elec. AC	62	51
3	2	Houston, TX	Slab	Elec. Air-Source HP	66	51
4	2	Houston, TX	Slab	Gas Furn. / Elec. AC	66	53
5	3	Memphis, TN	Slab	Elec. Air-Source HP	59	46
6	3	Memphis, TN	Slab	Gas Furn. / Elec. AC	60	49
7	4	Baltimore, MD	Bsmt.	Elec. Air-Source HP	61	48
8	4	Baltimore, MD	Bsmt.	Gas Furn. / Elec. AC	62	47
9	5	Chicago, IL	Bsmt.	Elec. Air-Source HP	68	51
10	5	Chicago, IL	Bsmt.	Gas Furn. / Elec. AC	70	49
11	6	Burlington, VT	Bsmt.	Elec. Air-Source HP	70	52
12	6	Burlington, VT	Bsmt.	Gas Furn. / Elec. AC	75	49
13	7	Duluth, MN	Bsmt.	Elec. Air-Source HP	69	50
14	7	Duluth, MN	Bsmt.	Gas Furn. / Elec. AC	72	45
15	8	Fairbanks, AK	Bsmt.	Elec. Air-Source HP	73	54
16	8	Fairbanks, AK	Bsmt.	Gas Furn. / Elec. AC	70	44

Section 2 includes Exhibits 7 through 22, which contain a more detailed breakout of the incremental upgrade costs presented for each home in Exhibit 5. While this analysis provides illustrative incremental costs and savings, these values will vary for any specific certified home, dependent on variables such as baseline construction practices, geographic location, house design, vendor relationships, and financial incentives. For example, builders are likely to experience lower incremental costs than stated in this document if they are able to procure equipment or materials below retail rates or if they already build above code-minimum requirements. In addition, many partners achieve decreasing costs over time as they gain experience and develop more cost-effective strategies to meet the program requirements. Finally, state and utility incentives and federal tax credits are often available and were not accounted for. Therefore, these estimates are only illustrative and are likely to represent the higher end of the cost spectrum.

Sections 3 through 8 provide a more detailed discussion of the incremental costs and savings associated with each of the mandatory measures required in the National Rater Field Checklist, National HVAC Design Supplement to Std. 310 for Dwellings & Units, National Rater Design Review Checklist, National HVAC Commissioning Checklist, and National Water Management System Builder Requirements.

Within these mandatory measures, the program provides two tracks for satisfying elements related to HVAC design and installation – Track A: HVAC Grading and Track B: HVAC Credential. Track A leverages ANSI / RESNET / ACCA / ICC 310, which requires the Rater to complete a design review and four field tasks to assess the installation quality of the HVAC equipment. Track B requires the Rater to review ENERGY STAR-specific HVAC design documentation and leverages HVAC contractors that have been credentialed by an HVAC Quality Installation Training & Oversight Organization to complete field commissioning. For this analysis, the use of Track A was assumed. However, Sections 4 through 7 also include a brief discussion of the comparable costs for Track B, had that track been chosen.

With this analysis, the measures used to achieve ENERGY STAR certification were compared to the requirements of the 2021 IECC and 2021 IRC codes, and only requirements above code were accounted for.

For example, code requires that HVAC systems be designed in accordance with Manual J, D, and S, or equivalent methodologies, so no costs or savings were assumed for meeting these design requirements. In contrast, code does not require commissioning of HVAC systems, so both incremental costs and savings were estimated for these requirements.

This approach was pursued for two reasons. The first reason is that code is a well-defined baseline from which costs and savings can be consistently evaluated. In contrast, standard practice often varies from code-minimum requirements (both below-code and above-code) and is therefore difficult to consistently benchmark against. The second reason for this approach is that most utility-sponsored programs are not able to claim savings for improvements from below-code to code-minimum practices. Therefore, estimating the incremental costs and savings only for the above-code measures of the ENERGY STAR v3.2 program requirements makes the analysis more relevant to utility sponsors and partners that wish to improve practices above code.

Despite the fact that many of the mandatory measures for the program are required by code, EPA believes that their inclusion provides significant benefits: code often allows these items to be traded-off for other improvements, while the ENERGY STAR program helps ensure that these details are included in every home to consistently deliver a complete thermal enclosure system, complete HVAC system, and complete water management system; the ENERGY STAR program consolidates critical code-required details in a relatively concise format that improves compliance; the ENERGY STAR program provides a consistent set of building science details from which to educate and train partners; and many of the ENERGY STAR mandatory measures are required to be third-party verified by a Rater, whereas most jurisdictions do not require such oversight.

Finally, Section 9 provides additional references to support the assumptions used in the analysis.

Section 2: Detailed Incremental Cost Estimates

Exhibits 7 through 22 contain a more detailed explanation of the incremental upgrade costs presented for each home in Exhibit 5. For each home, the costs are divided into six sections.

The first section in each exhibit contains the energy efficiency measures that are not mandatory for ENERGY STAR certification and were used solely to meet the ENERGY STAR ERI Target.

The next five sections contain the costs required to comply with, respectively, the Thermal Enclosure System section of the National Rater Field Checklist; the HVAC System section of the same checklist, assuming use of Track A – HVAC Grading; the National Rater Design Review Checklist, assuming use of Track A; the HVAC design documentation that must be completed for Track A; the National HVAC Commissioning Checklist, which would have been applicable if Track B – HVAC Credential had been selected instead; and the National Water Management System Builder Requirements; relative to the 2021 ICC codes.

Within these documents, some measures improve the ERI of the home and some do not, and they have been grouped accordingly. This is an important distinction because partners have expressed an interest in knowing what the cost of the mandatory measures of the program are, yet many of them might also be included as part of a standard energy rating. For example, Grade I insulation installation is mandatory in the National Rater Field Checklist, unless rigid insulation is used, so that cost is grouped with the checklist even though a builder not participating in the ENERGY STAR program might also select that measure to achieve a better ERI. Bedroom pressure balancing is also grouped with this checklist because it is another mandatory measure, though in this case it does not impact the ERI of the home.

For each measure, the exhibit lists the 2021 IECC baseline code requirement, the ENERGY STAR Version 3.2 (Rev. 12) requirement, the incremental unit cost, the quantity of units per home, the cost units (e.g., tons, square feet of window area, square feet of conditioned floor area), and the total incremental measure cost.

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Exhibit 7: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 1 - Config. A - Electric

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	5.0 ACH50	3.0 ACH50	$0.10	2,376	CFA (ft²)	$249
Cooling Equipment	(See Heating Equipment)	(See Heating Equipment)	-	-	-	-
Heating Equipment	8.8 HSPF / 15 SEER	9.2 HSPF / 16 SEER	$178.05	1	System	$178
Duct Location	Unconditioned Space	Conditioned Space	$2.40	570	Duct Surf. Area (ft²)	$1,369
Water Heater	2.15 UEF HPWH, 60 Gallons	2.20 UEF HPWH, 60 Gallons	$25.08	1	Water Heater	$25
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$1,954**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-30, Grade I Installation	R-30, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-13, Grade II Installation	R-13, Grade I Installation	$0.05	2,584	Insul. Surf. Area (ft²)	$141
Foundation Insulation	No Slab Insulation	No Slab Insulation	-	-	-	-
Windows	U-value: 0.40 / SHGC: 0.25	U-value: 0.40 / SHGC: 0.25	-	-	-	-
Doors	R-2.5	R-5.9	$2.88	42	Door Surf. Area (ft²)	$121
Additional Checklist Measures: Reduced Lumber from Advanced Framing, Rater Verification						-$50
Sub-Total of Thermal Enclosure System Checklist						**$212**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	570	Duct Surf. Area (ft²)	-$781
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$300
Sub-Total of HVAC System Checklist						**-$481**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	ENERGY STAR Supply Fan	ENERGY STAR Supply Fan	$0.00	1	System	$0
HVAC Equipment Right-Sizing	2.5 Tons	1.5 Tons	-$504.00	1.0	Tons	-$504
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**-$499**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$1,211**

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Exhibit 8: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 1 - Config. B - Gas

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	5.0 ACH50	3.0 ACH50	$0.10	2,376	CFA (ft²)	$249
Cooling Equipment	15 SEER Central AC	16 SEER Central AC	$124.00	1	System	$124
Heating Equipment	80 AFUE Gas Furnace	80 AFUE Gas Furnace	-	-	-	-
Duct Location	Unconditioned Space	Conditioned Space	$2.40	570	Duct Surf. Area (ft²)	$1,369
Water Heater	0.82 UEF Gas Tankless	0.90 UEF Gas Tankless	$245.14	1	Water Heater	$245
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$2,120**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-30, Grade I Installation	R-30, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-13, Grade II Installation	R-13, Grade I Installation	$0.05	2,584	Insul. Surf. Area (ft²)	$141
Foundation Insulation	No Slab Insulation	No Slab Insulation	-	-	-	-
Windows	U-value: 0.40 / SHGC: 0.25	U-value: 0.40 / SHGC: 0.25	-	-	-	-
Doors	R-2.5	R-5.9	$2.88	42	Door Surf. Area (ft²)	$121
Additional Checklist Measures: Reduced Lumber from Advanced Framing, Rater Verification						-$50
Sub-Total of Thermal Enclosure System Checklist						**$212**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	570	Duct Surf. Area (ft²)	-$781
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$300
Sub-Total of HVAC System Checklist						**-$481**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	ENERGY STAR Supply Fan	ENERGY STAR Supply Fan	$0.00	1	System	$0
HVAC Equipment Right-Sizing	2.5 Tons	1.5 Tons	-$504.00	1.0	Tons	-$504
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**-$499**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$1,377**

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Exhibit 9: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 2 - Config. A - Electric

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	5.0 ACH50	3.0 ACH50	$0.10	2,376	CFA (ft²)	$249
Cooling Equipment	(See Heating Equipment)	(See Heating Equipment)	-	-	-	-
Heating Equipment	8.8 HSPF / 15 SEER	9.2 HSPF / 16 SEER	$178.05	1	System	$178
Duct Location	Unconditioned Space	Conditioned Space	$2.40	570	Duct Surf. Area (ft²)	$1,369
Water Heater	2.15 UEF HPWH, 60 Gallons	2.20 UEF HPWH, 60 Gallons	$25.08	1	Water Heater	$25
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$1,954**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-49, Grade I Installation	R-49, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-13, Grade II Installation	R-13, Grade I Installation	$0.05	2,584	Insul. Surf. Area (ft²)	$141
Foundation Insulation	No Slab Insulation	No Slab Insulation	-	-	-	-
Windows	U-value: 0.40 / SHGC: 0.25	U-value: 0.40 / SHGC: 0.25	-	-	-	-
Doors	R-2.5	R-5.9	$2.88	42	Door Surf. Area (ft²)	$121
Additional Checklist Measures: Reduced Lumber from Advanced Framing, Rater Verification						-$50
Sub-Total of Thermal Enclosure System Checklist						**$212**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	570	Duct Surf. Area (ft²)	-$781
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$300
Sub-Total of HVAC System Checklist						**-$481**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	ENERGY STAR Supply Fan	ENERGY STAR Supply Fan	$0.00	1	System	$0
HVAC Equipment Right-Sizing	2.0 Tons	1.5 Tons	-$504.00	0.5	Tons	-$252
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**-$247**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$1,463**

