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Washington Residential Post-Code Market Research Report

Prepared For NEEA:

Meghan Bean
Sr. MRE Scientist

Prepared by:

Greg Lasher, Associate Project Manager

Marian Goebes, Director

Dan Wildenhaus, Sr. Technical Manager

Brian Farnsworth, Outreach Specialist III

Sean Jones, Residential Energy Efficiency
Account Manager

Desyana Halim, Research Associate

Andrea Gemme, Research Analyst

Niranjana Sreejayan, Research Associate

Julia Sinex, Project Engineer II

TRC Engineer

4105 SW International Way

Milwaukie, OR 97222

Northwest Energy Efficiency Alliance

PHONE

503-688-5400

EMAIL

info@neea.org

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1 Executive Summary

1.1 Introduction

On behalf of the Northwest Energy Efficiency Alliance (NEEA), TRC conducted a study of post-code adoption of the 2018 Washington State Energy Code (WSEC). The purpose of the study was to understand how builders are complying with the code, identify trends, and gather builder feedback to guide development of energy code proposals for consideration by the Washington State Building Code Council. NEEA was particularly interested in fuel selection, envelope, heating and cooling, ventilation, and water heating options called out in the Fuel Normalization Credits and Energy Credits of the 2018 WSEC.

1.2 Methods

TRC collected data by:

- Conducting online surveys with Washington builders (n = 26), and
- Reviewing approved building permit documents of homes that used 2018 WSEC (n = 178) from a sample of Washington jurisdictions.

The study focused entirely on single-family, new construction homes.

1.3 Findings

This study found that the 2018 WSEC is changing builder practices for single-family homes. One major impact is the shift to electric space heating and water heating. Based on permits pulled under the 2018 WSEC, 88% of homes have electric primary space heating¹. In comparison, a 2015 WSEC study ([CLEARResult 2020](#)) recorded a 20% incidence of electric primary space heating. Similarly, based on permits pulled under the 2018 WSEC, 87% of homes have electric water heating, compared to 44% in the 2015 WSEC study ([CLEARResult 2020](#)). The builder surveys conducted for this study corroborated the permit data finding that most builders are using electric space heating and electric water heating under the 2018 WSEC.

Compared to the WSEC 2015, the 2018 WSEC has a broader group of credit options and requires a higher number of credits for *medium* sized homes—defined as larger than 1,500 square feet (sf), and even more for credits for *large* homes—defined as larger than 5,000 sf. Based on both the permit data and builder surveys, the increase in the number of options and the required number of credits has diversified the common approaches to energy code compliance in Washington.

For the most part, permit data showed that builders made similar energy credit choices by climate zone, although there may be a slight preference towards more aggressive air tightness

¹ For the non-electric fuel sources, the permit data collected in TRC's study did not differentiate between propane versus natural gas space heating. It is likely that few homes are using propane, based on the [2016-2017 NEEA Residential Building Stock Assessment](#), which found that 1% of single-family homes in Washington use propane as the primary heating fuel.

and ventilation (energy recovery ventilation [ERV], heat recovery ventilation [HRV]) credits in Climate Zone 5B—a more extreme (and dryer) hot and cold climate, and a slight preference towards efficient heating, ventilation, and air conditioning (HVAC) distribution credits in Climate Zone 4C—a more moderate, marine climate.

From the permit review, more builders are choosing to earn credits by buying more efficient (and typically more expensive) equipment, compared with changing construction techniques such as building significantly tighter envelopes or placing ducts in conditioned space or deeply burying ducts. This aligns with builder feedback in the survey, in which builders reported that the 2018 WSEC was not more technically challenging compared to the 2015 WSEC, but that compliance is significantly more expensive.

Significant takeaways from each of the energy credit categories include:

- For efficient building envelopes, most builders chose a slight improvement worth 0.5 energy credit and avoided exterior continuous insulation.
- Most builders pursued the lowest credit option for air leakage and ventilation, which requires 3.0 ACH50 and no HRV.
- Many builders pursued high-efficiency HVAC equipment, but their interest in efficient HVAC distribution systems (from deeply buried ducts, locating all ducts in conditioned space, or duct sealing) was moderate.
- Heat pump water heaters topped all individual credit options in the study for popularity and credit impact, while drain water heat recovery (DWHR) was very unpopular.
- Most builders did not pursue credits in the renewable energy category.
- Most builders did not choose ENERGY STAR® appliance packages for energy credits.

Most builder open-ended feedback on the 2018 WSEC was negative, and by far the largest concern was the cost increase.

Overall, the study indicates that builder practices have significantly changed under the 2018 WSEC compared to the 2015 WSEC. This includes a shift towards electric space heating and water heating and a preference for efficient equipment options over changes in construction techniques.

2 Introduction

This study gathered market data on the impact of the 2018 WSEC on new construction single-family homes. The goal for this study was to provide state-level findings representative of the 2018 WSEC adoption across Washington. The study looked at primary space and water heating fuel selection, builders' selection of credits (options chosen), and other characteristics including envelope, heating and cooling, ventilation, and water heating choices. NEEA contracted with TRC to conduct the study to inform its 2021 Washington residential code development process.

2.1 Significant Changes in the 2018 WSEC

The 2018 WSEC posed several significant changes to the requirements for builders of single-family new construction homes, compared to the previous energy code (2015 WSEC). These included:

- **The number of energy credits required above the prescriptive minimum values increased for all home the sizes**

Section R406 of the 2018 WSEC requires three energy credits for small homes (under 1,500 sf), six energy credits for medium homes (between 1,500 and 5,000 sf), and seven energy credits for large homes (above 5,000 sf). In 2015 WSEC, a medium size home required 3.5 energy credits.

- **The code introduced a fuel normalization table to the energy credit calculation**

The fuel normalization table “established a base equalization between fuels used to define the equivalent carbon emissions of the options specified”². The table offers five options for primary heating source across all possible heating fuel choices. The builder must declare fuel choices, and the fuel normalization table calculates the mathematical contribution of energy credits towards the required amount.

- **The number and stringency of energy credits available changed significantly**

In the 2018 WSEC, R406.3 consists of 7 categorical measures with a total of 27 choices for energy credits—plus 5 choices for Fuel Normalization. Each individual choice contributes anywhere from 0.5 to 3.0 energy credits. The builder is not required to choose an item from each category, but the total energy credits must meet or exceed the minimum for the size of the home. The 2015 WSEC had 6 categories with a total of 17 choices with less stringent measures than the 2018 WSEC. Some of the more commonly used and less stringent credits in 2015 WSEC (for example, low-flow water devices) are absent in the 2018 WSEC, and all mechanical system efficiencies started at lower efficiencies in the 2015 WSEC.

² 2018 WSEC R406.2 Carbon emission equalization

3 Methodology

For this study, we collected data through:

- Online surveys with Washington builders (n = 26), and
- Reviews of approved building permit documents utilizing the 2018 WSEC (n = 178) from a sample of Washington jurisdictions.

