



WASHINGTON STATE UNIVERSITY
Energy Program

Cost Effective Energy Code Compliance Using the UA Alternate Path



Photo: 1jaimages

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Author

Blumenthal, Rick – Washington State University (WSU) Energy Program

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Table of Contents

Author and Acknowledgements	2
Author	2
Acknowledgements	2
Disclaimer	3
Non-Discrimination Statement.....	3
Table of Contents	4
Abstract.....	5
Introduction.....	6
Economic and Market Analysis	6
Comparison of Home Cost by Square Foot (sq. ft.)	6
Building Materials and Market Trends	8
Panelized, SIP, and DIY Kit Homes	10
Complying with the 2021 WSEC-R Cost Effectively	11
Prescriptive vs. U-Factor Pathways	11
Cost-Effective Building Assemblies.....	12
Attic and Ceiling Assemblies	12
Technical Wall Assembly Solutions	14
Summary	20
Case Studies and Modeling Results.....	21
Using the U-Factor Compliance Path with the Code Compliance Calculator (C ₃)	21
Single Family Modeling.....	22
Multifamily Modeling.....	23
Implementation of Resources and Industry Standards	25
Appendix: Examples of Cost Effective Energy Code Compliance	26

Abstract

According to the Washington Department of Commerce, the 2021 State Energy Strategy provides a roadmap for the state to meet its greenhouse gas emission reduction limits. Enacted in 2020, the law commits Washington State to three emission reduction targets: a 45% reduction from 1990 levels by 2030, a 70% reduction from 1990 levels by 2040, and a 95% reduction from 1990 levels—achieving net zero emissions—by 2050.¹

Buildings are a primary focus of the 2021 State Energy Strategy, as they account for 23% of Washington’s greenhouse gas emissions. According to the Strategy, addressing this will “require a 10-year market transformation approach that combines transitioning from fossil gas to electrification, with deep energy efficiency for new and existing buildings...” One of the key actions of the Strategy is to “strengthen and deepen energy efficiency programs and standards to focus on avoiding and reducing emissions.”²

To achieve the efficiency requirements set by the Washington State Energy Code-Residential (WSEC-R), federal, state, and utility programs provide incentives to offset costs in residential buildings. For example, the Federal 45L tax credit provides up to \$5,000 for single-family and multifamily buildings that achieve qualifying certifications, such as Energy Star, alongside additional credits for solar energy installations. Complementing these federal programs, Washington State offers incentives for renewable energy production, and public utilities provide rebates for high-efficiency HVAC equipment, water heaters, and appliances. These combined financial tools help align the WSEC-R with the 2021 energy policy.

Though these incentives help offset some of the costs of heightened energy efficiency standards, the challenge for builders is to reduce the (initial) cost of construction. In addition, a key concern for future projects is that current federal tax credits are proposed to expire at the end of 2025 for projects starting after that date.

Because residential requirements vary based on architecture, geography, and specific code mandates, this report provides standard sample plans for single-family and multifamily homes within each of the state's climate zones, all adhering to 2021 WSEC-R standards. Finally, while land, interest rates, and labor costs significantly impact the overall cost of a home, these variables are independent of the WSEC-R and fall outside the scope of this report.

¹ Washington State Legislature, “Chapter 19.285 RCW: Energy Independence Act,” <https://app.leg.wa.gov/rcw/default.aspx?cite=19.285>.

² Washington State Department of Commerce, *Washington 2021 State Energy Strategy*, (2020), 15, 19, <https://www.commerce.wa.gov/energy-policy/state-energy-strategy/>.

Introduction

This report summarizes diverse strategies for submitting residential permits that meet or exceed the 2021 Washington State Energy Code-Residential (WSEC-R) and the International Residential Code (IRC). By synthesizing the current code with historical data, peer-reviewed research, and direct insights from architects, engineers, building scientists, and material and component manufacturers and suppliers, this document identifies high-performance construction pathways with a primary focus on cost-effectiveness.

The purpose of this research is to highlight affordable methods for meeting mandatory requirements and energy credits using conventional design and construction practices, and to recommend alternative technologies and strategies that may offer additional savings. To assist with implementation, the [Report Appendix](#) provides practical compliance options specifically designed to lower initial construction costs using the [Code Compliance Calculator](#) (C3).

This report is structured around the 2021 WSEC-R. However, the fundamental relationships and strategies described herein remain applicable to the 2024 WSEC-R cycle. Although specific data values may evolve between code versions, the comparative performance and logic of these energy-saving measures remain consistent and relevant for the upcoming adoption.

Economic and Market Analysis

Comparison of Home Cost by Square Foot (sq. ft.)

The National Association of Home Builders (NAHB) periodically surveys builders on construction costs to determine the components of a sales price for a new single-family home. The most recent survey from 2024 demonstrates that “on average, 64.4% of the sales price is due to construction costs...up from 60.8% in 2022.” The survey also notes that the largest contribution to construction costs is interior finishes at 24.1%, followed by major system rough-ins (HVAC, plumbing, and electrical) at 19.2%.³ While these cost increases reflect higher sales prices, major system rough-ins can be compared to the 2021 WSEC-R for options that may reflect lower initial equipment costs.

³ Erin Lynch, *Cost of Constructing a Home 2024*, (National Association of Home Builders, 2025), <https://www.nahb.org/-/media/NAHB/news-and-economics/docs/housing-economics-plus/special-studies/2025/special-study-cost-of-constructing-a-home-2024-january-2025.pdf>.

To reduce the cost of housing and meet current housing affordability challenges, builders are constructing homes with less square footage. This is especially important as the share of first-time new home buyers falls. Table 1 (below) shows current NAHB data on home size by year. As home prices rose from 2020 to 2023, buyers showed a preference for smaller sized homes (between 2,000 and 3,000 sq. ft.). The shift toward smaller floor plans seems to be a win-win; it aligns builder output with market demand while providing cost-effective construction and housing options.

Table 1: Number of Houses Purchased (in thousands) by Square Foot

Square Feet of Floor Area in New Single-Family Houses Completed ¹														
(Components may not add to totals because of rounding. Percents computed from unrounded figures.)														
Year	Number of houses (in thousands) by square feet							Percent distribution						
	Total	Under 1,400	1,400 to 1,799	1,800 to 2,399	2,400 to 2,999	3,000 to 3,999	4,000 or more	Total	Under 1,400	1,400 to 1,799	1,800 to 2,399	2,400 to 2,999	3,000 to 3,999	4,000 or more
West														
2020	223	17	44	69	45	32	18	100	7	20	31	20	14	8
2021	237	18	45	76	44	38	16	100	8	19	32	18	16	7
2022	233	18	43	70	49	35	17	100	8	19	30	21	15	7
2023	214	24	43	64	36	30	16	100	11	20	30	17	14	8
2024	227	26	52	63	42	27	17	100	12	23	28	19	12	7
2025	224	31	46	66	39	26	17	100	14	21	29	17	12	7
RSE/SE	4	19	12	8	10	8	19	(NA)	2	2	2	2	1	1
Footnotes:														
¹ Includes houses built for rent (not shown separately).														