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Exhibit 10: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 2 - Config. B - Gas

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	5.0 ACH50	3.0 ACH50	$0.10	2,376	CFA (ft²)	$249
Cooling Equipment	15 SEER Central AC	16 SEER Central AC	$124.00	1	System	$124
Heating Equipment	80 AFUE Gas Furnace	80 AFUE Gas Furnace	-	-	-	-
Duct Location	Unconditioned Space	Conditioned Space	$2.40	570	Duct Surf. Area (ft²)	$1,369
Water Heater	0.82 UEF Gas Tankless	0.90 UEF Gas Tankless	$245.14	1	Water Heater	$245
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$2,120**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-49, Grade I Installation	R-49, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-13, Grade II Installation	R-13, Grade I Installation	$0.05	2,584	Insul. Surf. Area (ft²)	$141
Foundation Insulation	No Slab Insulation	No Slab Insulation	-	-	-	-
Windows	U-value: 0.40 / SHGC: 0.25	U-value: 0.40 / SHGC: 0.25	-	-	-	-
Doors	R-2.5	R-5.9	$2.88	42	Door Surf. Area (ft²)	$121
Additional Checklist Measures: Reduced Lumber from Advanced Framing, Rater Verification						-$50
Sub-Total of Thermal Enclosure System Checklist						**$212**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	570	Duct Surf. Area (ft²)	-$781
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$300
Sub-Total of HVAC System Checklist						**-$481**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	ENERGY STAR Supply Fan	ENERGY STAR Supply Fan	$0.00	1	System	$0
HVAC Equipment Right-Sizing	2.0 Tons	1.5 Tons	-$504.00	0.5	Tons	-$252
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**-$247**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$1,629**

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Exhibit 11: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 3 - Config. A - Electric

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	3.0 ACH50	3.0 ACH50	-	-	-	-
Cooling Equipment	(See Heating Equipment)	(See Heating Equipment)	-	-	-	-
Heating Equipment	8.8 HSPF / 15 SEER	9.2 HSPF / 16 SEER	$178.05	1	System	$178
Duct Location	Unconditioned Space	Conditioned Space	$2.40	570	Duct Surf. Area (ft²)	$1,369
Water Heater	2.15 UEF HPWH, 60 Gallons	2.20 UEF HPWH, 60 Gallons	$25.08	1	Water Heater	$25
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$1,705**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-49, Grade I Installation	R-49, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-20, Grade II Installation	R-20, Grade I Installation	$0.02	2,584	Insul. Surf. Area (ft²)	$64
Foundation Insulation	R-10, 2 Ft. Perimeter Slab Insulation	R-10, 2 Ft. Perimeter Slab Insulation	-	-	-	-
Windows	U-value: 0.30 / SHGC: 0.25	U-value: 0.30 / SHGC: 0.25	-	-	-	-
Doors	R-3.3	R-5.9	$1.63	42	Door Surf. Area (ft²)	$68
Additional Checklist Measures: Reduced Lumber from Advanced Framing, Rater Verification						-$125
Sub-Total of Thermal Enclosure System Checklist						**$8**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	570	Duct Surf. Area (ft²)	-$781
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$300
Sub-Total of HVAC System Checklist						**-$481**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	ENERGY STAR Supply Fan	ENERGY STAR Supply Fan	$0.00	1	System	$0
HVAC Equipment Right-Sizing	2.0 Tons	1.5 Tons	-$504.00	0.5	Tons	-$252
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**-$247**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$1,010**

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Exhibit 12: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 3 - Config. B - Gas

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	3.0 ACH50	3.0 ACH50	-	-	-	-
Cooling Equipment	15 SEER Central AC	16 SEER Central AC	$124.00	1	System	$124
Heating Equipment	80 AFUE Gas Furnace	80 AFUE Gas Furnace	-	-	-	-
Duct Location	Unconditioned Space	Conditioned Space	$2.40	570	Duct Surf. Area (ft²)	$1,369
Water Heater	0.82 UEF Gas Tankless	0.90 UEF Gas Tankless	$245.14	1	Water Heater	$245
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$1,871**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-49, Grade I Installation	R-49, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-20, Grade II Installation	R-20, Grade I Installation	$0.02	2,584	Insul. Surf. Area (ft²)	$64
Foundation Insulation	R-10, 2 Ft. Perimeter Slab Insulation	R-10, 2 Ft. Perimeter Slab Insulation	-	-	-	-
Windows	U-value: 0.30 / SHGC: 0.25	U-value: 0.30 / SHGC: 0.25	-	-	-	-
Doors	R-3.3	R-5.9	$1.63	42	Door Surf. Area (ft²)	$68
Additional Checklist Measures: Reduced Lumber from Advanced Framing, Rater Verification						-$125
Sub-Total of Thermal Enclosure System Checklist						**$8**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	570	Duct Surf. Area (ft²)	-$781
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$300
Sub-Total of HVAC System Checklist						**-$481**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	ENERGY STAR Supply Fan	ENERGY STAR Supply Fan	$0.00	1	System	$0
HVAC Equipment Right-Sizing	2.0 Tons	1.5 Tons	-$504.00	0.5	Tons	-$252
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**-$247**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$1,176**

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Exhibit 13: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 4 - Config. A - Electric

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	3.0 ACH50	3.0 ACH50	-	-	-	-
Cooling Equipment	(See Heating Equipment)	(See Heating Equipment)	-	-	-	-
Heating Equipment	8.8 HSPF / 15 SEER	9.2 HSPF / 16 SEER	$178.05	1	System	$178
Duct Location	Unconditioned Space	Conditioned Space	$2.40	760	Duct Surf. Area (ft²)	$1,825
Water Heater	2.15 UEF HPWH, 60 Gallons	2.20 UEF HPWH, 60 Gallons	$25.08	1	Water Heater	$25
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$2,162**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-60, Grade I Installation	R-60, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-20 + R-5 Cont., Grade II Installation	R-20 + R-5 Cont., Grade I Installation	$0.02	2,584	Insul. Surf. Area (ft²)	$64
Foundation Insulation	R-19 Frame Floor, Grade II Installation	R-19 Frame Floor, Grade I Installation	$0.17	1,188	Insul. Surf. Area (ft²)	$204
Windows	U-value: 0.30 / SHGC: 0.40	U-value: 0.30 / SHGC: 0.40	-	-	-	-
Doors	R-3.3	R-5.9	$1.63	42	Door Surf. Area (ft²)	$68
Additional Checklist Measures: Rater Verification						$100
Sub-Total of Thermal Enclosure System Checklist						**$437**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	760	Duct Surf. Area (ft²)	-$1,042
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$300
Sub-Total of HVAC System Checklist						**-$742**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	ENERGY STAR Supply Fan	ENERGY STAR Supply Fan	$0.00	1	System	$0
HVAC Equipment Right-Sizing	2.0 Tons	1.5 Tons	-$504.00	0.5	Tons	-$252
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**-$247**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$1,635**

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Exhibit 14: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 4 - Config. B - Gas

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	3.0 ACH50	3.0 ACH50	-	-	-	-
Cooling Equipment	15 SEER Central AC	16 SEER Central AC	$124.00	1	System	$124
Heating Equipment	80 AFUE Gas Furnace	90 AFUE Gas Furnace	$234.68	1	System	$235
Duct Location	Unconditioned Space	Conditioned Space	$2.40	760	Duct Surf. Area (ft²)	$1,825
Water Heater	0.82 UEF Gas Tankless	0.90 UEF Gas Tankless	$245.14	1	Water Heater	$245
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$2,562**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-60, Grade I Installation	R-60, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-20 + R-5 Cont., Grade II Installation	R-20 + R-5 Cont., Grade I Installation	$0.02	2,584	Insul. Surf. Area (ft²)	$64
Foundation Insulation	R-19 Frame Floor, Grade II Installation	R-19 Frame Floor, Grade I Installation	$0.17	1,188	Insul. Surf. Area (ft²)	$204
Windows	U-value: 0.30 / SHGC: 0.40	U-value: 0.30 / SHGC: 0.40	-	-	-	-
Doors	R-3.3	R-5.9	$1.63	42	Door Surf. Area (ft²)	$68
Additional Checklist Measures: Rater Verification						$100
Sub-Total of Thermal Enclosure System Checklist						**$437**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	760	Duct Surf. Area (ft²)	-$1,042
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$200
Sub-Total of HVAC System Checklist						**-$842**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	ENERGY STAR Supply Fan	ENERGY STAR Supply Fan	$0.00	1	System	$0
HVAC Equipment Right-Sizing	2.0 Tons	1.5 Tons	-$504.00	0.5	Tons	-$252
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**-$247**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$1,935**

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Exhibit 15: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 5 - Config. A - Electric

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	3.0 ACH50	3.0 ACH50	-	-	-	-
Cooling Equipment	(See Heating Equipment)	(See Heating Equipment)	-	-	-	-
Heating Equipment	8.8 HSPF / 15 SEER	9.2 HSPF / 16 SEER	$178.05	1	System	$178
Duct Location	Unconditioned Space	Conditioned Space	$2.40	760	Duct Surf. Area (ft²)	$1,825
Water Heater	2.15 UEF HPWH, 60 Gallons	2.20 UEF HPWH, 60 Gallons	$25.08	1	Water Heater	$25
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$2,162**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-60, Grade I Installation	R-60, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-20 + R-5 Cont., Grade II Installation	R-20 + R-5 Cont., Grade I Installation	$0.02	2,584	Insul. Surf. Area (ft²)	$64
Foundation Insulation	R-30 Frame Floor, Grade II Installation	R-30 Frame Floor, Grade I Installation	$0.17	1,188	Insul. Surf. Area (ft²)	$204
Windows	U-value: 0.30 / SHGC: 0.40	U-value: 0.27 / SHGC: 0.40	$0.80	356	Window Area (ft²)	$285
Doors	R-3.3	R-5.9	$1.63	42	Door Surf. Area (ft²)	$68
Additional Checklist Measures: Rater Verification						$100
Sub-Total of Thermal Enclosure System Checklist						**$722**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	760	Duct Surf. Area (ft²)	-$1,042
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$300
Sub-Total of HVAC System Checklist						**-$742**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	ENERGY STAR Exhaust Fan w/ Controls	ENERGY STAR Exhaust Fan w/ Controls	$0.00	1	System	$0
HVAC Equipment Right-Sizing	2.5 Tons	2.0 Tons	-$504.00	0.5	Tons	-$252
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**-$247**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$1,920**