This section describes each of these efforts.

3.1 Builder Surveys

In order to identify trends and receive builder feedback on the 2018 WSEC, TRC conducted a survey of builders of single-family homes across the state of Washington with a representative distribution of code compliant and above-code builders and custom and production builders.

To identify builders, TRC collected publicly available builder contact information from 11 home builder associations in Washington state³. This was the primary sampling frame, because it was the most comprehensive and diverse group of builders that TRC identified. For some builders, the builder association website provided a builder email address. For some builders where this was not the case, TRC was able to obtain email addresses using ZoomInfo⁴. In addition, TRC supplemented the list of builders from program partners from BetterBuilt Northwest and Energy Trust of Oregon's SW Washington program offering. Working with the program partners enabled TRC to verify above-code builders and provide insight into the builder's annual home construction volume. Finally, TRC leveraged partnerships with trade organizations and energy raters to gather more builder contacts and increase the survey response rate.

TRC fielded the online survey between December 2021 and February 2022 using Qualtrics, an online survey platform. To increase response rate, TRC offered respondents a \$100 electronic gift card for completing the survey and contacted builders up to four times.

3.1.1 Firmographics of Builder Survey Responses

TRC sent survey invites out to 228 builders. A total of 26 builders completed the survey for a response rate of 12%. As shown in the figures below, the builders that completed the survey represent a mix of to-code builders and builders that participate in above-code programs, production builders and custom builders, as well as builders that operate throughout the state of Washington. All survey respondents confirmed to TRC that they had submitted at least one home under the 2018 WSEC.

³ BIA of Whatcom County, Skagit/Island Counties Builders Association, MBA of King and Snohomish Counties, MBA of Pierce County, Olympia Masters Builders, North Peninsula Building Association, BIA of Clark County, Lower Columbia Contractors Association, Spokane Home Builders Association, Jefferson County Home Builders Association, HBA of Tri-Cities

⁴ Zoominfo Technologies is a service that sells access to its database of information about businesspeople and companies. TRC used Zoominfo to acquire company email addresses.

As shown in Figure 1, 58% of respondents reported participating in above-code programs (for example, ENERGY STAR homes or Built Green), and the remainder reported they build to-code. Figure 2 presents the number of single-family homes that the survey respondents reported their company builds each year in Washington. About half of the survey respondents (54%, n = 14) are considered custom builders (as defined for this study), since they reported their company builds 1-10 homes per year. About one-fifth of the builders (19%, n = 5) reported their company builds 11-50 homes per year, which this study considers low-level production builders, and another one-fourth reported building more than 50 homes per year, considered as production builders in this study.

Figure 1. Survey Respondents' Building Practices (Above-Code Program Participation versus At-Code Building Practices) (n = 26)

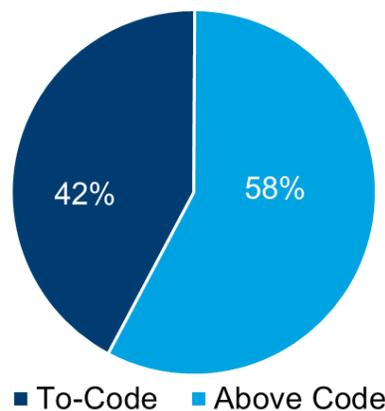


Figure 2: Number of Homes Built Annually by Survey Respondents (n = 26)

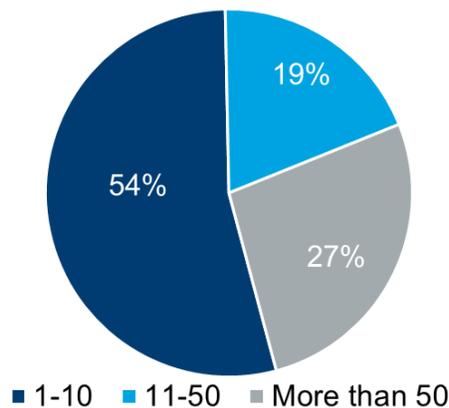
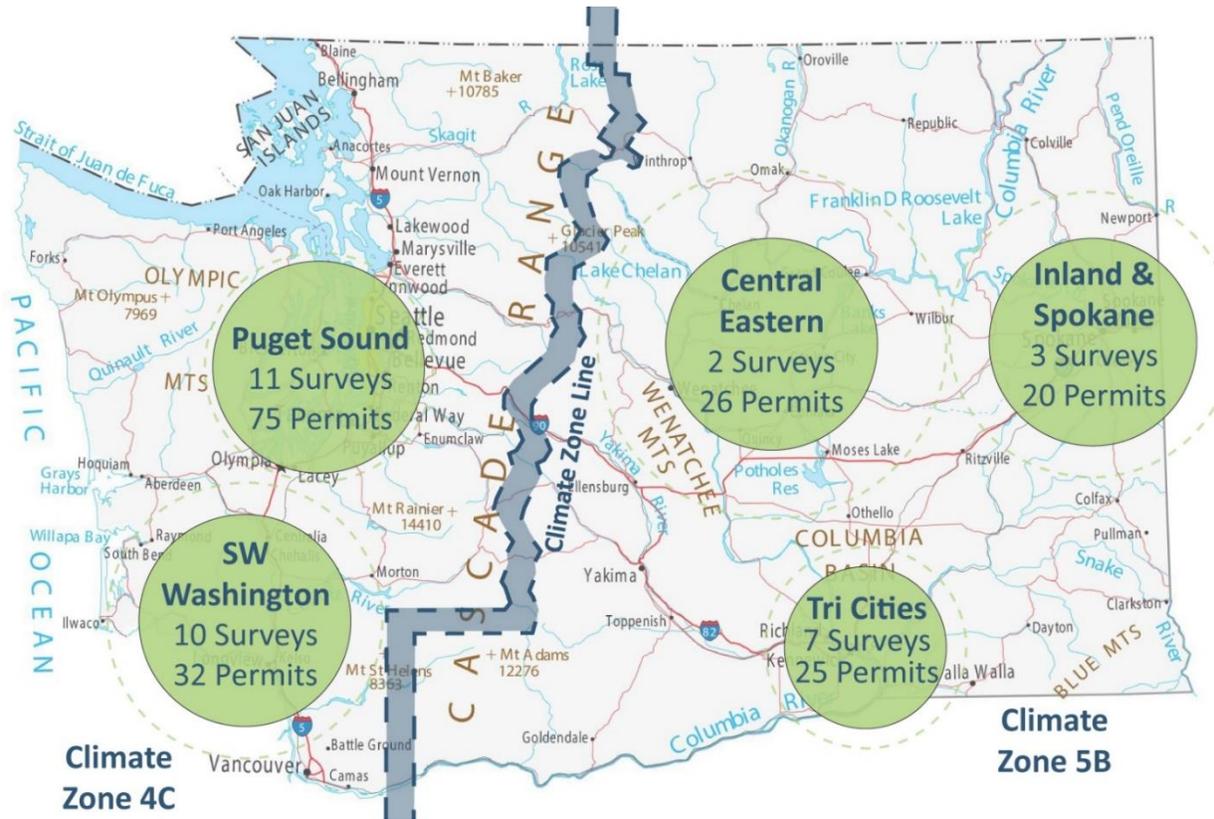