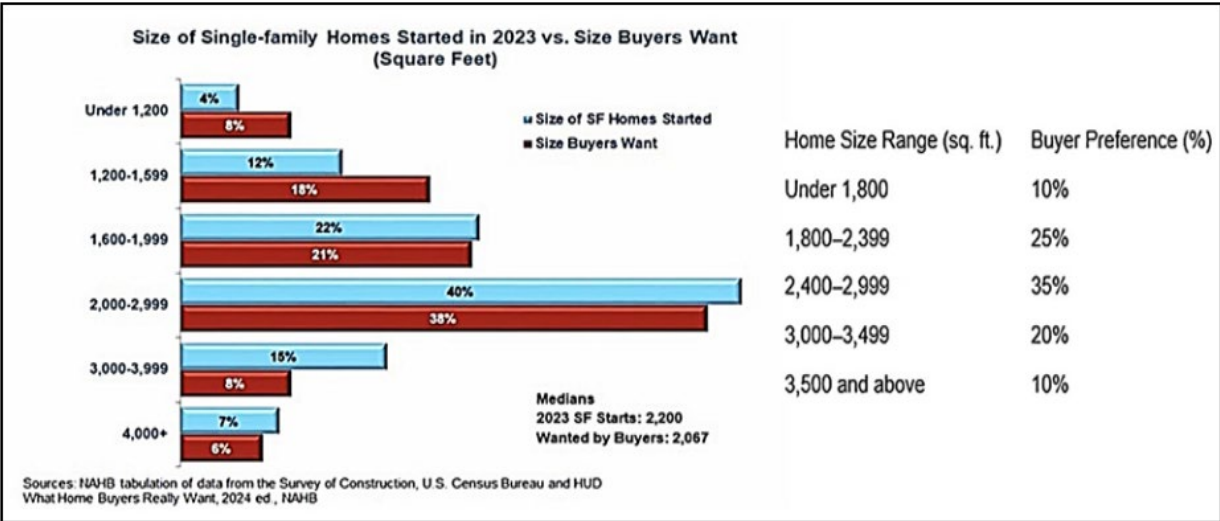


Figure 1. An illustration of homebuyers' home size preferences. This helps builders understand market demand and align construction strategies accordingly.

Key Insights from Table 1 and Figure 1: The preferred home-size range is between 2,000 and 3,000 sq. ft, indicating strong market interest in moderately sized homes. Smaller homes (under 1,800 sq. ft.) and larger homes (over 3,000 sq. ft.) are less preferred, suggesting a shift toward more affordable and manageable housing options.

Building Materials and Market Trends

According to commodity.com, four primary factors drive material pricing: construction and housing data, trade policies, the availability and price of substitutes, and supply chain challenges.⁴ Given these external market forces, builders have limited avenues for cost control. Their primary control is to reduce lumber expenses, either by using less lumber or identifying more affordable, code-compliant substitutes.

To estimate framing requirements, a standard rule of thumb is 6.3 board feet (BF) of lumber per square foot of living space. For a 2,000 sq. ft. home, this metric—which covers floors, walls, the roof, and sheathing—typically results in a range of 12,600 to 16,000 BF. Applying this to the 2,200 sq. ft. model found in this report requires approximately 10% more material, bringing the total to between 13,860 and 17,600 BF. The exact volume remains dependent on the home's style, number of stories, construction methods, and architectural complexity.

The cost of materials remains a primary driver of rising housing prices. While builders cannot control market rates, they can reduce cost impact by constructing smaller footprints, employing modular design, selecting cost-effective alternative materials, and designing specifically for constructability.

Budget volatility is exacerbated by regular fluctuations in lumber pricing. For example, the price of framing lumber increased by 10% between January and June 2025.⁴ This volatility directly impacts overall housing costs. For example, according to Houzeo.com, the cost of single-family homes in Washington State rose from \$619,998 to \$649,700 between January 2025 and June 2025, a \$29,702 increase.⁵

Short-term spikes can be especially dramatic, with some instances showing a \$50,000 increase in single-family residences over a single four-month period (December 2025 to April 2026). These fluctuations demonstrate the necessity for builders to adopt cost-control strategies. Notably, though townhome costs also rose by \$5,000 during this period, they continue to represent a more affordable alternative for both builders and buyers (see Figure 3).

⁴ "Lumber Price Impact: Housing Market, Homebuilders & Construction," Commodity. <https://www.commodity.com>.

⁵ "Washington Housing Market Overview," Houzeo, <https://www.houzeo.com/housing-market/washington>.

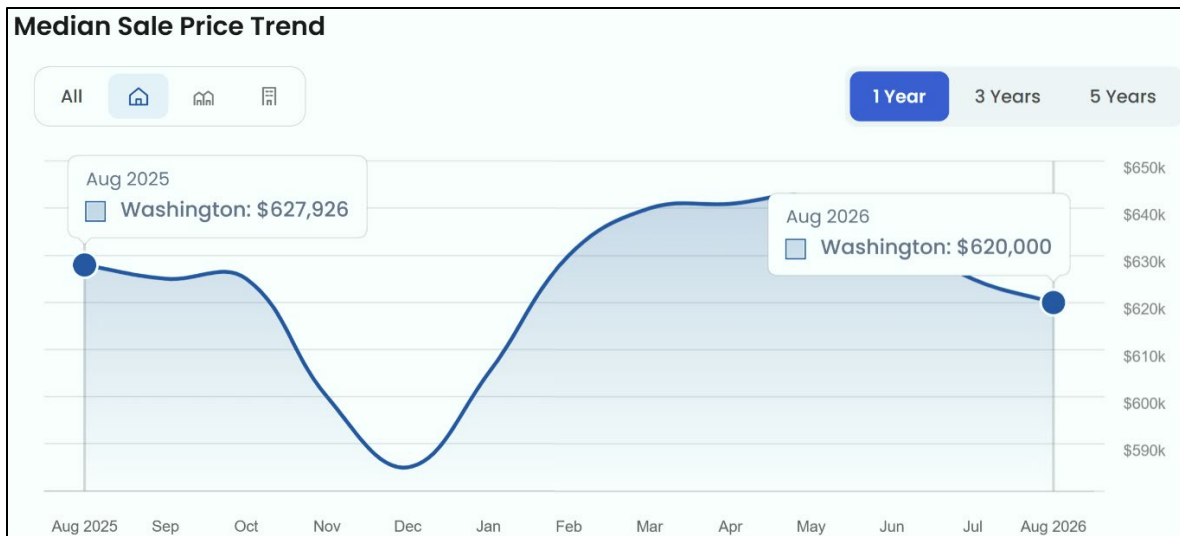


Figure 2. Single-Family Home Cost Comparison: August 2025 to August 2026. Figure from Houzeo.com

Figure 2 demonstrates the changing cost of single-family homes over one year. Here is what builders and developers should take away from this information:

- Understanding cost trends help builders estimate future project costs more accurately.
- The graph shows changes in single-family home prices in Washington from August 2025 to August 2026, reflecting market pressures such as material costs, labor shortages, or demand shifts.
- A steep slope means rapid price changes, which could impact budgeting and project timelines.
- If the graph rises and falls, it may indicate seasonal trends (e.g., prices rising in spring/summer due to higher demand).