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Exhibit 16: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 5 - Config. B - Gas

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	3.0 ACH50	3.0 ACH50	-	-	-	-
Cooling Equipment	14 SEER Central AC	14 SEER Central AC	-	-	-	-
Heating Equipment	80 AFUE Gas Furnace	95 AFUE Gas Furnace	$701.68	1	System	$702
Duct Location	Unconditioned Space	Conditioned Space	$2.40	760	Duct Surf. Area (ft²)	$1,825
Water Heater	0.82 UEF Gas Tankless	0.90 UEF Gas Tankless	$245.14	1	Water Heater	$245
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$2,905**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-60, Grade I Installation	R-60, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-20 + R-5 Cont., Grade II Installation	R-20 + R-5 Cont., Grade I Installation	$0.02	2,584	Insul. Surf. Area (ft²)	$64
Foundation Insulation	R-30 Frame Floor, Grade II Installation	R-30 Frame Floor, Grade I Installation	$0.17	1,188	Insul. Surf. Area (ft²)	$204
Windows	U-value: 0.30 / SHGC: 0.40	U-value: 0.27 / SHGC: 0.40	$0.80	356	Window Area (ft²)	$285
Doors	R-3.3	R-5.9	$1.63	42	Door Surf. Area (ft²)	$68
Additional Checklist Measures: Rater Verification						$100
Sub-Total of Thermal Enclosure System Checklist						**$722**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	760	Duct Surf. Area (ft²)	-$1,042
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$200
Sub-Total of HVAC System Checklist						**-$842**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	ENERGY STAR Exhaust Fan w/ Controls	ENERGY STAR Exhaust Fan w/ Controls	$0.00	1	System	$0
HVAC Equipment Right-Sizing	2.0 Tons	1.5 Tons	-$504.00	0.5	Tons	-$252
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**-$247**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$2,563**

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Exhibit 17: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 6 - Config. A - Electric

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	3.0 ACH50	3.0 ACH50	-	-	-	-
Cooling Equipment	(See Heating Equipment)	(See Heating Equipment)	-	-	-	-
Heating Equipment	8.8 HSPF / 15 SEER	9.2 HSPF / 16 SEER	$178.05	1	System	$178
Duct Location	Unconditioned Space	Conditioned Space	$2.40	760	Duct Surf. Area (ft²)	$1,825
Water Heater	2.15 UEF HPWH, 60 Gallons	2.20 UEF HPWH, 60 Gallons	$25.08	1	Water Heater	$25
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$2,162**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-60, Grade I Installation	R-60, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-20 + R-5 Cont., Grade II Installation	R-20 + R-5 Cont., Grade I Installation	$0.02	2,584	Insul. Surf. Area (ft²)	$64
Foundation Insulation	R-30 Frame Floor, Grade II Installation	R-30 Frame Floor, Grade I Installation	$0.17	1,188	Insul. Surf. Area (ft²)	$204
Windows	U-value: 0.30 / SHGC: 0.40	U-value: 0.27 / SHGC: 0.40	$0.80	356	Window Area (ft²)	$285
Doors	R-3.3	R-5.9	$1.63	42	Door Surf. Area (ft²)	$68
Additional Checklist Measures: Rater Verification						$100
Sub-Total of Thermal Enclosure System Checklist						**$722**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	760	Duct Surf. Area (ft²)	-$1,042
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$300
Sub-Total of HVAC System Checklist						**-$742**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	ENERGY STAR Exhaust Fan w/ Controls	ENERGY STAR Exhaust Fan w/ Controls	$0.00	1	System	$0
HVAC Equipment Right-Sizing	3.0 Tons	2.0 Tons	-$504.00	1.0	Tons	-$504
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**-$499**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$1,668**

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Exhibit 18: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 6 - Config. B - Gas

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	3.0 ACH50	3.0 ACH50	-	-	-	-
Cooling Equipment	14 SEER Central AC	14 SEER Central AC	-	-	-	-
Heating Equipment	80 AFUE Gas Furnace	95 AFUE Gas Furnace	$701.68	1	System	$702
Duct Location	Unconditioned Space	Conditioned Space	$2.40	760	Duct Surf. Area (ft²)	$1,825
Water Heater	0.82 UEF Gas Tankless	0.90 UEF Gas Tankless	$245.14	1	Water Heater	$245
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$2,905**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-60, Grade I Installation	R-60, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-20 + R-5 Cont., Grade II Installation	R-20 + R-5 Cont., Grade I Installation	$0.02	2,584	Insul. Surf. Area (ft²)	$64
Foundation Insulation	R-30 Frame Floor, Grade II Installation	R-30 Frame Floor, Grade I Installation	$0.17	1,188	Insul. Surf. Area (ft²)	$204
Windows	U-value: 0.30 / SHGC: 0.40	U-value: 0.27 / SHGC: 0.40	$0.80	356	Window Area (ft²)	$285
Doors	R-3.3	R-5.9	$1.63	42	Door Surf. Area (ft²)	$68
Additional Checklist Measures: Rater Verification						$100
Sub-Total of Thermal Enclosure System Checklist						**$722**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	760	Duct Surf. Area (ft²)	-$1,042
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$200
Sub-Total of HVAC System Checklist						**-$842**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	ENERGY STAR Exhaust Fan w/ Controls	ENERGY STAR Exhaust Fan w/ Controls	$0.00	1	System	$0
HVAC Equipment Right-Sizing	1.5 Tons	1.5 Tons	-$504.00	-	Tons	$0
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**$5**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$2,815**

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Exhibit 19: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 7 - Config. A - Electric

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	3.0 ACH50	3.0 ACH50	-	-	-	-
Cooling Equipment	(See Heating Equipment)	(See Heating Equipment)	-	-	-	-
Heating Equipment	8.8 HSPF / 15 SEER	9.2 HSPF / 16 SEER	$178.05	1	System	$178
Duct Location	Unconditioned Space	Conditioned Space	$2.40	760	Duct Surf. Area (ft²)	$1,825
Water Heater	2.15 UEF HPWH, 60 Gallons	2.20 UEF HPWH, 60 Gallons	$25.08	1	Water Heater	$25
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$2,162**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-60, Grade I Installation	R-60, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-20 + R-5 Cont., Grade II Installation	R-20 + R-5 Cont., Grade I Installation	$0.02	2,584	Insul. Surf. Area (ft²)	$64
Foundation Insulation	R-38 Frame Floor, Grade II Installation	R-38 Frame Floor, Grade I Installation	$0.17	1,188	Insul. Surf. Area (ft²)	$204
Windows	U-value: 0.30 / SHGC: 0.40	U-value: 0.27 / SHGC: 0.40	$0.80	356	Window Area (ft²)	$285
Doors	R-3.3	R-5.9	$1.63	42	Door Surf. Area (ft²)	$68
Additional Checklist Measures: Rater Verification						$100
Sub-Total of Thermal Enclosure System Checklist						**$722**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	760	Duct Surf. Area (ft²)	-$1,042
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$300
Sub-Total of HVAC System Checklist						**-$742**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	HRV	HRV	$0.00	1	System	$0
HVAC Equipment Right-Sizing	3.5 Tons	2.5 Tons	-$504.00	1.0	Tons	-$504
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**-$499**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$1,668**

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Exhibit 20: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 7 - Config. B - Gas

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	3.0 ACH50	3.0 ACH50	-	-	-	-
Cooling Equipment	14 SEER Central AC	14 SEER Central AC	-	-	-	-
Heating Equipment	80 AFUE Gas Furnace	95 AFUE Gas Furnace	$701.68	1	System	$702
Duct Location	Unconditioned Space	Conditioned Space	$2.40	760	Duct Surf. Area (ft²)	$1,825
Water Heater	0.82 UEF Gas Tankless	0.90 UEF Gas Tankless	$245.14	1	Water Heater	$245
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$2,905**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-60, Grade I Installation	R-60, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-20 + R-5 Cont., Grade II Installation	R-20 + R-5 Cont., Grade I Installation	$0.02	2,584	Insul. Surf. Area (ft²)	$64
Foundation Insulation	R-38 Frame Floor, Grade II Installation	R-38 Frame Floor, Grade I Installation	$0.17	1,188	Insul. Surf. Area (ft²)	$204
Windows	U-value: 0.30 / SHGC: 0.40	U-value: 0.27 / SHGC: 0.40	$0.80	356	Window Area (ft²)	$285
Doors	R-3.3	R-5.9	$1.63	42	Door Surf. Area (ft²)	$68
Additional Checklist Measures: Rater Verification						$100
Sub-Total of Thermal Enclosure System Checklist						**$722**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	760	Duct Surf. Area (ft²)	-$1,042
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$200
Sub-Total of HVAC System Checklist						**-$842**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	HRV	HRV	$0.00	1	System	$0
HVAC Equipment Right-Sizing	1.5 Tons	1.5 Tons	-$504.00	-	Tons	$0
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**$5**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$2,815**

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Exhibit 21: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 8 - Config. A - Electric

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	3.0 ACH50	3.0 ACH50	-	-	-	-
Cooling Equipment	(See Heating Equipment)	(See Heating Equipment)	-	-	-	-
Heating Equipment	8.8 HSPF / 15 SEER	9.2 HSPF / 16 SEER	$178.05	1	System	$178
Duct Location	Unconditioned Space	Conditioned Space	$2.40	760	Duct Surf. Area (ft²)	$1,825
Water Heater	2.15 UEF HPWH, 60 Gallons	2.20 UEF HPWH, 60 Gallons	$25.08	1	Water Heater	$25
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$2,162**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-60, Grade I Installation	R-60, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-20 + R-5 Cont., Grade II Installation	R-20 + R-5 Cont., Grade I Installation	$0.02	2,584	Insul. Surf. Area (ft²)	$64
Foundation Insulation	R-38 Frame Floor, Grade II Installation	R-38 Frame Floor, Grade I Installation	$0.17	1,188	Insul. Surf. Area (ft²)	$204
Windows	U-value: 0.30 / SHGC: 0.40	U-value: 0.27 / SHGC: 0.40	$0.80	356	Window Area (ft²)	$285
Doors	R-3.3	R-5.9	$1.63	42	Door Surf. Area (ft²)	$68
Additional Checklist Measures: Rater Verification						$100
Sub-Total of Thermal Enclosure System Checklist						**$722**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	760	Duct Surf. Area (ft²)	-$1,042
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$300
Sub-Total of HVAC System Checklist						**-$742**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	HRV	HRV	$0.00	1	System	$0
HVAC Equipment Right-Sizing	4.0 Tons	3.0 Tons	-$504.00	1.0	Tons	-$504
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**-$499**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$1,668**