Figure 3 shows the area(s) of Washington where survey respondents reported building homes. Some builders identified more than one area, so the total in Figure 3 is greater than 26 builders. As shown, builder survey respondents are well distributed throughout the state. Most of the respondents (42%, n = 11) primarily build single-family homes in the Puget Sound region. Almost two-fifths of the builders (38%, n = 10) build in the southwest Washington area. About a quarter (27%, n = 7) build in the Tri-Cities region. The smallest number of responses came from the central/eastern and Inland/Spokane regions. In general, this follows construction (and population) patterns, since a recent 2015 WSEC code study (CLEARResult 2020) found a larger

share of construction permits along the I-5 corridor (Puget Sound and southwest Washington). However, to better represent building practices across the state, it is important to capture feedback from other regions and builders working in less-populated areas, so the 12 responses from the central/eastern region, Inland/Spokane region, and Tri-Cities region are critical.

Figure 3. Survey and Permit Counts Across Regions of Washington (Survey n = 26, Multiple Responses Allowed; Permit n = 178)



3.2 Permit Review

After completing a brief targeted literature review, TRC collected a representative sample of approved permit documents for new construction single-family homes across the state of Washington utilizing the 2018 WSEC.

3.2.1 Sampled Jurisdictions for Permit Data

To collect statistically significant results at the measure level for water heating, space heating/cooling, and envelope, TRC anticipated needing approximately 100 to 130 total permits. TRC simplified this to 10 permits from 12 representative jurisdictions. TRC chose to stratify the jurisdictions by the size of the jurisdiction and across Climate Zones 4C and 5B.

To identify which jurisdictions to sample for permits, TRC leveraged the work of CLEAResult (2020⁵), which provided a sampling approach for jurisdictions as part of a new construction

⁵ <https://neea.org/img/documents/2019-2020-Washington-Residential-New-Construction-Code-Study.pdf> see p. 13.

code study in Washington. That study found that 301 jurisdictions represent over 90% of all building permits in Washington. The study stratified jurisdictions into three strata for sampling: large, medium, and small—which is based on the quantity of homes in the jurisdiction—and developed a sample of 20 jurisdictions to ensure a diversity of jurisdictions by size. TRC determined that this stratified sample represented a split of 70% of jurisdictions in Climate Zone 4C and 30% in Climate Zone 5B.

TRC verified, with the use of Construction Monitor⁶, that the size categories of the 20 sampled jurisdictions in the CLEAResult study (CLEAResult 2020) still hold true for 2020, the last year of full data available in Construction Monitor. This distribution of large, medium, and small jurisdictions also includes a diversity of urban (e.g., Seattle, Spokane), suburban (e.g., unincorporated King County), and rural (e.g., unincorporated Douglas County) jurisdictions.

Expecting some jurisdictions to not respond with data, TRC reached out to all 20 of the jurisdictions in the stratified sample. Ultimately, 10 jurisdictions from this original sample provided data to TRC. Subsequently, TRC contacted 18 additional jurisdictions that met the size and climate zone characteristics of the stratified sample, and 12 of those jurisdictions responded with data that was entered into the final data set.

3.2.2 Jurisdictions Reflected in Permit Data

Table 1 shows, for each jurisdiction size, the original distribution of sampled jurisdictions, the distribution of jurisdictions that provided permits, and the distribution of permits in the study data set. Permits in the final data set were fairly evenly distributed across the jurisdiction size categories.

Table 1. Distribution of Jurisdictions and Permits by Jurisdiction Size

Jurisdiction Size	Jurisdictions in Original Sampling Frame		Jurisdictions that Provided Permits		Permits in Data Set	
	Count	Percent	Count	Percent	Count	Percent
Large	9	45%	7	32%	65	37%
Medium	4	20%	7	32%	53	30%
Small	7	35%	8	37%	60	34%
Total	20	100%	22	100%	178	100%

Table 2 shows, for each climate zone, the original distribution of sampled jurisdictions, the distribution of jurisdictions that provided permits, and the distribution of permits in the study data set. Climate Zone 4C comprised 60% of the permits analyzed. Climate Zone 4C is the more populated area since it includes Seattle, which is the most populated city in Washington.

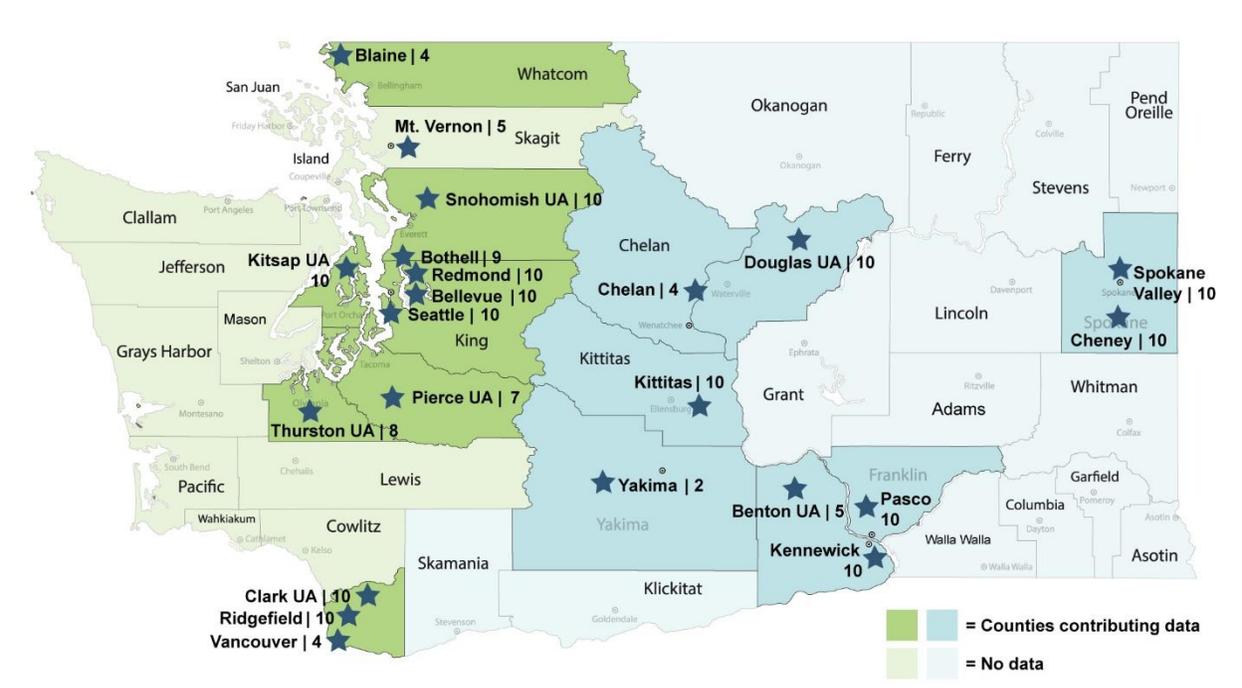
⁶ Construction Monitor is a paid service that shows data on building permits, including location and date pulled.