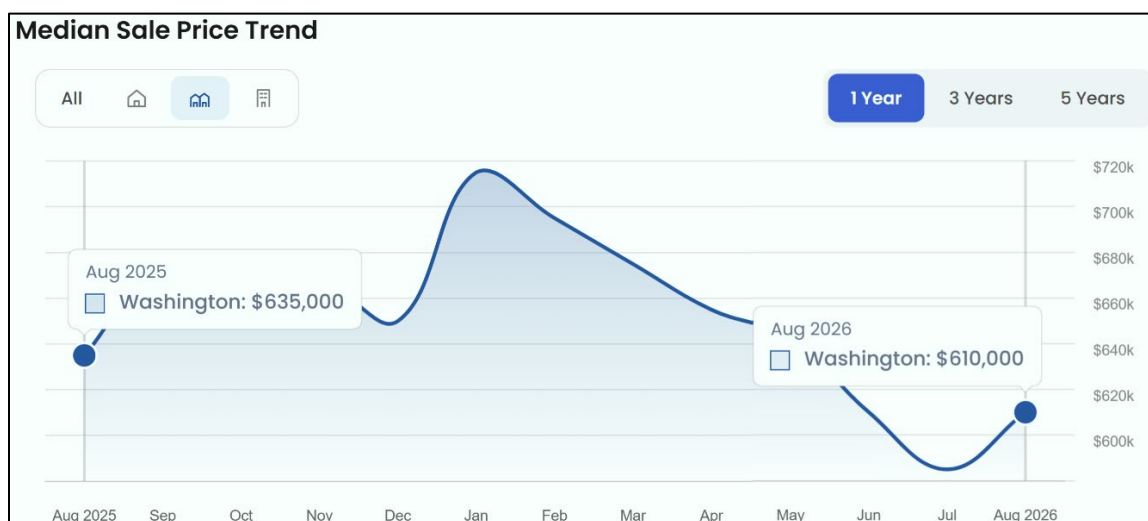


Figure 3. Townhouse Cost Comparison: August 2025 to August 2026. Figure from Houzeo.com

Figure 3 illustrates changes to townhouse housing costs from August 2025 to August 2026. Here is what builders and developers should take away:

- While costs of townhouses do increase sporadically, the rise tends to be less steep compared to single-family homes.
- The graph demonstrates a decrease of \$25,000 in townhouse costs over the year.
- Builders can position multifamily housing as a more affordable option for buyers and renters.

Panelized, SIP, and DIY Kit Homes

Panelized Construction

Cost savings can be elusive using panelized construction. Builders may assume that projects cost less, given that the structure is assembled in a controlled environment and saves time on site builds. According to construction business owner Josh Salinger, panelization saves time, but only on the enclosure part of the building. In his experience, “the rest of the build takes just as long as conventional construction.”⁶

In addition, cost savings are eliminated by panel transport to the site, crane service, and additional carpentry necessary for blocking and backing, stairs, and attached structures like decks and porches. Salinger also notes that spending dozens of hours on scheduling, design, and reviewing shop drawings consumed more time than predicted. In owning and operating a residential construction company, the author has had similar experiences with panelized construction. In the author’s case, the up-front costs related to reviews, scheduling, and site costs were greater than expected and used valuable resources against any anticipated savings.

Structural Insulated Panels (SIP)

Another form of panelized construction uses Structural Insulated Panels (SIP), prefabricated panels made up of insulation. SIPs usually contain a rigid foam core captured between structural sheathing panels. SIP Panels may be installed as floors, walls, and roofs. Studies have shown that the cost for wall construction using SIPs is about 10-15% greater than traditional site-built methods.⁵ Note this is only the cost of walls and does not include floors or roofs. The payback is in energy savings over time, though the challenges are consistent with other initial up-front and on-site costs, just like panelized and kit builds.

⁶ Salinger, Josh, “The Pros and Cons of a Panelized House,” *Fine Homebuilding*, February 2024, <https://www.finehomebuilding.com/2024/01/10/the-pros-and-cons-of-a-panelized-house>.

DIY Kit Homes

An alternative option to panelized construction is to construct or purchase a kit home. These can be knock-down systems for the owner to complete or turnkey projects after the manufacturer completes the entire project (not including the cost of the land and site prep). Legislation (SB 5349) was reintroduced to the Washington State Senate to simplify kit home construction. The bill would permit jurisdictions to place kit homes in areas designated for single-family residences but not for permanent housing.

Kit homes are defined as “any structures intended for residential use that are comprised of prefabricated walls, floors, and roofs which are assembled on-site and are 800 sq. ft. or smaller in size.” A new section has been added to chapter 19.27 in the Revised Code of Washington (RCW) to read as follows:

- (1) The state building code council is instructed to perform rule 23, making the state building codes applicable to kit homes no later than December 31, 2025.
- (2) The state building code council may update the state building code applicable to kit homes.⁷

The concern over cost control has led to discussions related to the 2021 WSEC-R, specifically on the increased efficiency requirements as they relate to the cost of housing. Builders are looking to use the energy code to reduce costs.

Complying with the 2021 WSEC-R Cost Effectively

The 2021 WSEC-R (or the Code), like earlier editions, requires compliance with both the mandatory minimum energy standards and credit requirements. Both requirements can be difficult to achieve when trying to lower initial project costs.

Prescriptive vs. U-Factor Pathways

To address this challenge, the Code offers two pathways for compliance: the prescriptive or R-value pathway and the U-factor pathway, each with mandatory minimum and maximum efficiency requirements.

⁷ Washington State Legislature, “Chapter 19.27 RCW: State Building Code Act,” <https://app.leg.wa.gov/rcw/default.aspx?cite=19.27>.