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Exhibit 22: ENERGY STAR Single-Family New Home v3.2 vs 2021 IECC Home - CZ 8 - Config. B - Gas

Measure	2021 IECC Baseline	ENERGY STAR v3.2	Incremental Unit Cost	Cost Qty	Cost Unit	Inc. Cost
Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						
Infiltration	3.0 ACH50	3.0 ACH50	-	-	-	-
Cooling Equipment	14 SEER Central AC	14 SEER Central AC	-	-	-	-
Heating Equipment	80 AFUE Gas Furnace	95 AFUE Gas Furnace	$701.68	1	System	$702
Duct Location	Unconditioned Space	Conditioned Space	$2.40	760	Duct Surf. Area (ft²)	$1,825
Water Heater	0.82 UEF Gas Tankless	0.90 UEF Gas Tankless	$245.14	1	Water Heater	$245
Lighting	100% Fluorescent Lighting	100% LED Lighting	$0.04	2,376	CFA (ft²)	$97
Dishwasher	Standard Efficiency Dishwasher	ENERGY STAR Dishwasher	$30.83	1	Dishwasher	$31
Refrigerator	Standard Efficiency Refrigerator	ENERGY STAR Refrigerator	$6.41	1	Refrigerator	$6
Sub-Total of Measures Not Required by Checklists & Used to Meet ENERGY STAR ERI Target						**$2,905**
Rater Field Checklist: Thermal Enclosure System						
Ceiling Insulation	R-60, Grade I Installation	R-60, Grade I Installation	-	-	-	-
Above-Grade Wall Insulation	R-20 + R-5 Cont., Grade II Installation	R-20 + R-5 Cont., Grade I Installation	$0.02	2,584	Insul. Surf. Area (ft²)	$64
Foundation Insulation	R-38 Frame Floor, Grade II Installation	R-38 Frame Floor, Grade I Installation	$0.17	1,188	Insul. Surf. Area (ft²)	$204
Windows	U-value: 0.30 / SHGC: 0.40	U-value: 0.27 / SHGC: 0.40	$0.80	356	Window Area (ft²)	$285
Doors	R-3.3	R-5.9	$1.63	42	Door Surf. Area (ft²)	$68
Additional Checklist Measures: Rater Verification						$100
Sub-Total of Thermal Enclosure System Checklist						**$722**
Rater Field Checklist: HVAC System for Track A - HVAC Grading						
Duct Sealing - Total Leakage	4 CFM per 100 ft² of CFA @ Rough-In	4 CFM per 100 ft² of CFA @ Rough-In	-	-	-	-
Duct Insulation	R-8	No Ins.; Ducts in Conditioned Space	-$1.37	760	Duct Surf. Area (ft²)	-$1,042
Additional Checklist Measures: Rater Verification of HVAC Airflow, Watt Draw, and Refrigerant Charge; Bedroom Pressure Balancing; Ventilation System; and Filter						$200
Sub-Total of HVAC System Checklist						**-$842**
Rater Design Review Checklist for Track A - HVAC Grading						
Sub-Total of Rater Design Review Checklist: Rater Collection of HVAC Design Documentation, Rater Review of Design, Confirmation of Partnership						**$25**
HVAC Design Documentation for Track A - HVAC Grading						
Ventilation	HRV	HRV	$0.00	1	System	$0
HVAC Equipment Right-Sizing	1.5 Tons	1.5 Tons	-$504.00	-	Tons	$0
Additional Measures: Completion by HVAC Designer of ANSI / RESNET / ACCA / ICC 310-Compliant Design Report, Plus ENERGY STAR National HVAC Design Supplement						$5
Sub-Total of HVAC Design Documentation						**$5**
Water Management System Builder Requirements						
Sub-Total of Water Management System Builder Requirements: Relative to Code, No Incremental Tasks Are Required						**$0**
Total Incremental Cost for the Home						**$2,815**

Section 3: Incremental Cost & Savings of the National Rater Field Checklist: Thermal Enclosure System

Average Estimated Incremental Cost

As can be seen in Exhibits 7 through 22, the net cost for complying with the Thermal Enclosure System section of the National Rater Field Checklist was estimated to be between $8 and $722, depending on Climate Zone and house configuration, and encompasses both requirements that improve the ERI and those that do not.

Excluding the requirements that improve the ERI, the remaining checklist requirements address reduced thermal bridging requirements and Rater verification of the checklist items and result in a net savings of $50 in Climate Zone 1 and 2, a net savings of $125 in Climate Zone 3, and a net cost of $100 in Climate Zones 4 through 8. Net savings occur in certain Climate Zones because reduced lumber costs, which occur as a result of the reduced thermal bridging requirements, outweigh the third-party verification costs.

The Rationale section, below, discusses the costs for all measures in more detail.

Average Estimated Incremental Savings

The savings for all requirements of the Thermal Enclosure System section of the National Rater Field Checklist that impact the ERI were captured within Ekotrope.

The Rationale section, below, discusses the approach to estimating savings for all measures in more detail.

Rationale

Section 1 of the checklist requires high-performance fenestration. The incremental cost for improving fenestration from the requirements of the 2021 IECC to ENERGY STAR certified windows was captured in Exhibits 7 through 22. The energy savings from this measure were captured within Ekotrope.

Section 1 also requires quality-installed insulation that meets 2021 IECC levels and achieves Grade I insulation installation (or Grade II for surfaces that contain a layer of continuous, air impermeable insulation that meets a minimum specified insulation level).

The insulation levels were modeled to be consistent with the 2021 IECC requirements and, therefore, no incremental cost or energy savings were estimated. In contrast, an incremental cost was estimated for achieving Grade I insulation installation in walls and floors, relative to the Grade II that was assumed for the baseline homes. The installation grade of the baseline homes was based upon the predominant insulation grade, by assembly type, identified for single-family residential homes not indicated as ‘above-code,’ using data from the U.S. Department of Energy Residential Energy Code Field Studies. The incremental cost for this measure was estimated for each home configuration and each relevant assembly (i.e., wall, floor) as shown in Exhibits 7 through 22. The energy savings from Grade I insulation installation were estimated within Ekotrope.

Section 2 requires fully-aligned air barriers in walls, floors, and ceilings. These details are generally implicitly or explicitly required by the 2021 IECC. For example, code requires that the exterior thermal envelope insulation for framed walls be installed in substantial contact and continuous alignment with the building envelope air barrier, that insulation be installed to maintain permanent contact with the underside of subfloor decking, that a minimum of a 1-inch space be provided between insulation and the roof sheathing to not block the free flow of air at the location of the vent, and that air barriers in any dropped ceiling or soffit be substantially aligned with insulation. Because these requirements are required by code, no incremental cost or energy savings were estimated. The one detail not required by code that is required by this section of the checklist is that, in Climate Zones 4 through 8, an air barrier must be included on the interior vertical surface of wall insulation. This is anticipated to be accomplished by achieving Grade I insulation installation, per Section 1, which will minimize gaps, voids, and compressions that would prevent alignment with drywall. Therefore, no additional incremental cost or energy savings were estimated for this section.

Section 3 requires the use of details that reduce thermal bridging. Several of these details are required by the 2021 IECC, such as extending full height uncompressed insulation over the wall top plate at the eaves, and requiring that access be provided to all equipment in attics that prevents damaging or compressing the insulation beneath.

However, Section 3 also requires that a strategy be selected to reduce thermal bridging in above-grade walls. For this analysis, the advanced framing option was selected for Climate Zones 1 through 3. In Climate Zones 4 through 8, the continuous insulation option was selected instead because the 2021 IECC prescriptive path requires the use of continuous wall insulation.

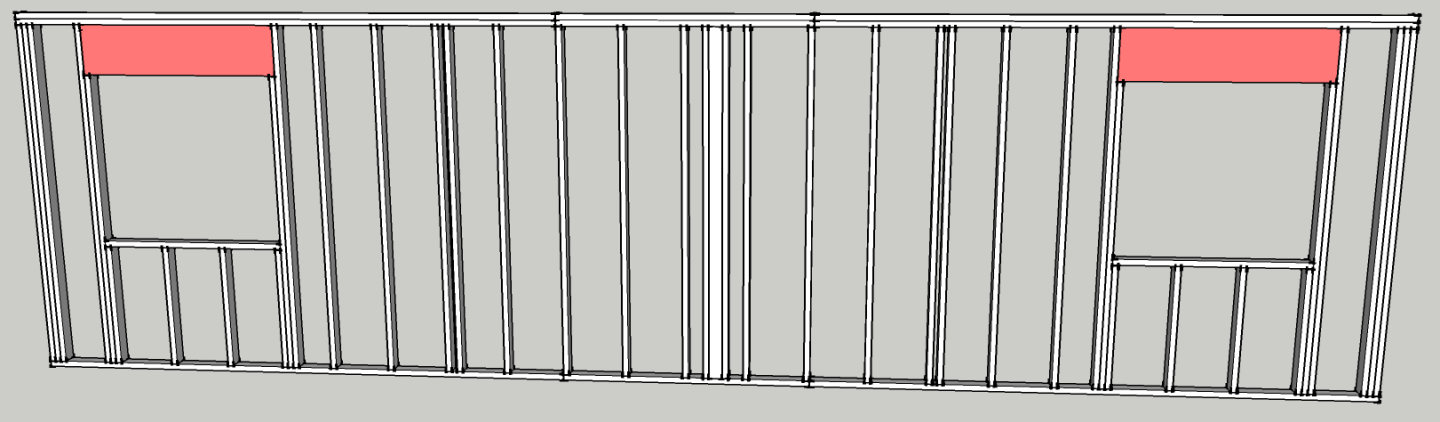
ENERGY STAR Single-Family New Homes, Version 3.2 (Rev. 12)
Cost & Savings Estimates

The cost and energy savings associated with the advanced framing option were estimated using a reduced framing fraction of 19%, rather than the default of 23%, in each home.

Code requires that all headers be insulated, which generally aligns with the checklist requirement to insulate all headers above windows and doors ≥ R-3 for 2x4 framing or equivalent cavity width, and ≥ R-5 for all other assemblies (e.g., with 2x6 framing). The remaining advanced framing details are not required by code, including that corners use modified framing or high-density insulation to achieve ≥ R-6, that framing be limited at all windows & doors, that all interior / exterior wall intersections be insulated to the same R-value as the rest of the exterior wall, and that extraneous use of framing be minimized. These details are achieved by reducing the amount of lumber used in the walls, resulting in a reduced framing fraction.