Table 2. Distribution of Jurisdictions and Permits by Climate Zone

Climate Zone	Jurisdictions in Original Sampling Frame		Jurisdictions that Provided Permits		Permits in Data Set	
	Count	Percent	Count	Percent	Count	Percent
4C	14	70%	13	59%	107	60%
5B	6	30%	9	41%	71	40%
Total	20	100%	22	100%	178	100%

Another view of the final data set for this study is shown in Figure 4 below. In this map the distribution of permits entered into the final data set and the location of the permit offices is displayed across the two climate zones. The green counties are in Climate Zone 4C, and the blue counties are in Climate Zone 5B.

Figure 4. Permits Entered into the Final Data Set for this Study by Climate Zone



3.2.3 Collection of Permit Data

To obtain permits from jurisdictions in Washington, TRC reached out directly to jurisdiction offices by email and by telephone. The outreach team requested approved building permits and plan sets that included the 2018 WSEC energy credits from Table R406.2 (Fuel Normalization) and Table 406.3 (Energy Credits) for new construction single-family homes. TRC requested 10 or 12 data sets of approved document permits from each jurisdiction with the intention of fulfilling a maximum of 10 permits being entered into the final data set. If a jurisdiction shared more than 10 data sets, TRC randomly chose 10 permits from the jurisdiction to be entered into

the data set. Some permits had little information⁷. At a minimum, for TRC to enter a permit into the final data set, a data record for an approved home permit needed to have:

- Home address or location and the home's square footage.
- Dates from the jurisdiction approving the permit to build after 2/1/2021.
- Declared energy credits from Tables R406.2 and 406.3 from the 2018 WSEC.

TRC also used industry contacts, particularly the Washington State Energy Program, to carry the outreach request to building officials during webinars. Project team members spread the request for jurisdiction assistance to known industry representatives. The most effective outreach method was the TRC project team's direct contact and follow-up with building code officials.

10 of the 20 jurisdictions identified in the original sample did not respond to TRC's request for permit data. In addition, some jurisdictions responded, but they did not provide 10 records that fulfilled the data criteria to be entered within the data collection timeframe. Of the 22 jurisdictions in the final dataset, 13 provided a full 10 permits, and 9 jurisdictions provided fewer than 10.

For jurisdictions that did not provide permits (or enough permits), TRC identified substitute jurisdictions that closely matched the climate zone and size represented in the original stratified sample. The completed dataset of 178 permits includes data from 10 of the original sampled jurisdictions and 12 from substituted jurisdictions.

While outreach to jurisdictions was the primary method for obtaining permits, TRC also requested permits directly from builders as part of the survey for an incentive amount of \$40 per permit. Survey respondents contributed eight of the permits in the final data set.

In addition, while most jurisdictions fulfilled TRC's permit requests via phone and email, a TRC subcontractor successfully added data from three jurisdictions after visiting offices in person. Of note, one small jurisdiction provided 10 permits that could only be viewed in person; it was critical to provide an in-person effort to diversify the sample.

In total, TRC collected 255 permits from jurisdictions and analyzed 178 permits.

- Twenty-five (25) of the 255 data records shared with TRC utilized 2015 WSEC. TRC did not include these in the final data set. Permit offices did not provide an explanation for why they approved building permits issued after the February 1, 2021 that utilized the 2015 WSEC.
- Some permits from jurisdictions arrived after the completion of the study or in excess of 10 permits already entered.

3.2.4 Data Collected from Permits

To collect data from permits, TRC developed an Excel[®] workbook to capture information relevant for the study. This workbook included fields for basic information about the home (e.g.,

⁷ It was beyond the scope of this project to investigate why some jurisdictions had permits with missing data.

location, builder, home size) and detailed information of each energy credit earned. The workbook allowed TRC to collect data systematically and efficiently.

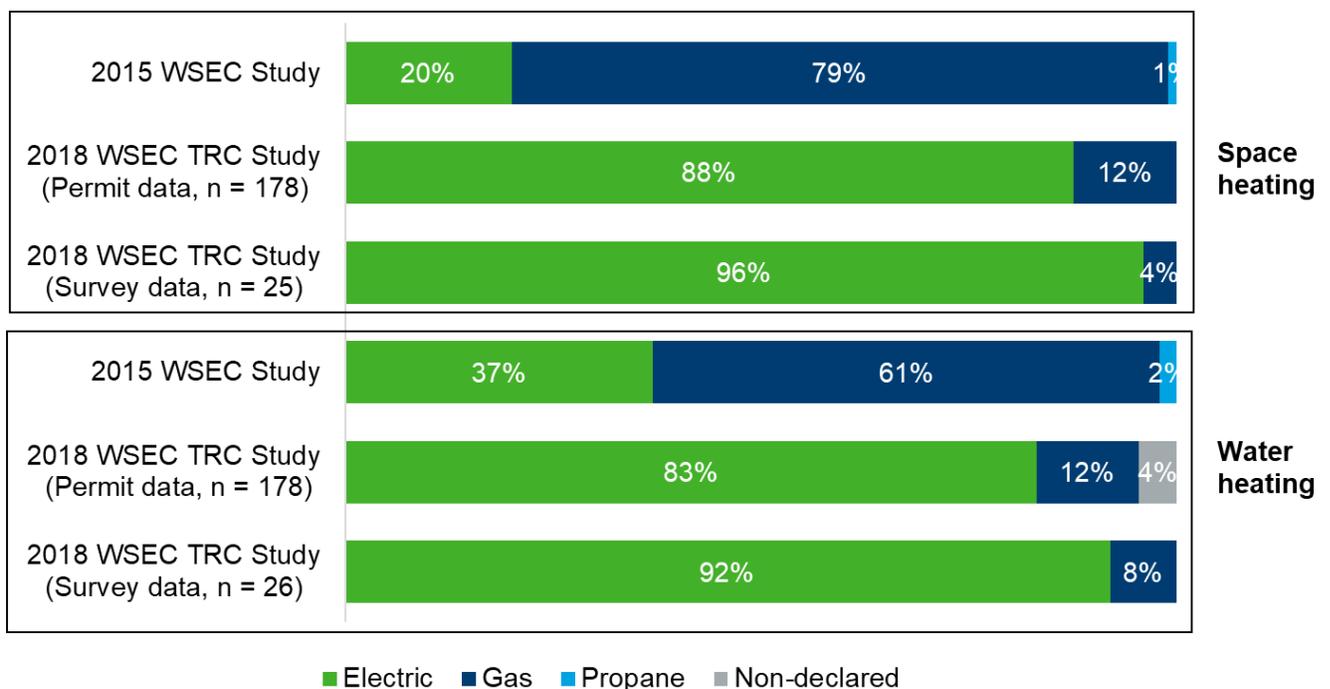
4 Results

This section provides results from both data collection activities: the permit data and builder survey. The subsection headings generally align with the 2018 WSEC code, Section R406 (Appendix A). As described in the Introduction, homes must earn a minimum number of energy credits (depending on home size), and builders may choose which credits they earn.