Table 2: WSEC- R Insulation Minimum R-Values and Fenestration Requirements by Components

INSULATION MINIMUM R-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENTS^a

CLIMATE ZONE 5 AND MARINE 4	
Fenestration U-Factor ^{b, i}	0.30
Skylight ^b U-Factor	0.50
Ceiling R-Value ^e	60
Wood Frame Wall ^{g, i} R-Value	20+5 or 13+10
Floor R-Value	30
Below-Grade ^{c, h} Wall R-value	10/15/21 int + 5TB
Slab ^{d, f} R-Value & Depth	10, 4 ft

The R-value pathway (outlined in Table 2) is the more restrictive option, requiring the meeting of all line items listed in the table for compliance. Line items can be adjusted if the changes result in increased efficiencies, such as elevating an R-30 insulated floor to R-38. However, reducing the line item below R-30 is not permitted. However, some flexibility exists in this pathway. For example, the R-60 ceiling R-value can be reduced to R-49 according to the 2021 WSEC-R section R402.2.1:

R402.2.1 Ceilings with attic spaces. Where Section R402.1.3 would require R-60 in the ceiling or attic, installing R-49 over 100 percent of the ceiling area requiring insulation shall satisfy the requirement for R-60 wherever the full height of uncompressed R-49 insulation extends over the wall top plate at the eaves. This reduction shall not apply to the insulation and fenestration criteria in Section R402.1.2 and the Total U-factor alternative in Section R402.1.5.⁸

Cost-Effective Building Assemblies

Attic and Ceiling Assemblies

This provision presents a decision for the designer and builder focused on cost: is it less expensive to install R-60 insulation with a standard truss heel over the top plate, or to reduce the insulation to R-49 and instead increase the truss heel height? The choice balances the cost

⁸ Washington State Legislature, "WAC 51-11R-40220: Section R402.2—Specific Insulation Requirements," <https://app.leg.wa.gov/wac/default.aspx?cite=51-11R-40220>.

of the raised heel and R-49 insulation against the R-60 insulation and a standard heel (see Figure 4 below).

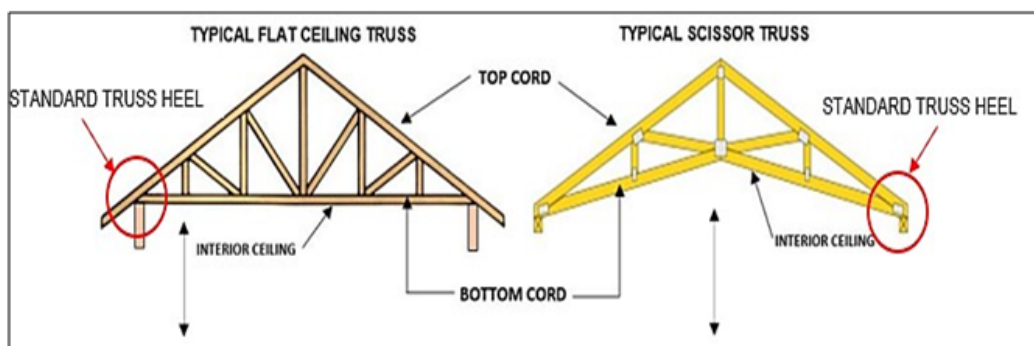


Figure 4. A typical flat ceiling truss and a typical scissor truss. Credit: WSU Energy Program

The use of specific structural components, such as raised-heel trusses (e.g., King Post or Scissor trusses), is key to making this tradeoff work. The truss diagram in Figure 4 illustrates two types of structural trusses used to support the roof and ceiling. These consist of straight members connected at joints to form a rigid framework that distributes loads efficiently across open, unsupported ceiling space.

Both trusses are designed for residential or light commercial buildings. They may include raised heel sections, which increase the available space above the top wall plate, allowing deeper eave insulation and improving energy efficiency. These trusses have a vertical or near-vertical web over the top plate of the exterior wall, creating a taller heel to accommodate full-depth uncompressed insulation to meet the required R-value above the wall plate.

When scissor trusses are used, WSEC-R states that, "Open-blown or poured loose fill insulation may only be used in attic spaces where the slope of the interior ceiling is not more than a 3 in 12 slope, and there is at least 30 inches of clear distance from the top of the bottom chord of the truss to the underside of the sheathing at the roof ridge."⁹

Another choice is to construct a vaulted ceiling using a single rafter (i.e., dimensional lumber, manufactured I-Joists, or parallel-cord open-web truss (see Figure 5 below). This allows the insulation reduction to R38 if the full depth of the insulation is over the top exterior wall plate and the insulation fills the entire cavity (no voids). The vent way must be at least one and one-half inches clear from eave to ridge.

⁹ Washington State Legislature, WAC 51-11R-40220 Section R402.2—Specific Insulation Requirements, <https://app.leg.wa.gov/wac/default.aspx?cite=51-11R-40220>.



Figure 5. Examples of single component rafters for vaulted roof assemblies. Credit: WSU Energy Program

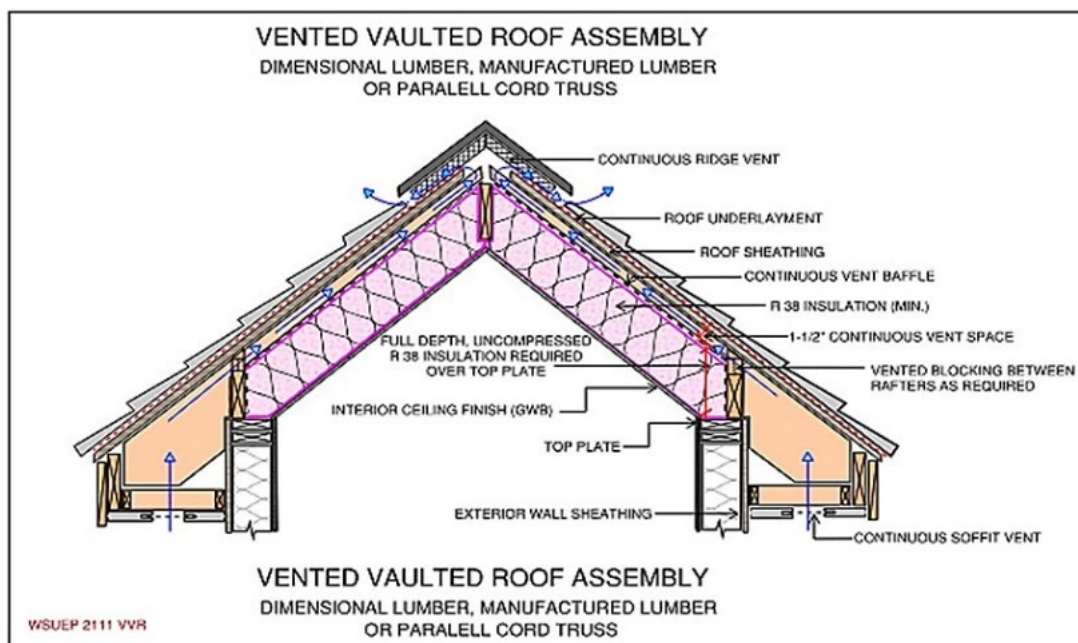


Figure 6. A vented vault roof assembly with dimensional lumber, manufactured lumber, or parallel cord truss. Credit: WSU Energy Program