To estimate the impact on framing fraction from these details, a 30'x8' wall was modeled with and without these details. The wall below was modeled without these features and has a framing fraction of 23%.

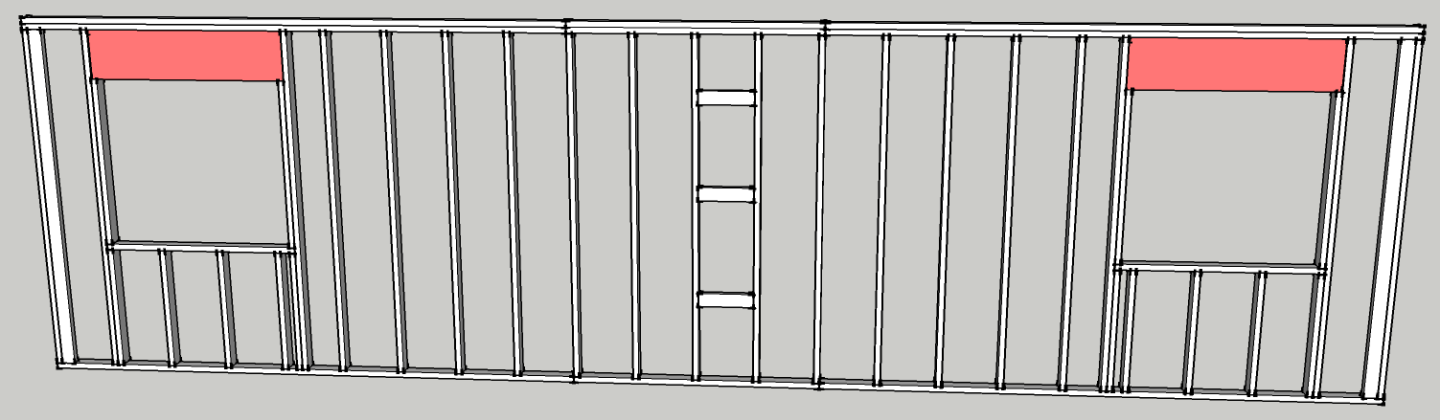
30' Long by 8' High 2x4 16" OC Standard Wall with Two Windows (4'-1" x 3'-8.5")



Top & Bottom Plates:	3 * 30' * 1.5"	= 11.3 sq. ft.
King Studs:	23 * 7'-7.5" * 1.5"	= 21.9 sq. ft.
Int. / Ext. Wall Intersection:	7'-7.5" * 3.5"	= 2.2 sq. ft.
Exterior Wall Corner:	4 * 7'-7.5" * 1.5"	= 3.8 sq. ft.
Window Header:	2 * 4'-4" * 11.5"	= 8.3 sq. ft.
Jacks / Trimmers:	4 * 6'-8" * 1.5"	= 6.0 sq. ft.
Window Sills:	2 * 4'-1" * 1.5"	= 1.0 sq. ft.
Cripples:	8 * 2'-8.5" * 1.5"	= 2.7 sq. ft.
Total Wood Area		= 54.6 sq. ft.
Total Wall Area		= 240 sq. ft.
Framing Fraction	= 54.6 / 240	= 23%

The wall below was modeled with these features and has a framing fraction of 18%.

30’ Long by 8’ High 2x4 16” OC ENERGY STAR Wall with Two Windows (4’-1” x 3’-8.5”)



Top & Bottom Plates:	3 * 30’ * 1.5”	= 11.3 sq. ft.
King Studs:	19 * 7’-7.5” * 1.5”	= 18.1 sq. ft.
Int. / Ext. Wall Intersection:	(Insulated Ladder Wall)	= 0 sq. ft.
Exterior Wall Corner:	(Insulated 3-Stud Corner)	= 0 sq. ft.
Window Header:	2 * 4’-4” * 11.5”	= 8.3 sq. ft.
Jacks / Trimmers:	4 * 3’-10” * 1.5”	= 1.9 sq. ft.
Window Sills:	2 * 4’-4” * 1.5”	= 1.1 sq. ft.
Cripples:	10 * 2’-8.5” * 1.5”	= 3.4 sq. ft.
Total Wood Area		= 44.1 sq. ft.
Total Wall Area		= 240 sq. ft.
Framing Fraction	= 44.1 / 240	= 18%

Recognizing that not all walls will achieve the exact same reduction in framing fraction, for this analysis the baseline and improved framing fraction values were aligned with the default framing fractions in ANSI / RESNET / ICC 301-2019, December 2018. Table 4.2.2(5) of this Standard defines a default framing fraction of 23% for 16 inch on-center Standard walls and 19% for 16 inch on-center Advanced walls. Energy savings from this reduction in framing were estimated within Ekotrope. In addition to saving energy, the lower framing fraction will reduce material costs. To estimate the material cost savings, the net wall area of each home modeled in Climate Zones 1 through 3 was multiplied by 23% for the baseline home and by 19% for the ENERGY STAR certified home. The resulting lumber area was converted to thousand board-feet and multiplied by the material cost for 2x4 8.5 ft. high studs in Climate Zones 1 and 2 and 2x6 8.5 ft. high studs in Climate Zone 3. This resulted in material savings of $130 per home in Climate Zones 1 and 2 and $204 in Climate Zone 3.

For Climate Zones 4 through 8, where the continuous insulation option was selected, there were no incremental costs and no incremental savings relative to the baseline homes, which were also configured with continuous insulation to meet the prescriptive path of the 2021 IECC.

Section 4 requires air sealing of penetrations, cracks, and other openings in the home’s thermal enclosure system. These details largely overlap with the 2021 IECC, which requires that all joints, seams, and penetrations; other sources of infiltration; and utility penetrations be caulked, gasketed, weather-stripped or otherwise sealed with an air barrier material, suitable film or solid material. Code specifically requires that the junction of the foundation and sill plate be sealed (but does not require a gasket); that the space between window/door jambs and framing be sealed; and that duct shafts, utility penetrations, knee walls and flue shafts opening to exterior or unconditioned space be sealed. For recessed luminaires, code requires that they be IC-rated and labeled as meeting ASTM E283 and be sealed with a gasket or with caulk between the housing and the interior wall or ceiling covering. Finally, code requires that access doors from conditioned spaces to unconditioned spaces be weather-stripped and insulated to a level equivalent to the insulation on the surrounding surfaces.

As a result of these code requirements, no incremental costs were estimated for the air sealing measures in Section 4. Instead, it was assumed that these requirements will largely be met to achieve the code-required infiltration limit of 3 or 5 ACH50. Also note that no incremental cost was estimated for the blower door test, as it was assumed that a blower door test will be used to demonstrate compliance with the code-required infiltration limit of 3 or 5 ACH50. However, an

incremental cost was estimated in Exhibits 7 through 10 to account for additional air sealing, beyond that required by Section 4, to reduce the infiltration rate in Climate Zones 1 and 2 from 5 ACH50 to the level included in the ENERGY STAR Version 3.2 Reference Design. Included in this cost was the one air sealing detail from the checklist that is not required by code – the inclusion of a gasket between the sill plate and foundation.

Finally, despite the fact that many of the requirements in the checklist are also required by code, the 2021 IECC does not require third-party verification of these details by a Rater. It is estimated that this will require two inspections plus transportation time. Combined, this was estimated to take an average of 1.5 hours per home. At a labor rate of $60 per hour for a Rater, this was estimated to cost $91.

In summary, the costs for the measures that impact the ERI are itemized in Exhibits 7 through 22. The additional costs for the reduced thermal bridging requirements and Rater verification of the checklist sum to -$39 in Climate Zones 1 and 2, -$113 in Climate Zone 3, and $91 in Climate Zones 4 through 8, and were rounded to the nearest $25, for a final estimated cost of -$50, -$125, and $100 respectively. Note that negative costs are estimated for Climate Zones 1 through 3 because the savings from reduced material costs that result from a lower framing fraction more than offset the added costs required for third-party verification.

Section 4: Incremental Cost & Savings of the National Rater Field Checklist: HVAC System

Average Estimated Incremental Cost

For this analysis, it was assumed that Track A: HVAC Grading had been selected to satisfy the HVAC design and commissioning requirements. As part of this track, the Rater is required to complete three additional field assessment tasks, per ANSI / RESNET / ACCA / ICC 310.

As can be seen in Exhibits 7 through 22, the net cost for complying with the HVAC System sections of the National Rater Field Checklist was estimated to be between -$842 and -$481, depending on Climate Zone and house configuration, and encompasses both requirements that improve the ERI and those that do not.

Excluding the requirements that impact the ERI, the remaining checklist requirements address Rater assessment of the blower fan airflow, blower fan watt draw, and refrigerant charge, per ANSI / RESNET / ACCA / ICC 310, as well as Rater verification of the bedroom pressure balancing, ventilation system, and filter, which are estimated to cost $307 for both electric and gas homes in Climate Zones 1 through 3; for electric homes, $307 in Climate Zone 4, $292 in Climate Zones 5 and 6, and $307 in Climate Zones 7 & 8; and for gas homes, $207 in Climate Zone 4, $192 in Climate Zones 5 & 6, and $207 for Climate Zones 7 and 8.

The Rationale section, below, discusses the costs for all measures in more detail.

Had Track B: HVAC Credential been selected to satisfy the HVAC design and commissioning requirements instead of Track A: HVAC Grading, the Rater would not have been required to complete the three field assessment tasks per ANSI / RESNET / ACCA / ICC 310. Instead, they would have been required to verify that the equipment model numbers match the design documentation and to measure static pressure. Rounded to the nearest $25, these requirements would have resulted in a cost of $25, rather than $50 for the Rater to complete the field assessment tasks associated with Track A. However, the HVAC contractor would have been required to complete additional tasks as discussed in Section 7.

Average Estimated Incremental Savings

The three field assessment tasks completed by the Rater as part of Track A: HVAC Grading help ensure that the HVAC system has been properly designed and installed. The savings that result from this proper installation are reflected in the ERI of the home and were therefore captured within Ekotrope.

The remaining requirements of this section simply help ensure that the heating, cooling, ventilation, and duct system requirements contained in the National HVAC Design Supplement to Std. 310 for Dwellings & Units have been met. Therefore, no additional energy savings were associated with these requirements.

Had Track B: HVAC Credential been selected to satisfy the HVAC design and commissioning requirements instead of Track A: HVAC Grading, the savings would have been identical because Track B also requires proper design and installation.

Rationale

When Track A: HVAC Grading has been selected, Section 5 of the National Rater Field Checklist requires Raters to complete three additional field tasks, per ANSI / RESNET / ACCA / ICC 310: an assessment of blower fan airflow, blower fan watt draw, and refrigerant charge.