4.1 Fuel Choice

A key aspect of the 2018 WSEC are credits for space heating and water heating that impact fuel choice.⁸ Figure 5 combines results from both the builder surveys and permit review, for both space heating and water heating, and compares these results to a different study of 2015 WSEC (CLEAResult 2020) declared choices.

Figure 5. Fuel Choice for Space Heating and Water Heating



A major impact of the 2018 WSEC is the shift to electric space heating and water heating compared to builder’s choices under the 2015 WSEC. That study found that 79% used natural gas for primary space heating (1% used propane) and 61% used natural gas for water heating. Electric space heating comprised 20% and electric water heating totaled 37%

⁸ The data collected for the 2018 WSEC did not differentiate between propane versus natural gas space heating. “System type one” for the fuel normalization table is “combustion heating equipment,” which includes natural gas and propane. But the permits do not distinguish between the two fuels. It is likely that propane is a small percent based on the [2016-2017 NEEA Residential Building Stock Assessment](#), which found that 1% of single-family homes in Washington use propane as the primary heating fuel.

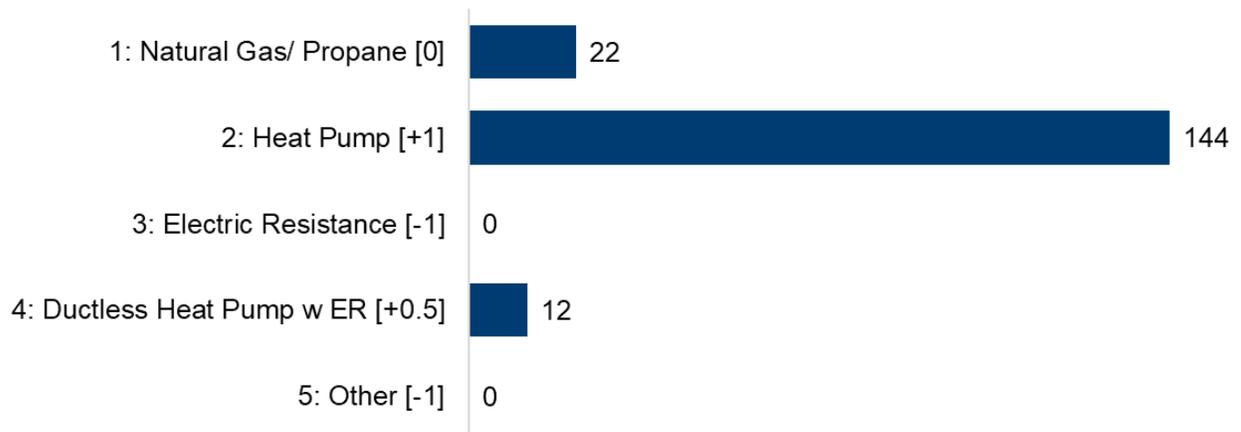
(CLEAResult 2020). Both the permit data and survey results from the present study indicate approximately 90% penetration of electric appliances for space heating and water heating⁹.

All builders must complete the fuel normalization table for a project for the home’s primary space heating source. When faced with meeting the required energy credits for construction of a new home in Washington, 88% of permits (157 out of 178) showed a form of electric space heat, and the vast majority (81%) showed electric heat pumps. A minority (12%) selected natural gas, and the remainder selected mini-split heat pumps with electric resistance (7%). No permits reviewed selected “electric resistance” or “other.”

For

Figure 6 below and for all other figures from the permit data collection showing credits obtained, the labels include a brief description of the credit and the number of points it represents in parentheses [+points]. The number to the right of the bar represents the number of permits (out of the 178 reviewed) declaring this credit.

Figure 6. Fuel Normalization Choices from Permits (n = 178)



4.2 Credit Categories Targeted and Changes to Building Practices

This section provides an overview of the seven credit categories included in the 2018 WSEC along with insights on how the 2018 WSEC is changing builder practices in Washington.

For this analysis, TRC analyzed the permit data and the survey responses. The survey results are mostly in line with the permit results. For a few questions, the results differed. This may be because:

⁹ While the permit data shows 83% electric water heating, the estimate is 87% after removing the undeclared choices for water heating. Water heating fuel source can only be determined if the builder selects energy credits from the Efficient Water Heating Options in Section 5 of Table 406.3. Water heating fuel type is not declared in the Fuel Normalization Table 406.2.

- The survey results provide insight into builders' *interest* in the category, whereas the permit results show interest in and the average *impact* of the credits from the category (that is, average credits earned in the category). For example, survey respondents demonstrated high interest in air leakage, but the permit data show that air leakage had lower impact in the permits because the most popular air leakage credit only contributes 0.5 credits.
- TRC did not collect many permits from the builders that took that survey¹⁰, so the builders for the homes reflected in the permit data are assumed to be different from the builders in the survey data.