Technical Wall Assembly Solutions

The Double-Wall Alternative for Continuous Insulation

While the traditional prescriptive path often requires 2x6 studs with external rigid foam to meet Continuous Insulation (CI) standards, the U-factor path allows for a more cost-effective double-wall assembly. This method, seen in Figure 7 below, utilizes 2x4 studs on 24-inch centers across two separate plates, creating a deep cavity for high-density fibrous insulation (R-4.2 per inch fibrous insulation) like fiberglass batts or dense-pack Blown-in-Blanket (BIB)

system. This configuration ensures that the cavity insulation alone meets the code requirements, effectively eliminating the need for expensive exterior rigid foam and the specialized labor associated with its installation. See Figure 7 below for an example. Both agree with Table 2, the prescriptive path, and are less expensive to construct with fewer board feet than a 2 x 6 wall on 16-inch centers. Tables 3 and 4 (below) demonstrate cost-effectiveness.

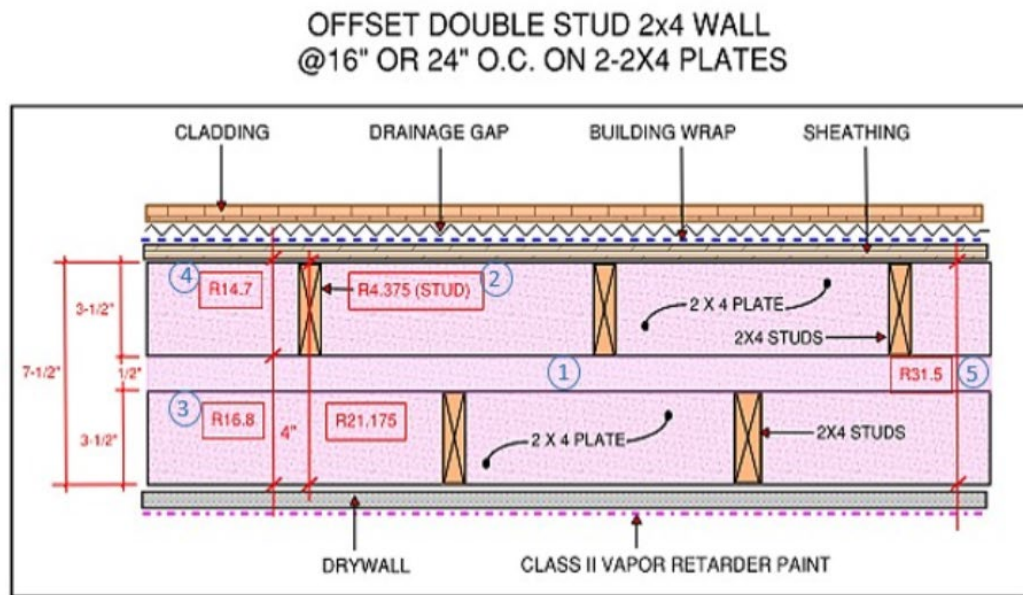


Figure 7. An example of an offset double wall study, of a 2x4 wall at 16 or 24 inches O.C. on 2-2x4 wall plates separated by a 1/2" space.

①	HIGH DENSITY FIBROUS INSULATION @ R 4.2 PER INCH
②	*R-VALUE OF SOFTWOOD LUMBER @ 1.25 PER INCH X 3.5 = R 4.375
③	R @ 4.2 PER INCH X 4 INCHES = R 16.8
④	R @ 4.2 PER INCH X 3.5 INCHES = R 14.7
⑤	TOTAL CAVITY R VALUE = R 31.5, greater than the R 21 cavity requirement by R 10.

Figure 8. A detailed legend with ASHRAE Design Values and calculation summary for the "Offset Double Stud 2x4 Wall", Figure 7 wall diagram. *

* ASHRAE Fundamentals 2017, Table 1, 26.12 Building and Insulating Materials: Design Values, Douglas Fir/Larch, lowest thermal resistance based on conductivity of 1.01 in Btu • in / h • ft² • °F is 1.49. R-1.25 / inch, a more conservative value used in the calculation is from the Colorado Energy R-value Table, <https://www.coloradoenergy.org/procorner/stuff/r-values.htm>

Table 3: Cost Analysis for 2x6 Single-Stud Wall vs. 2-2x4 double Offset Stud Walls

WALL FRAMING	STUD LENGTH LF	BD FT/STUD*	NO. OF STUDS + 2 STUD CORNERS	TTL LF STUDS + 3 PLATES	LF OF WALL	TTL BD FT STUDS AND PLATES*
2 X 6 @ 16" O.C.	8	8	41	472	48	472
2 X 6 @ 24" O.C	8	8	30	384	48	384
2 X 4 @ 24" O.C.	8	5.34	30	240	48	160
2 X 4 @ 24" O.C.	8	5.34	30	240	48	160
2 X 6 PLATE @ 48 LF	16	16		144	48	144
TTL BF OFF SET DBL 2X4 W/ 2X6 PLATE	NOTE: THIS ASSEMBLY DOES NOT MEET COMPLIANCE FOR CI					464
ESTIMATED AVERAGE COST PER 1,000 BD FT	WALL TYPE	TTL LINEAL FT	TTL BD FT	\$ TTL COST	\$ COST /BD Ft ^a	
\$1,100.00	2 X 6 @16 O.C	472	472	\$519.20	\$1.00	
\$1,100.00	2 X 6 @ 24 O.C.	384	384	\$422.40	\$1.00	
\$1,100.00	2 X 4 @ 24 O.C.	160	106.67	\$117.33	\$1.00	
\$1,100.00	2 X 4 @ 24 O.C.	160	106.67	\$117.33	\$1.00	
\$1,100.00	2 X 4 PLATE	32	21.33	\$23.47	\$1.00	
	TOTAL	352	234.67	\$258.13		

Table 4: Framing Comparison – Single 2x6 Wall vs Double 2x4 Wall

Wall Type	Total Board Feet (BF)	Estimated Material Cost
2x6 Plate + Studs @ 24" on center	464 BF	\$422
Double 2x4 Plates + Double Studs @ 24" o.c.	235 BF	\$258

Comparative Efficiency and Cost Savings

A comparative analysis of framing methods reveals that the double 2x4 wall is more efficient in terms of material usage and upfront costs. A single 2x6 wall uses nearly twice the lumber, totaling approximately 464 board feet, whereas the double 2x4 wall requires only 235 board feet. This represents a 97% reduction in lumber usage.