During a pilot of the standard, Raters reported that these three tasks took, on average, a total of 26 minutes per system. For this analysis, this average time was doubled to 52 minutes per home to account for two-system homes, the potential for re-testing, and to account for process inefficiencies because the standard is relatively new. At a labor rate of $60 per hour for a Rater, this results in an incremental cost of $52.

The energy savings associated with proper installation are reflected in the ERI of the home. The baseline homes were configured with the default Grade III installation for blower fan airflow, blower fan watt draw, and refrigerant charge because no HVAC installation quality grade is defined or required by code. ENERGY STAR certified homes are allowed to be certified with Grade I or II airflow and watt draw. The refrigerant charge is generally required to achieve Grade I; however, an exemption is provided under certain circumstances. Therefore, savings were conservatively estimated by configuring the homes with Grade II airflow and watt draw and Grade III refrigerant charge. These are the worst-performing grades allowed while still permitting a home to be ENERGY STAR certified.

Had Track B: HVAC Credential been selected to satisfy the elements related to HVAC design and installation, the Rater would have been required to check the manufacturer and model number of the installed equipment against the National HVAC Design Report. It is estimated that this review would have taken 5 minutes per home. At a labor rate of $60 per hour for a Rater, the estimated cost is $5. Raters would also have been required to duplicate the static pressure test

conducted by the contractor. It is estimated that the Rater could conduct this test while on-site for their final inspection and complete the test in approximately 10 minutes. Therefore, it is estimated that this would have cost $10 at a labor rate of $60 per hour. In total, these Rater tasks for Track B: HVAC Credential would have summed to $15. The same energy savings would have been assumed as for Track A because both tracks are designed to result in HVAC systems that are properly designed and installed.

Section 6 requires, in part, that the duct system be visually inspected for proper installation. It is expected that this visual inspection will occur concurrent with the visual inspections conducted for the Thermal Enclosure System section of the National Rater Field Checklist and therefore no incremental cost was estimated for this task.

Next, Section 6 requires that the bedrooms in the home be pressure-balanced. Assuming that pressure relief is provided by a transfer grille, at a cost of $46 per grille (including two interior registers, a galvanized frame, and a sound baffle), the total cost for this feature was estimated to be $138 for a three-bedroom home, plus 30 minutes of installation by an HVAC Assistant at a labor rate of $60 per hour, equal to $30. In addition, the Rater must verify that the pressure balancing requirements have been met. Estimating 5 minutes per bedroom, at a labor rate of $60 per hour, the cost for verification was $15. These three costs add to a total of $183.

Section 6 also requires that duct insulation levels be visually verified. While the home configurations analyzed do not contain duct insulation because the ducts are in conditioned space, it is expected that this visual inspection for other home configurations would occur concurrent with the visual inspections conducted for the Thermal Enclosure System section of the National Rater Field Checklist and therefore no incremental cost was estimated for this task.

Finally, Section 6 requires that ducts be tested and verified to meet air leakage limits. The 2021 IECC also requires this for the baseline home configurations analyzed. Therefore, no incremental cost was assumed for testing. In addition, the duct leakage limits in the 2021 IECC for testing at rough-in are equally stringent to those in the National Rater Field Checklist. Therefore, no incremental cost was assumed for duct sealing.

Section 7 requires the whole-house mechanical ventilation rate to be measured. The 2021 IECC also requires testing of mechanical ventilation systems. Because Rater-verification of the ventilation rate can also be used to satisfy the code requirement, no incremental cost was assumed for this task.

Section 7 also defines whole-house mechanical ventilation control, fan efficiency, inlet location, and sound requirements, which are not addressed in the 2021 IRC. Not all of the requirements will apply to all homes. Therefore, these quick visual inspections were estimated to take 5 minutes per home. At a labor rate of $60 per hour, the cost for verification was $5.

Section 8 primarily defines airflow requirements for kitchen and bath exhaust fans. While the 2021 IRC requires bath and kitchen exhaust fan airflow rates that are consistent with the requirements of the National Rater Field Checklist, it does not require a third-party to verify the airflow rates. Because airflow must be verified by the Rater for ENERGY STAR certified homes, an incremental cost was estimated to purchase a bath fan with 70 CFM of rated airflow rather than 50 CFM, to help ensure compliance. This incremental cost was estimated to be $15 per fan. Two bathroom fans are assumed to be present in the home. In Climate Zones 1 through 4, 7, and 8, both fans are upgraded to meet this requirement, resulting in a total cost of $30. In Climate Zones 5 and 6, only one fan is upgraded for a total cost of $15 because the other is upgraded as part of the whole-house mechanical ventilation system, as accounted for with the National HVAC Design Supplement to Std. 310 for Dwellings & Units. Estimating that it takes 5 minutes to measure each bath fan, 10 minutes are required to complete this test. Due to the complexity of some kitchen exhaust fan inlets, it was estimated that it will take 10 minutes to verify the kitchen exhaust requirements. In total, this equals 20 minutes. At a labor rate of $60 per hour, this equates to $20. Because sound limits are now recommended, rather than required, for all but continuously-running bath fans, no incremental cost was assumed to achieve these limits.

Section 9 defines filtration requirements. The 2021 IRC does not explicitly require the installation of a filter, that all return air and mechanically supplied outdoor air pass through filter prior to conditioning, or that the filter access panel include a gasket or comparable sealing mechanism and fit snugly against the exposed edge of the filter when closed to prevent bypass. However, a filter is routinely included with new equipment and can be installed to meet these requirements with little to no added effort or cost. Therefore, only an incremental cost of $12 was estimated to upgrade the filter from MERV 2 to MERV 6. In addition, visual verification of these requirements by the Rater was estimated to take 5 minutes. At a labor rate of $60 per hour, this equates to $5.

Section 10 defines combustion safety requirements. Unlike the National Rater Field Checklist, the 2021 IRC does not explicitly require power-vented or direct-vented combustion appliances, nor does it explicitly require combustion safety testing. However, with the selection of the service water heating upgrade option to meet the 2021 IECC, the resulting water heating equipment (i.e., an instant gas water heater, which would require power-venting, or electric heat pump water heater) would satisfy these requirements. For space-heating appliances in Climate Zones 1 through 3, it was

assumed that the most common compliance path would be to move the combustion appliances outside the pressure boundary, either into the unconditioned attic or the garage, or to use electric equipment. In Climate Zones 4 through 8, the most common compliance path would be to use power-vented or direct-vented combustion appliances or electric space heating equipment. The cost associated with upgrading to a direct-vented furnace was accounted for in Exhibits 14 through 22 for the gas fueled homes in Climate Zones 4 through 8. For these home configurations, it was assumed that a “B-vent” metal combustion vent was replaced with a PVC side-wall combustion inlet and vent system, resulting in savings of $100.

The remainder of Section 10 defines requirements for fireplaces that are not mechanically-drafted or direct-vented and for unvented combustion appliances other than cooking ranges or ovens. On average, it is not expected that homes will have combustion appliances of these types and, therefore, no incremental cost was assumed for compliance.

In summary, the costs for the measures that impact the ERI are itemized in Exhibits 7 through 22. The remaining checklist requirements address Rater verification of the HVAC system installation quality, bedroom pressure balancing, ventilation system, and filter. For electric homes, these sum to $307 in Climate Zones 1 through 4, 7, and 8, and to $292 in Climate Zones 5 and 6. For gas homes, these sum to $307 in Climate Zones 1 through 3, to $207 in Climate Zones 4, 7 and 8, and to $192 in Climate Zones 5 and 6. These were rounded to the nearest $25, for a final estimated cost of $300 for electric homes in all climate zones and gas homes in Climate Zones 1 through 3, and $200 for gas homes in Climate Zones 4 through 8.

Had Track B: HVAC Credential been selected, the remaining checklist requirements would have addressed Rater verification of the equipment model numbers and static pressure, in lieu of HVAC system installation quality per ANSI / RESNET / ACCA / ICC 310. All other tasks would have remained the same. For electric homes, these would have summed to $270 in Climate Zones 1 through 4, 7 and 8 and to $255 in Climate Zones 5 and 6. For gas homes, these would have summed to $270 in Climate Zones 1 through 3, to $170 in Climate Zones 4, 7, and 8, and to $155 in Climate Zones 5 and 6. If rounded to the nearest $25, this would have resulted in a final estimated cost of $275 for electric homes in Climate Zones 1 through 4, 7 and 8, and to $250 in Climate Zones 5 and 6; to $275 for gas homes in Climate Zones 1 through 3, $175 for gas homes in Climate Zones 4, 7 and 8, and to $150 for gas homes in Climate Zones 5 and 6.

Section 5: Incremental Cost & Savings of the National HVAC Design Supplement to Std. 310 for Dwellings & Units

Average Estimated Incremental Cost

For this analysis, it was assumed that Track A: HVAC Grading had been selected to satisfy the HVAC design and commissioning requirements. As part of this track, the HVAC designer is required to complete a design report compliant with ANSI / RESNET / ACCA / ICC 310, plus the ENERGY STAR National HVAC Design Supplement to Std. 310 for Dwellings & Units.

As can be seen in Exhibits 7 through 22, the net cost for completing the HVAC design report compliant with ANSI / RESNET / ACCA / ICC 310, plus the ENERGY STAR National HVAC Design Supplement, and ensuring that the design meets the underlying requirements contained within, was estimated to range between -$499 and $5, depending on Climate Zone and house configuration, and encompasses both requirements that impact the ERI and those that do not.

Excluding the requirements that impact the ERI, the only remaining requirement is the completion of the design documentation by the designer, which is estimated to cost $5 based upon current labor rates.

The Rationale section, below, discusses the costs for all measures in more detail.

Had Track B: HVAC Credential been selected to satisfy the HVAC design and commissioning requirements instead of Track A: HVAC Grading, the costs would have been identical because Track B requires the completion of design documentation, and underlying design requirements, that are substantially the same as Track A.

Average Estimated Incremental Savings

Because code requires that heating and cooling design loads be properly calculated, that equipment capacity be properly selected, and that ducts be properly designed, no energy savings were associated with these requirements.

In addition, no energy impacts were associated with meeting the filter requirements of ASHRAE 62.2-2010. However, energy use required to meet the ventilation requirements of ASHRAE 62.2-2010 was captured within Ekotrope.

The Rationale section, below, discusses all measures in more detail.

Had Track B: HVAC Credential been selected to satisfy the HVAC design and commissioning requirements instead of Track A: HVAC Grading, the savings would have been identical because Track B also requires proper load calculation, equipment selection, duct design, and compliance with ASHRAE 62.2-2010.

Rationale

RESNET maintains a template for an HVAC design report that is compliant with ANSI / RESNET / ACCA / ICC 310. For Track A: HVAC Grading, this template or an equivalent report containing the same information must be completed.