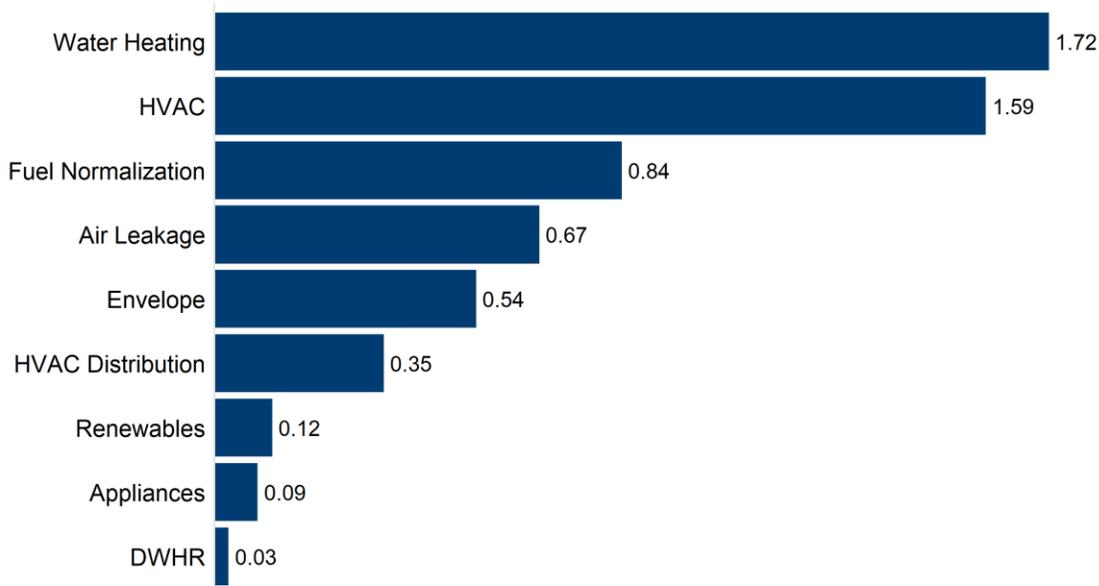
4.2.1 Permit Results

After completing the required fuel normalization table in the 2018 WSEC, a builder can earn the remainder of the required credits from any of seven categories in any combination. Figure 7 below shows permits results in the seven broad credit categories, the fuel normalization credits, and DWHR¹¹. The number to the right of the bar represents the **average number of credits** from that category, which indicates the popularity of the category **and** its contribution towards the energy credit requirement. Based on the permits reviewed, the efficient water heating and efficient HVAC system categories were by far the most popular categories. Tier 3 heat pump water heaters and heating seasonal performance factor (HSPF) air source heat pumps (ASHP) were popular choices within these categories. DWHR, ENERGY STAR® appliances, and renewable energy sources were the least popular categories.

¹⁰ TRC did ask builders that responded to the survey if they would be willing to provide a sample of permits for an additional incentive. A few did, but the vast majority of the permit data that TRC collected came from jurisdictions, not the builders.

¹¹ Drain water heat recovery is the only credit that can be combined with another credit within its category (efficient water heating) and so it is listed in the figure as a separate category.

Figure 7. Average Credits Achieved from Each Credit Category from Permits (n = 178)

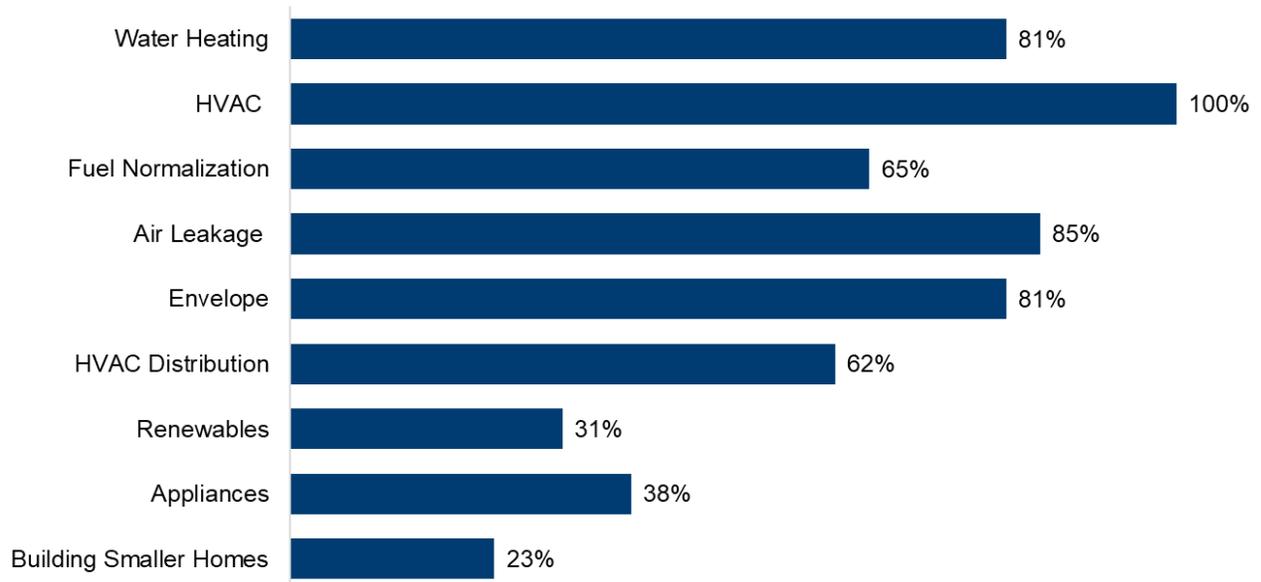


4.2.2 Builder Survey

TRC asked survey respondents how they are meeting the 2018 WSEC requirement for credits. As shown in Figure 8, respondents claim to use a variety of credit categories to meet requirements. High-efficiency HVAC and air leakage control and ventilation are the **most** popular. Appliance package, renewable energy, and building smaller homes are the **least** popular.

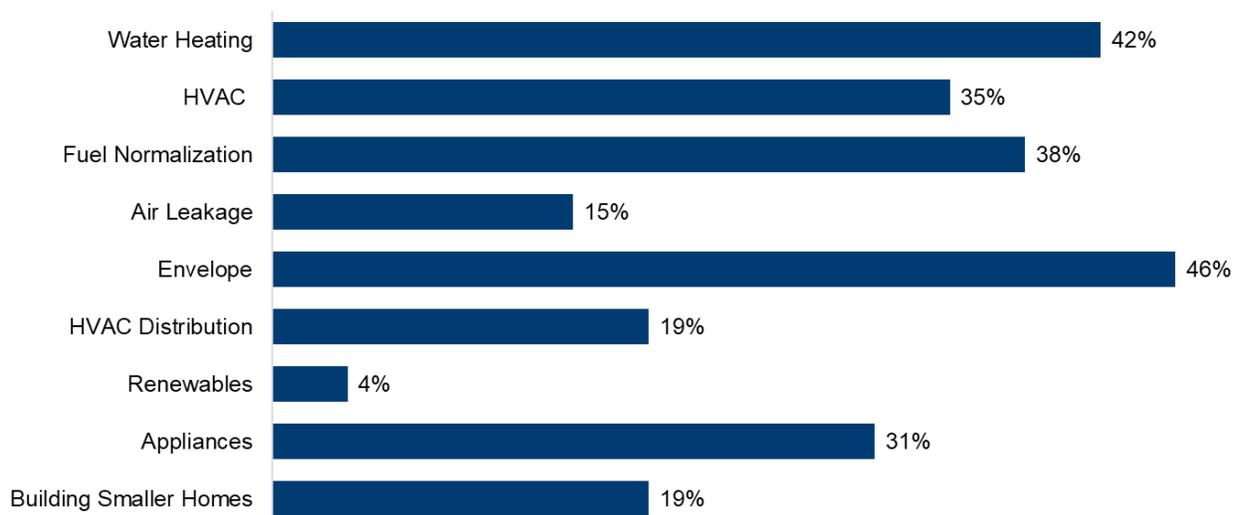
As shown in Figure 8, all survey respondents reported using energy credits from high-efficiency HVAC equipment. Top choices include selecting energy credits for air leakage control and ventilation, followed by efficient water heating credits and efficient envelope. Around two-thirds of the respondents meet the energy credits through fuel normalization and HVAC distribution. Less popular choices include selecting the ENERGY STAR® appliance package, including renewable energy, and building smaller homes to meet targeted credits.