Financially, this transition saves approximately \$164 for framing materials per section, as the 2x6 wall would cost \$422 and the double 2x4 wall would cost \$258. Beyond the cost of lumber, this approach allows for better insulation performance due to the depth of the cavity and avoids the higher costs associated with rigid foam types such as XPS or Polyiso.

Table 5: Cost Comparison of Rigid Foam Insulation Types

INSULATION R VALUE, TYPE & THICKNESS	EXTERIOR WALL SQ. FT.	TOTAL PIECES REQUIRED	COST OF EACH PIECE	TTL INSULATION COST	MATERIAL COST SAVINGS (\$) BETWEEN DIFFERENT TYPES
	ESTIMATED TOTAL EXTERIOR WALL SQ. FT. INCLUDING 10% WASTE*	ESTIMATED TOTAL No. PCS. @ 4'x8'x1"	ESTIMATED COST PER EA.	ESTIMATED TOTAL MATERIAL COST SINGLE FAMILY RES	MATERIAL SAVINGS (FROM R-5 XPS)
R-5 XPS* EXTERIOR 1" RIGID FOAM	3227	101	\$29	\$2,929.00	
R-5 GPS* EXTERIOR 1" RIGID FOAM	3227	101	\$20	\$2,020.00	\$909
R-5 POLYISO** EXTERIOR 3/4" RIGID FOAM	3227	101	\$18	\$1,818.00	\$1,111
					FROM R-10 XPS
R-10 XPS* EXTERIOR 2" RIGID FOAM	3227	101	\$33	\$3,333.00	
R-10 GPS* EXTERIOR 2" RIGID FOAM	3227	101	\$32	\$3,232.00	\$101
R-10 POLYISO** EXTERIOR 1.5" RIGID FOIL FACE FOAM	3227	101	\$50.00	\$5,050.00	(\$1,717)

*Home Depot – cost for bulk pricing for 10 or more sheets.
 **Home Depot - cost for bulk pricing for 10 or more sheets.

Table notes:

- XPS = Extruded Polystyrene (used as the baseline for comparison)
- GPS = Graphite Polystyrene
- Polyiso = Polyisocyanurate
- All prices are based on *bulk pricing* (10 or more sheets) from Home Depot
- "Estimated Savings" compares each option to the baseline R-10 XPS

Additional Wall Solutions

Savings can be realized by using the U-factor value for the exterior wall assembly. The published Above Grade Wall U-factor in Table 7 (below) is 0.056. Installing an R-21 cavity insulation meets that requirement without having to install CI.

Using the ceiling/attic insulation, the structure, and the exterior wall assembly, the energy code can be met with no difference in construction methods, constructability, or additional labor needed from the previous 2018 WSEC-R.

Here is the path:

ATTIC ASSEMBLY – Meets Table 7 “U-factor Compliance Path” using the Code Compliance Calculator. This approach is parallel to Table 2, except that Table 7 uses U-factors instead of R-values. Because the tables are related, if all the requirements of Table 2 are met except for CI or raised-heel trusses, using the U-factor Compliance path analysis setup in the Code Compliance Calculator will comply. Table 6 below shows the two-line items in the R-Value table (Ceiling R-Value and Wood Frame Wall R-Value) that can be claimed if the UA values in Table 7 are met.

Table 6: Insulation Minimum R-Values and Fenestration Requirements by Components (with code max. standard and savings opportunities highlighted)

TABLE R402.1.3 INSULATION MINIMUM R-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENTS ^a		
Climate Zone 5 and Marine 4		
Fenestration ^{b,j} U-Factor	0.30	← CODE MAX. STANDARD
Skylight ^b U-Factor	0.50	← CODE MAX. STANDARD
Ceiling ^e R-Value	60	← SAVINGS OPPORTUNITY
Wood Frame Wall ^{g,i} R-Value	20+5 or 13+10	← SAVINGS OPPORTUNITY
Floor R-Value	30	← CODE MAX. STANDARD
Below-Grade Wall ^{c,h} R-Value	10/15/21 int + 5TB	
Slab ^{d,f} R-Value and Depth	10, 4 ft.	

Installing open-blown loose-fill insulation with a rated R-Value of R₃ per inch for an R-49 ceiling/attic requires at least seventeen inches in depth across the entire attic and above the top exterior wall plate, requiring a raised heel truss. If installing a standard heel truss, slope the insulation up to twenty inches for an R-60 (only three inches more insulation than R-49), and save money by using a standard heel truss to eliminate added sheathing, weather barrier, siding, and labor for the same. The above-grade wall plate requires only an R-21 of uncompressed insulation over the top. You may use intermediate framing or frame walls with 2 x 6's on 24-inch centers to save on lumber.

Table 7: Insulation and Fenestration Requirements by Component for Climate Zone 5 and Marine 5

TABLE R402.1.2 INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT^a	
CLIMATE ZONE 5 AND MARINE 4	
Fenestration <i>U</i> -Factor ^b	0.30
Skylight <i>U</i> -Factor	0.50
Ceiling <i>U</i> -Factor	0.024 ← Same as R-60 ceiling
Above-Grade Wall <i>U</i> -Factor	0.056 ← Same as R-21 cavity
Floor <i>U</i> -Factor	0.029
Slab on Grade <i>F</i> -Factor	0.54
Below Grade 2' Depth	
Wall <i>U</i> -Factor	0.042
Slab <i>F</i> -Factor	0.59
Below Grade 3.5' Depth	
Wall <i>U</i> -Factor	0.040
Slab <i>F</i> -Factor	0.56
Below Grade 7' Depth	
Wall <i>U</i> -Factor	0.035
Slab <i>F</i> -Factor	0.50

*R-49 requires a raised heel truss and is more efficient (better) than R-60 W/ standard truss. Note that R-38 requires a 13-inch raised heel if R-3 per inch insulation is installed and vented or use a standard frame and offset by substituting a higher efficiency component somewhere else to make up the loss.

Table 8: Default U-Factors for Ceilings

Table A102.1 Default U-factors for Ceilings		
	Standard Frame	Advanced Frame
Ceilings Below Vented Attics		
Flat	Baffled	
R-19	0.049	0.047
R-30	0.036	0.032
R-38	0.031	0.026
R-49	0.027	0.020*
R-60	0.025	0.017

Credit: WSEC-R 2021.

Scissor trusses require a raised heel for R-49; R-60 is not an option for a scissor truss.

Table 9: Default U-Factors for Ceilings

Table A102.1 Default U-factors for Ceilings		
	Standard Frame	Advanced Frame
Scissors Truss		
R-30 (4/12 roof pitch)	0.043	0.031
R-38 (4/12 roof pitch)	0.040	0.025
R-49 (4/12 roof pitch)	0.038	0.020
R-30 (5/12 roof pitch)	0.039	0.032
R-38 (5/12 roof pitch)	0.035	0.026
R-49 (5/12 roof pitch)	0.032	0.020

Credit: WSEC-R 2021 Appendix CA-4.