Section 1 of this template requires the designer to provide a basic overview of their design. While not explicitly required by the 2021 IECC, providing this information does not add any incremental cost other than the time required to complete the paperwork.

Section 2 of the template requires the designer to document basic information about any whole-house mechanical ventilation systems included in the design. While ANSI / RESNET / ACCA / ICC 310 itself does not require that a ventilation system be included, both the 2021 IRC and ENERGY STAR Version 3.2 do.

In Climate Zones 1 through 4, a ventilation system was modeled comprised of an inline supply ventilation fan with an on-board controller for ASHRAE 62.2 compliance and an integrated motorized fresh air damper. Such a system can be ducted to provide fresh air directly to one or more rooms or provide ventilation air to the return-side of the HVAC system. The on-board controller can optimize run-time to coincide with times when the HVAC fan is in heating or cooling mode and can optionally turn on the HVAC blower fan to run simultaneously with the ventilation system during the remaining run-time. For this analysis, it was assumed that the system is connected to the return-side of the HVAC system, optimizes run-time to coincide with the HVAC system, and does not turn on the HVAC blower fan during the remaining run-time.

For Climate Zones 5 and 6, a ventilation system was modeled comprised of an ENERGY STAR certified bathroom exhaust fan and bath fan controller. Homes with this system use the bathroom exhaust fan to provide all required ventilation.

For Climate Zones 7 and 8, a ventilation system was modeled comprised of an HRV. The 2021 IECC requires use of an HRV or ERV in these locations.

No incremental costs were estimated for these ventilation systems because the 2021 IRC also requires a whole-house system. However, the energy impact from the ventilation load and the fan power were captured within Ekotrope.

Sections 3 through 5 of the template require that designers properly calculate heating and cooling design loads (generally per ACCA Manual J), and document key characteristics of the selected heating and cooling equipment and the duct system design. No incremental costs or savings were estimated specifically for these design tasks, as they are also required by the 2021 IRC.

The ENERGY STAR National HVAC Design Supplement to Std. 310 for Dwellings & Units must also be completed for Track A: HVAC Grading. It requires the designer to provide supplemental design information not required by ANSI / RESNET / ACCA / ICC 310.

Section 1 simply requires several of the same design overview fields as the ANSI / RESNET / ACCA / ICC 310 template so that the two documents can be linked together.

Section 2 requires additional details about the whole-house mechanical ventilation systems included in the design, to ensure compliance with ASHRAE 62.2, as required for ENERGY STAR v3.2.

Section 3 requires basic information about local mechanical exhaust systems, also to ensure compliance with ASHRAE 62.2.

Section 4 requires capacity and sizing information about air conditioners, heat pumps, and furnaces to ensure compliance with ENERGY STAR v3.2 sizing limits. These limits are based upon ACCA Manual S, but for the ENERGY STAR program include more lenient allowances in some instances. In general, both code and the ENERGY STAR program require that equipment be right-sized. In many climate zones, this resulted in a smaller air conditioner and heat pump capacity for ENERGY STAR certified homes than the baseline homes. This occurred because of the reduced load resulting from the efficiency measures used to meet the program's performance target, such as improved insulation installation, reduced infiltration, and upgraded fenestration. The capacity reduction is conveyed in half ton increments, reflecting generally available equipment sizes. The values shown in Exhibit 23 were used and reflect the general trends in capacity reduction found in this analysis.

Exhibit 23: Equipment Capacity Reduction of ENERGY STAR Homes Relative To Baseline Homes

CZ	Heat Pump Reduction (Tons)	Air Conditioner Reduction (Tons)
1	1.0	1.0
2	0.5	0.5
3	0.5	0.5
4	0.5	0.5
5	0.5	0.5
6	1.0	0
7	1.0	0
8	1.0	0

The cost savings from this reduction in equipment size is included in Exhibits 7 through 22.

While not required by the 2021 IECC, providing the information required by the supplement does not add any incremental cost other than the time required to complete the paperwork.

In summary, the costs for the measures that impact the ERI (i.e., the inclusion of a whole-house mechanical ventilation system and right-sized HVAC equipment) are itemized in Exhibits 7 through 22. The additional cost for the completion of an HVAC design report compliant with ANSI / RESNET / ACCA / ICC 310, plus the ENERGY STAR National HVAC Design Supplement to Std. 310 for Dwellings & Units, by the designer is estimated to be $5. EPA has worked to automate this task, such that it requires negligible time or money to complete. However, some designers still complete this task manually. Filling out one HVAC design report plus ENERGY STAR supplement manually is estimated to take 20 minutes. This might be done multiple times for one plan if multiple designs are needed to accommodate options. On the other hand, one HVAC design might be used multiple times in a production environment where the same house plan and HVAC design is built repeatedly. Assuming that the average HVAC design is used 5 times, the average time per house is 4 minutes. At a labor rate of $97 per hour, the total labor cost equates to $6, which was rounded to the nearest $5, for a final estimated cost of $5.

Section 6: Incremental Cost & Savings of the National Rater Design Review Checklist

Average Estimated Incremental Cost

For this analysis, it was assumed that Track A: HVAC Grading had been selected to satisfy the HVAC design and commissioning requirements. As a result, the Rater is required to complete the Track A: HVAC Grading portion of the National Rater Design Review Checklist. These requirements do not directly affect the ERI. As can be seen in Exhibits 7 through 22, the net cost for complying with the National Rater Design Review Checklist was estimated to be $25.

The Rationale section, below, discusses the costs for all measures in more detail.

Had Track B: HVAC Credential been selected to satisfy the HVAC design and commissioning requirements instead of Track A: HVAC Grading, the costs would have been identical because Track B requires a substantially equivalent design review.

Average Estimated Incremental Savings

While the tasks required on the National Rater Design Review Checklist add value, there are no estimated savings directly associated with them.

Rationale

The National Rater Design Review Checklist requires the Rater to verify that the builder is an ENERGY STAR partner and to verify that the fenestration and insulation specified in the home energy rating file complies with the program's requirements. In addition, for Track A: HVAC Grading, the Rater is required to collect an HVAC design report compliant with ANSI / RESNET / ACCA / ICC 310, plus the ENERGY STAR National HVAC Design Supplement to Std. 310 for Dwellings & Units. The Rater must review this documentation to ensure that the documented HVAC design falls within the tolerances of ANSI / RESNET / ACCA / ICC 310 and the ENERGY STAR program.

Therefore, the incremental costs of this checklist are all related to the labor of the Rater. The estimated time required to verify that the builder is an ENERGY STAR partner is 1 minute. Verification that the fenestration and insulation meets program requirements automatically occurs within the Approved Software Rating Tool, so no time is estimated for compliance. Assuming that the same HVAC design is built five times, and that the time required to collect the required HVAC design documentation is one hour, the average time per house to complete this task is estimated to be 12 minutes. Lastly, by again assuming that one set of design documentation is needed per five homes constructed, and estimating that 30 minutes are required to review the documentation, the estimated time to review the HVAC design documentation is 6 minutes per home.

In summary, the tasks on the National Rater Design Review Checklist require 19 minutes per home. At a labor rate of $60 per hour, the total labor cost equates to $19. This was rounded to the nearest $25, for a final estimated cost of $25.

Section 7: Incremental Cost & Savings of the National HVAC Commissioning Checklist

Average Estimated Incremental Cost

For this analysis, it was assumed that Track A: HVAC Grading had been selected to satisfy the HVAC design and commissioning requirements. Therefore, completion of the National HVAC Commissioning Checklist would not have been required.

Had Track B: HVAC Credential been selected to satisfy the HVAC design and commissioning requirements instead of Track A: HVAC Grading, an HVAC contractor credentialed by an EPA-recognized HVAC Quality Installation Oversight Organization (H-QUITO) would have been required to complete the checklist, resulting in an average incremental cost of $75.

The Rationale section, below, discusses the costs for all measures in more detail.

Average Estimated Incremental Savings

The three field assessment tasks completed by the Rater as part of Track A: HVAC Grading help ensure that the HVAC system has been properly designed and installed. The savings that result from this proper installation are reflected in the ERI of the home and were therefore captured within Ekotrope.

Had Track B: HVAC Credential been selected to satisfy the HVAC design and commissioning requirements instead of Track A: HVAC Grading, the savings would have been identical because Track B also requires proper design and installation.

Rationale

Under Track B: HVAC Credential, contractors are required to be credentialed by an H-QUITO prior to installation of HVAC systems and completion of the National HVAC Commissioning Checklist. Two H-QUITO's are available, each with its own fee structure and an overall cost per home that is dependent on the number of homes that the contractor installs systems in annually. The number of ENERGY STAR homes certified in 2020 divided by the number of credentialed contractors available that year is equal to 83 homes per contractor. Using this average results in credential costs of approximately $7 per home after the first year of being credentialed, assuming no significant quality assurance issues.

Section 1 of the National HVAC Commissioning Checklist requires the contractor to provide a basic overview of the system they are commissioning. While not explicitly required by the 2021 IECC, providing this information does not add any incremental cost other than the time required to complete the paperwork.

The remainder of the National HVAC Commissioning Checklist requires two HVAC commissioning tests to be completed, which are not explicitly required by the 2021 IRC. In Section 2, the contractor is required to verify the refrigerant charge. Using a digital manifold, this is estimated to take 20 minutes. In Section 3, the contractor is required to assess the air handler airflow using the measured static pressure and fan-speed setting. This was estimated to take 15 minutes. Section 4 recommends, but does not require, that the contractor measure and balance the register airflow. Because this is only a recommendation, no incremental cost was assumed. Lastly, it was estimated to take 5 minutes to fill out the checklist with the information gathered in the field. The total time for commissioning (i.e., measuring refrigerant charge, using static pressure and the fan-speed setting to approximate air handler airflow, and completing the checklist) was estimated to take 40 minutes. At a labor rate of $97 per hour for an HVAC Contractor, this translates to $65. With the addition of the $7 per home credential fee, this sums to a total cost of $72. This was rounded to the nearest $25, which is $75.

Section 8: Incremental Cost & Savings of the National Water Management System Bldr. Req.'s

Average Estimated Incremental Cost

The requirements of the National Water Management System Builder Requirements do not impact the ERI. Furthermore, because they are also required by the 2021 IRC, there is estimated to be no net cost for meeting these requirements.

The Rationale section, below, discusses the measures in more detail.

Average Estimated Incremental Savings

Energy savings were not anticipated as a result of implementing the National Water Management System Builder Requirements, as the measures implemented are focused on water management details.