Figure 8. Builders' Reported Energy Credit Selections Under the 2018 WSEC from Survey (n = 26, Multiple Responses Allowed)



TRC asked survey respondents which credit option is the easiest to comply with. As seen in Figure 9, survey respondents most frequently chose efficient envelope, followed by efficient water heating. Respondents reported that the renewable energy credit was the most difficult to comply with. For the most part, the proportion of builders reporting that they pursue a credit category corresponds with the proportion of builders reporting that that credit category is easy to comply with. The patterns differed for air leakage and renewables. The survey did not probe into why builders may not always pursue credits they report are easiest.

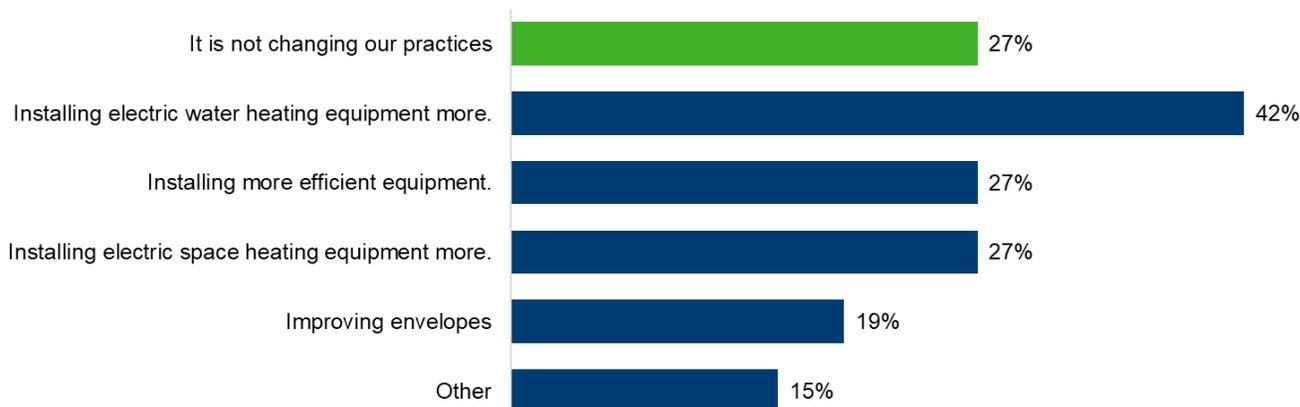
Figure 9: Builders' Reports of which Credit Options are Easiest (n = 26, Multiple Responses Allowed)



TRC also asked survey respondents how (if at all) the 2018 WSEC is changing their building processes. As shown in Figure 10 below, 73% of builders report that the 2018 WSEC is changing their practices.

In terms of how their building practices changed, about two-fifths (42%) of the respondents reported installing electric water heating equipment more frequently. More than one-quarter reported installing more efficient equipment (27%) and electric space heating equipment (27%). Around one-fifth (19%) of the builders reported installing improved envelopes. In general, this indicates that—at least at this time—builders are preferring to install upgraded equipment, as opposed to changing construction techniques (such as improving envelopes).

Figure 10. Survey Respondents’ Changes to Building Practices Due to the 2018 WSEC (n = 26, Multiple Responses Allowed)



Respondents that selected “Other” specified the following additional ways they are meeting the code:

- ◆ “We will have to figure out ducting, as we often do a ductless, ducted system in the attic space.”
- ◆ “Making homes more expensive for our buyers.”
- ◆ “We are building the same as we did before but now with more expensive equipment to meet the energy code credit.”

4.3 Choices by Credit Category

This section provides analysis on how builders are earning credits in each credit category of the 2018 WSEC. For each of the seven categories, the permit data will be discussed first, followed by a comparison to the survey results.

4.3.1 Efficient Building Envelope Options

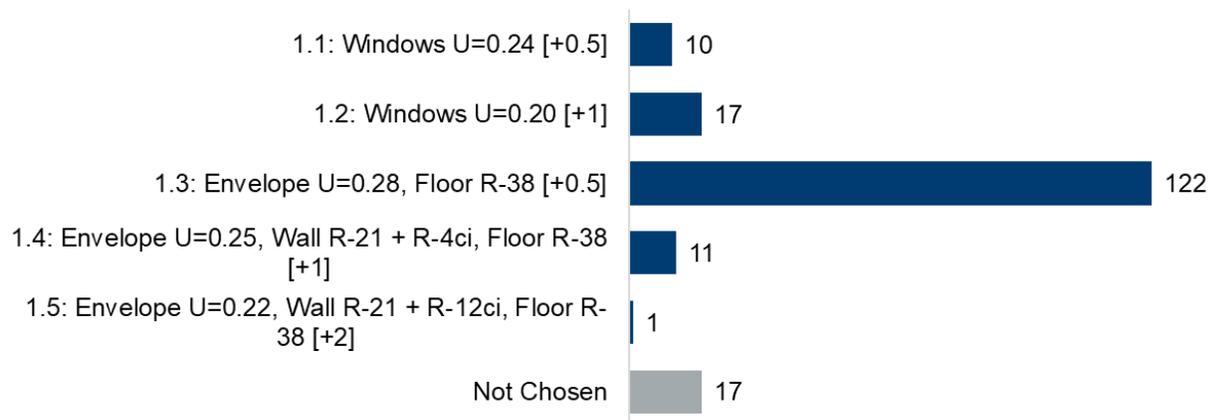
This category offers builders options to improve the envelope of a home beyond the prescriptive minimums. This includes more efficient windows, walls, floors, attics, raised heel trusses, and advanced framing. Fenestration products have a U-value, where a lower U-value means less heat passes through the product. Similarly, insulation products and envelope assemblies have an R-value, where a higher R-value means less heat passes through the product.

Builders can only choose one selection in this category. **As shown below, for efficient building envelopes, most builders are choosing a slight improvement worth 0.5 energy credit and are avoiding exterior continuous insulation.**

Permit Results

While many builders are earning credits in the envelope category, most are choosing energy Credit Option 1.3, worth only 0.5 point. This measure is a slight improvement over the prescriptive minimums for the assemblies involved. Credits 1.1 and 1.2 exclusively target the fenestration of the new homes, with 1.1 representing a very efficient, double-pane window and 1.2 requiring the emerging technology of triple-pane windows. Credits 1.4, 1.5, and 1.6 prescriptively require the installation of exterior continuous insulation.