Vaulted ceilings require an R-38-filled cavity, leaving no voids, including over the exterior top wall plate. Savings can occur with both less structure and less insulation. A 2 x 12 rafter can accept an R-38 High Density Batt or a dense pack, Blown-In-Blanket (BIB) system. Insulation manufacturers' published data provides the required density to achieve their published R-value. For example, visit this [JM Spider Premium Fiber Glass Blowing Wool Insulation Guide \(PDF\)](#) to see product specifications. Blown-In-Blanket systems provide greater R-values than required. The added R-value can offset less efficient components, another cost-saving opportunity. R-38 High-Density fiberglass batts (R-4.2 per inch) are also available that will fit in a 2 x 12 Rafter or manufactured I-Joist. Note that all insulation manufacturers may not have R-38 High-Density Batt's that fit into 12-inch rafters, so it is best to check ahead of time.

Summary

- Single vault rafters must be insulated to a minimum R-38 value, with no voids, including above the exterior top wall plate.
- This can be achieved by installing high-density batts or Blown-In-Blanket (BIB) systems, each of which provides an approximate R-4.2 per inch. Confirm with the manufacturer's published data.
- Using less structure and insulation can reduce costs.

Case Studies and Modeling Results

Using the U-Factor Compliance Path with the Code Compliance Calculator (C3)

The examples in the case studies adhere to the mandatory requirements outlined in Table 7 (UA Table). When using the Code Compliance Calculator (C3) for the “Total U-Factor Alternative, Whole Building Trade-off Analysis” pathway, the specific requirements in Table 2 may be traded or balanced against one another. Under this pathway, if a specific component—such as a ceiling—fails to meet its stipulated R-value or U-factor, the efficiency loss can be offset by increasing the performance of another component, such as floor insulation.

ANALYSIS SET UP	
What code compliance pathway are you using?	Total UA Alternative, Whole Building Trade Off Analysis
→ Project Building Type?	New Construction
→ Occupancy Type?	R3 Single family dwellings and townhouses
→ Code Version?	WSEC 2021
Classification:	Medium Dwelling Unit -- 2100 sq. ft.
Baseline Description:	Code Baseline - Maximum baseline window area is 15% of floor area.
About Your Selection:	No exempt window or door areas
	-

Figure 9. A screenshot of the Analysis Set Up section of the Code Compliance Calculator. Credit: WSU Energy Program

Understanding C3 Tool Results

The C3 tool displays the analysis results in the Messages / Comments section. A green light in this section signifies that all project components meet the requirements and are fully compliant with the 2021 WSEC-R. Conversely, a red light indicates failure with these standards.

Building, component, and assembly efficiency is measured by UA calculations. A positive UA reduction reflects a decrease in total UA, which indicates improved efficiency. A lower or negative UA represents a more efficient building envelope than a higher UA. The tool also provides a percentage value to demonstrate how much the project exceeds the established code baseline. Both a UA reduction and a positive percentage score serve as indicators of enhanced energy performance.

Messages / Comments *	RESULT= PASS
UA Reduction = 10.28, Proposed UA is better than baseline by 3.9% Window area is 6% of floor area - Whole House Mechanical Ventilation Airflow Rate: 55 CFM with Run Time Percent of 100%, Balanced, Distributed Maximum allowable total measured duct leakage: 84 CFM25	

Figure 10. This section of the C3 tool shows pass or fail comments that notify applicants of project code compliance.

Single Family Modeling

In a standard 2,100 sq. ft. two-story home, energy credits are claimed based on the total conditioned floor area. This modeling requires adherence to the mandatory requirements outlined in Table 10 (the UA Table below) and the selection of appropriate credit options from Table 11 for dwellings between 1,500 and 5,000 sq. ft. The architectural floor plan provided in Figure 11 serves as the basis for these calculations, ensuring that the theoretical savings translate to standard residential designs used across Washington State Climate Zones.

Table 10: 2021 WSEC-R Mandatory Requirements from the UA Table

COMPONENT	U-FACTOR	QUANTITY	NOTES
EXT.DOORS	0.3	3	
WINDOWS	0.3	8	
CEILING	0.025	1,578 SF	
WALLS ABOVE	0.054	2,206	R21 + 0 FOAM + INT + 2X6 W LAP
FLOOR W/ VENTED	0.029	1,578	
VENTILATION	BALANCED	55 CFM	100% RUN TIME
LOCATION			VANCOUVER
HVAC			DUCTLESS HP

Table 11: Credit Options from 2021 WSEC-R Credit Requirements Tables for Single Family Dwellings $\geq 1,500$ Sq. Ft. and $\leq 5,000$ Sq. Ft.

OPTION No.	CREDITS	COMPLIANCE PATH
#2 - R406.2	3	Variable Ref. Heat Pump (ductless) or Air to Water HP
3.7	2	Ductless w/ no elect. Resistance in primary area
5.1	0.5	Drain water heat recovery
5.2	0.5	Compact water distribution design
5.6	2	Tier 3 HP water heater
TOTAL CREDIT	8	

Multifamily Modeling

Cost-effective compliance for smaller footprints, such as a 900 sq. ft. two-story multifamily unit, is achieved by following the pathway setup illustrated in Figure 12 (below). These generic 3-bedroom models for Climate Zones 4c and 5b demonstrate that a successful UA reduction is possible even in denser housing configurations. The results provided in the message area for these units confirm that the proposed UA remains better than the baseline, meeting both mandatory requirements and specialized credit options for multifamily construction.



Figure 11. Architectural floor plans for the first and second floors of a generic 900 SF 2-story, 3-bedroom R2 multifamily home.

ANALYSIS SET UP	
What code compliance pathway are you using?	Total UA Alternative, Whole Building Trade Off Analysis
Project Building Type?	New Construction
Occupancy Type?	R2 Multifamily
Code Version?	WSEC 2021
Classification:	Small Dwelling Unit -- 900 sq. ft.
Baseline Description:	Code Baseline - Maximum baseline window area is 15% of floor area.
About Your Selection:	No exempt window or door areas

Figure 12. A screenshot of the C3 tool analysis setup showing the specific pathway chosen by a user.

Messages / Comments *	RESULT= PASS
UA Reduction = 6.19, Proposed UA is better than baseline by 5% Window area is 7% of floor area Whole House Mechanical Ventilation Airflow Rate: 68.75 CFM with Run Time Percent of 100%, Balanced, Not Distributed	

Figure 13. A screenshot of the C3 Tool result section. These results show a pass in which the proposed UA is better than the baseline.