Rationale

Section 1 defines water management details applicable to the site and to the home's foundation, Section 2 defines details applicable to the wall assembly, Section 3 defines details applicable to the roof assembly, and Section 4 defines requirements that help manage water in building materials. These requirements are aligned with the requirements of the 2021 IRC. Therefore, no incremental cost was estimated for meeting these code-required checklist items. Furthermore, since the National Water Management System Builder Requirements is simply a list of requirements and not a formal checklist that must be completed, there is no cost associated with documenting compliance with the requirements.

Section 9: Cost References

A. Thermal Enclosure System

Air Sealing

Reference	NREL National Residential Efficiency Measures Database v3.1.0, accessed via BEopt 2.8.0.0
Accessed	August 2021
Notes	• Material costs and new construction installation labor costs for infiltration rates of 3 and 5 ACH50 were taken from this database.

Doors

Reference	NREL National Residential Efficiency Measures Database v3.1.0, accessed via BEopt 2.8.0.0
Accessed	August 2021

Notes	• Material costs and new construction installation labor costs were taken from this database.
	• Costs linearly interpolated by U-factor using the following entries:
	  ○ Swinging Entry, Opaque, Wood Frame, U-Value: 0.48
	  ○ Swinging Entry, Opaque, Fiberglass Frame, U-Value: 0.20

Framing

Reference	RS Means Construction Cost Data 2010
Accessed	August 2021
Notes	• Framing costs for the advanced framing strategy are based upon RS Means Line Number 06 11 10.40 6145, representing 2x4 8.5 ft. high studs in Climate Zones 1 and 2, and RS Means Line Number 06 11 10.40 6165, representing 2x6 8.5 ft. high studs in Climate Zones 3. Note that the advanced framing strategy was not analyzed for Climate Zones 4 through 8. • All costs prorated by 22.2% to adjust for inflation between 2010 and 2019 using BLS Producer Price Index Materials for Construction cost data.

Insulation Installation

Reference	RS Means Construction Cost Data 2010
Accessed	August 2021

Notes	• Incremental cost for going from Grade II to Grade I wall insulation:
	  ○ In Climate Zones 1-2: Assumed to cost 17.5% more than labor rate for RS Means Line Number 07 21 16.20 0080, representing batt insulation,
	  ○ In Climate Zones 3-8: Assumed to cost 12.5% more than labor rate for RS Means Line Number 07 21 26.10 0020, representing blown insulation.
	• Incremental cost for going from Grade II to Grade I floor insulation assumed to cost 25% more than labor rate for RS Means Line Number 07 21 16.10 2215, representing blown insulation.
	• All labor rates prorated by 24.8% to adjust for inflation between 2010 and 2019 using BLS Current Employment Statistics Survey hourly earnings data.

Windows

Reference	ENERGY STAR Windows V7.0 Criteria Analysis Report, July 2021. https://www.energystar.gov/sites/default/files/asset/document/ES_Residential_WDS_Draft%201_Criteria%20Analysis%20Report.pdf
Accessed	August 2021

Notes	• Costs were taken from Table 7, which provides the incremental consumer ('retail') cost over the market baseline for a variety of U-factors and SHGC values, assuming a 15 square foot window. • Specifically, the incremental costs in Climate Zones 5 through 8 were determined by subtracting the retail cost of a window with a 0.28-0.31 U-factor and a SHGC > 0.25 from the retail cost of a window with a 0.27 U-factor and a SHGC > 0.25. • Note that the no incremental cost was calculated in Climate Zones 1 through 4, because there was no upgrade in window performance relative to code.

B. Space Conditioning Equipment & Filter

Air-Source Heat Pump

Reference	NREL National Residential Efficiency Measures Database v3.1.0, accessed via BEopt 2.8.0.0
Accessed	August 2021
Notes	• Material costs and new construction installation labor costs were taken from this database for equipment ranging in efficiency from 8.2 HSPF / 14 SEER to 9.5 HSPF / 19 SEER. These costs were then linearly interpolated by SEER and HSPF to calculate the incremental cost of the equipment used in the baseline and ENERGY STAR certified homes.

Central Air Conditioner

Reference	NREL National Residential Efficiency Measures Database v3.1.0, accessed via BEopt 2.8.0.0
Accessed	August 2021
Notes	• Material costs and new construction installation labor costs were taken from this database for 15 and 16 SEER equipment and used to calculate the incremental cost of the equipment used in the baseline and ENERGY STAR certified homes.

Filter

Reference	http://www.homedepot.com, Watertown Store #2602
Accessed	August 2021
Notes	• Sample filter used to estimate baseline cost: Pamlico Air 20 in. x 25 in. x 1 in. Fiberglass Air Filter FPR 1, Model # 11004-012025 • Sample filter used to estimate upgrade cost: Honeywell 20 in. x 25 in. x 1in. Allergen Plus Pleated MERV 11 – FPR 7 Air Filter, Model # 90701.012025

Gas Furnace

Reference	NREL National Residential Efficiency Measures Database v3.1.0, accessed via BEopt 2.8.0.0
Accessed	August 2021
Notes	• Material costs and new construction installation labor costs were taken from this database for 80 AFUE, 90 AFUE, and 95 AFUE equipment. These costs were then linearly interpolated by AFUE to calculate the incremental cost of the equipment used in the baseline and ENERGY STAR certified homes.

C. Ductwork

Duct Location

Reference	NREL National Residential Efficiency Measures Database v3.1.0, accessed via BEopt 2.8.0.0
Accessed	August 2021

Notes	• New construction installation labor costs, reported per square foot of duct surface area, were taken from this database for bringing ducts into finished space. • The total duct surface area was 760 square feet, equal to the default defined within ANSI / RESNET / ICC 301-2022, assuming a home with a single return and 2,376 square feet of conditioned floor area. For homes with a slab-on-grade foundation, in Climate Zones 1 through 3, 75% of this area was assumed to be moved from unconditioned to conditioned space. For homes with an unconditioned basement foundation, in Climate Zones 4 through 8, 100% of this area was assumed to be moved from unconditioned to conditioned space. • The difference in cost was multiplied by the square feet of duct surface area moved from unconditioned to conditioned space to arrive at a final incremental cost.

Duct Insulation

Reference	NREL National Residential Efficiency Measures Database v3.1.0, accessed via BEopt 2.8.0.0
Accessed	August 2021
Notes	• Material costs and new construction installation labor costs, reported per square foot of duct surface area, were taken from this database for ducts sealed to 4 CFM of total leakage per 100 square feet of conditioned floor area, both uninsulated and insulated to R-8. • The total duct surface area was 760 square feet, equal to the default defined within ANSI / RESNET / ICC 380-2022, assuming a home with a single return and 2,376 square feet of conditioned floor area. For homes with a slab-on-grade foundation, in Climate Zones 1 through 3, 75% of this area was assumed to be moved from unconditioned to conditioned space. For homes with an unconditioned basement foundation, in Climate Zones 4 through 8, 100% of this area was assumed to be moved from unconditioned to conditioned space. • The difference in cost was multiplied by the square feet of duct surface area moved from unconditioned to conditioned space to arrive at a final incremental cost.

Transfer Grille

Reference	https://www.tamtech.com/product/return-air-pathway-12-x-6-new-construction/
Accessed	August 2021
Notes	• The Tamarack Return Air Pathway 12x6” New Construction product was used to estimate the cost of a transfer grille. Contents include 2-white interior grilles, 1-galvanized frame, and 1-interior baffle. • A discounted price of $46 per grille, for volume purchases, was obtained via phone call on 08-10-2021 and was used for this analysis.

D. Domestic Hot Water Equipment

Electric Water Heater

Reference	• NREL National Residential Efficiency Measures Database v3.1.0, accessed via BEopt 2.8.0.0 • www.lowes.com • www.homedepot.com
Accessed	August 2021
Notes	• Material costs and new construction installation labor costs were taken from the NREL database for a heat pump water heater with an efficiency of 2.30 EF (equivalent to 2.40 UEF using RESNET’s Energy Factor Conversion Equations) and 2.35 EF (equivalent to 2.44 UEF. Because there were limited other efficiencies available in the database, retail costs were taken from Lowes for equipment with an efficiency of 3.45 UEF and from Home Depot for equipment with an efficiency of 3.85 UEF. These costs were then linearly interpolated by UEF to calculate the incremental cost of the equipment used in the baseline and ENERGY STAR certified homes.

Gas Water Heater

Reference	NREL National Residential Efficiency Measures Database v3.1.0, accessed via BEopt 2.8.0.0
Accessed	August 2021
Notes	• Material costs and new construction installation labor costs were taken from this database for 0.82 EF (equivalent to 0.82 UEF using RESNET's Energy Factor Conversion Equations) and 0.96 EF (equivalent to 0.96 UEF) equipment. These costs were then linearly interpolated by UEF to calculate the incremental cost of the equipment used in the baseline and ENERGY STAR certified homes.

E. Appliances & Lighting

Dishwasher

Reference	NREL National Residential Efficiency Measures Database v3.1.0. https://remdb.nrel.gov/group_listing.php
Accessed	August 2021
Notes	• Material costs were taken from this database for a dishwasher with consumption of 259 and 307 kWh/yr. Because the database represents retrofit costs, the low-end of the cost range was used to approximate the costs of new construction. These costs were then interpolated to estimate the cost of a baseline and ENERGY STAR certified dishwasher.

Lighting

Reference	• NREL National Residential Efficiency Measures Database v3.1.0, accessed via BEopt 2.8.0.0 • Residential Lighting End-Use Consumption Study: Estimation Framework and Initial Estimates. https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_residential-lighting-study.pdf
Accessed	August 2021
Notes	• Material costs and new construction installation labor costs for 100% CFL lighting and 100% LED lighting were taken from this database and the difference was used to calculate the incremental cost. These costs are defined per square foot of living area and garage area. Because only hard-wired fixtures will be upgraded at the time of certification, these costs were reduced based on an estimate that 56% of lighting are hard-wired ceiling fixtures from Table 4.5 of the Residential Lighting End-Use Consumption Study.

Refrigerator

Reference	NREL National Residential Efficiency Measures Database v3.1.0, accessed via BEopt 2.8.0.0
Accessed	August 2021
Notes	• Material costs and new construction installation labor costs were taken from this database for a refrigerator with consumption of 434 and 480 kWh/yr. These costs were then interpolated to estimate the cost of a baseline and ENERGY STAR certified refrigerator.

F. Labor

Reference	RS Means Construction Cost Data 2010
Accessed	August 2021
Notes	• Hourly rate listed by position:

Cost & Savings Role	RS Means Trade	Hourly Rate with Overhead and Profit
Rater	'Helpers' Average	$60

HVAC Assistant	'Helpers' Average	$60
HVAC Contractor	Plumber	$97
Foreman	Foreman Average, Outside	$86

- All labor rates prorated by 24.8% to adjust for inflation between 2010 and 2019 using BLS Current Employment Statistics Survey hourly earnings data.