Table 12: Example Mandatory Requirements for Multifamily Dwellings

COMPONENT	U-FACTOR	QUANTITY	NOTES
EXT. DOORS	0.3	2	
WINDOWS	0.3	4	
CEILING			
WALLS ABOVE	0.054	846	R-21 + 0 Foam + int + 2x6 w/ lap
FLOOR W/ VENTED	0.029	900	
VENTILATION	BALANCED	55	100% RUN TIME
LOCATION			VANCOUVER
HVAC			DUCTLESS HP

Table: 13 Options for Multifamily Compliance

OPTION No.	CREDITS	COMPLIANCE PATH
#4 - R406.2 (R2)	2	Variable refrigerant heat pump or air to water
3.7	3	Ductless w/ no elect. Resistance in primary areas
5.6	2.5	Tier III elect. HP water heater
TOTAL CREDIT	7.5	

More compliance path examples for a 2,100 sq. ft. single-family residence are provided in Appendix A. The first example is (likely) the most cost-effective approach. This may be useful for comparing your proposed design to the examples below.

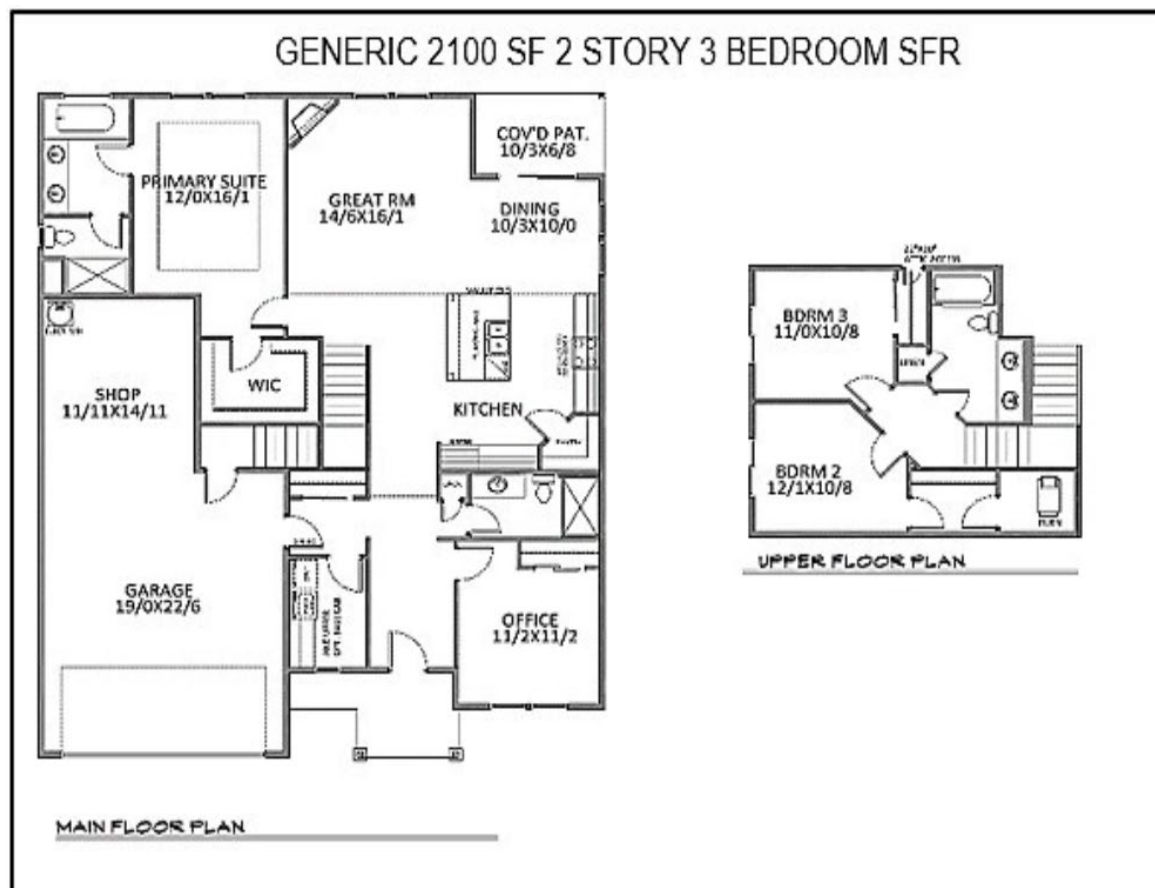


Figure 7. An architectural floor plan of a generic, 2,100 sf, 2-story, 3-bedroom single-family residence.

Implementation of Resources and Industry Standards

For additional guidance, the 2021 [WSEC-R Energy Code Cookbook](#) provides builders with specific “recipes” for compliance. These templates cover small, medium, and large single-

family residence groups and focus on achieving Section R406 requirements. Though these options are not only focused on cost savings, many demonstrate cost efficiency. Figure 15 highlights an example recipe for a 2,100 sq. ft. residence that aligns with the current industry's best practices and the data provided in this report.

RECIPE 08
MEDIUM HOMES 1,500 - 5,000 SQ FT

Ductless Heat Pump with Heat Pump Water Heater



This recipe for a medium home includes a high-efficiency heat pump for both heating and cooling. An efficient heat pump water heater is also included, and it features a compact hot water distribution system. Additionally, it features drain water heat recovery to meet the required energy credits.

#	POINTS	COMPLIANCE PATHWAY
Opt. 4	3	406.2 Energy Credit: 100% DHP
3.7	2	HVAC: DHP with min. HSPF of 10 (HSPF2 of 9) with no electric resistance in primary living areas
5.1	0.5	DHW: Drain Water Heat Recovery
5.2	0.5	DHW: Compact Distribution System
5.6	2	DHW: HPWH Tier 3
8		TOTAL CREDITS REQUIRED

BENEFITS

- Zonal heating/cooling offers flexibility and targets specific areas in the home, requiring no ductwork and making it easier to install
- Cost-effective way to recover and reuse heat from wastewater, compatible with all water heaters
- Occupies less space and minimizes heat loss to ensure quick delivery of hot water, reducing wait times for homeowner
- HPWHs are popular and well-recognized for efficiency, making them a sales feature

RELATED TRAINING & RESOURCES

- [2021 WSEC-R Code Changes and HVAC Strategies](#)
- [Heat Pumps: Mastering Design Principles](#)
- [Heat Pumps: The Art of Commissioning](#)
- [Drain-Water Heat Recovery](#)
- [Compact Water Design Savings](#)
- [HPWH Technical Guide for Single Family](#)

See the 'Trainings & Resources' page for more

Figure 8. Example recipe for a generic 2,100 sf single-family residence from BetterBuiltNW's Energy Code Cookbook.

Appendix: Examples of Cost Effective Energy Code Compliance

To access several UA Alternative Path use examples using the Code Compliance Calculator, [please visit the report appendix](#).

For more information, contact:

Richard Blumenthal, WSU Energy Program

richard.blumethal@wsu.edu

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Washington State University Energy Program

Olympia, Washington

www.energy.wsu.edu

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