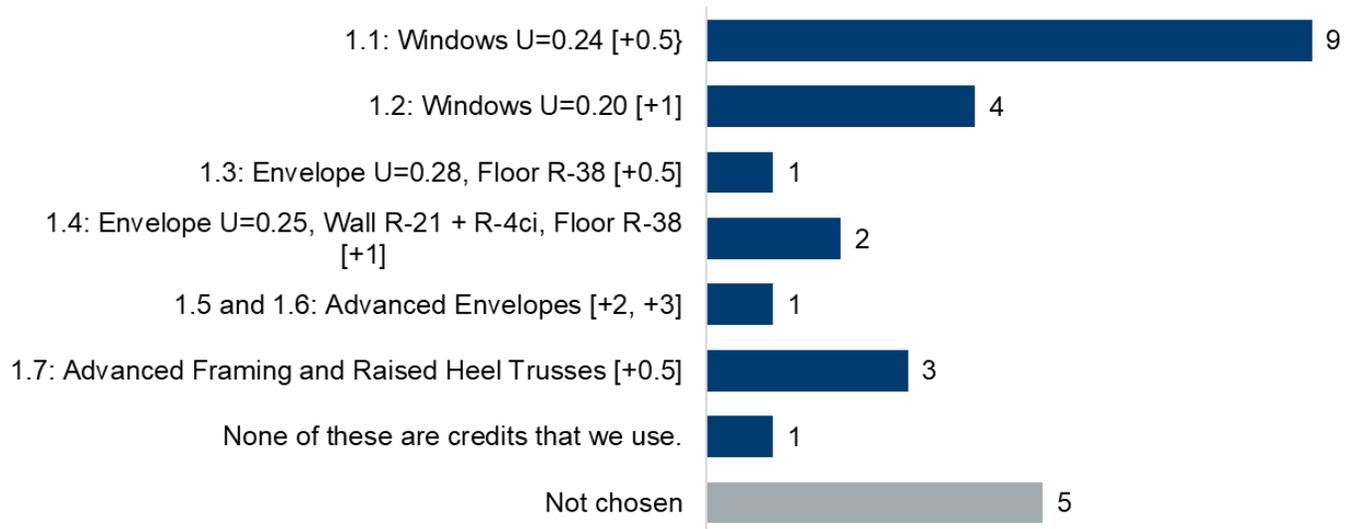
Figure 11. Efficient Envelope Choices from Permits (n = 178)



Builder Survey

Most (81%) survey respondents reported using the envelope category to meet the 2018 WSEC. Figure 12 below shows the level of interest survey respondents reported for each envelope credit option. These results differ from the larger sample of approved permits. Specifically, survey respondents showed much higher interest in the U=0.24 windows (represented by Credit 1.1) than Measure 1.3, which improves the windows and envelope.

Figure 12: Efficient Envelope Choices by Survey Respondents (n = 26)¹²



4.3.2 Air Leakage Control and Efficient Ventilation Options

This category offers builders the option of increasing the air tightness of the building envelope for energy credits. Only one choice can be made in this category, and each air leakage control level requires a specific ventilation technique.

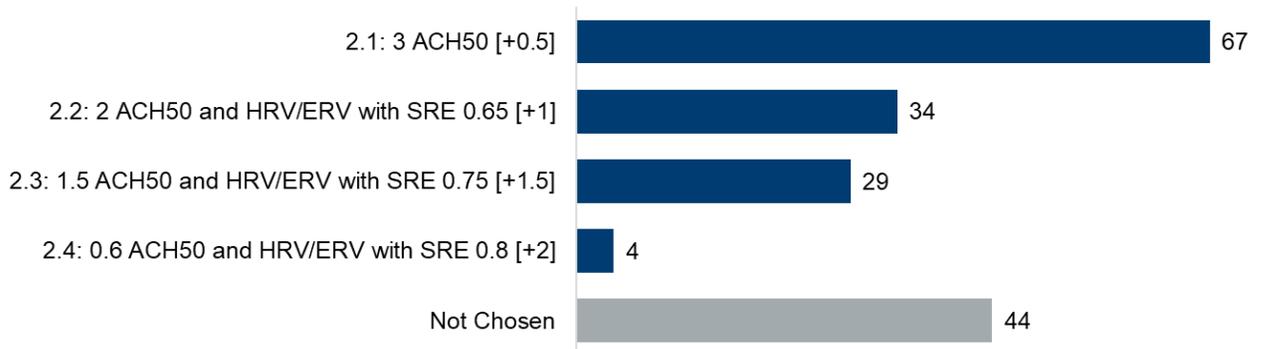
Air tightness is measured in air changes per hour (ACH) measured at 50 Pascals (ACH50). **As shown below, most builders are pursuing the lowest credit option for air leakage control and ventilation, which requires 3.0 ACH50 and no HRV.**

Permit Results

Of the permits reviewed, 75% earned an air leakage control and ventilation energy credit, making it a popular credit category. However, half of the permits that earned a credit in this category (n = 67) chose the easiest compliance path, Energy Credit 2.1, which requires 3.0 ACH50 and no HRV. Credits 2.2 through 2.4 require a tighter envelope and heat (or energy) recovery ventilation (HRV or ERV). Credits 2.3 and 2.4 have increasingly higher sensible recovery efficiency requirements for the HRV/ERV. Overall, reduced air leakage and ventilation was not a strong contributor to the total energy credits declared for builders per home.

¹² For Figure 12 and other figures from survey data below, "Not Chosen" indicates that the survey respondent did not report using this category for energy credit compliance. "None of these are credits that we use" indicates that the respondent used this credit category but their approach was not represented in the options provided in the survey. This suggests that the builder chose a compliance path to reduce the total conductive UA by a percentage.

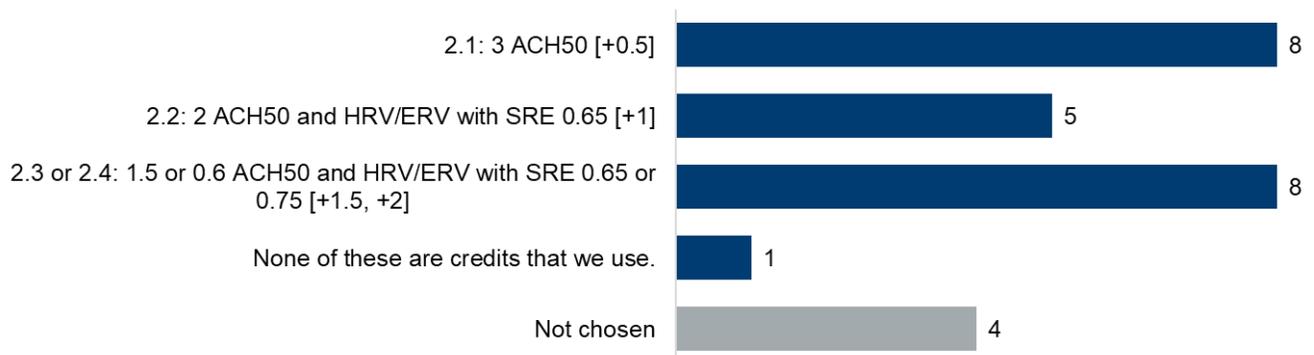
Figure 13. Air Leakage and Ventilation Choices from Permits (n = 178)



Builder Survey

Most survey respondents (85%) reported using the air leakage control and ventilation effectiveness credits to meet the 2018 WSEC. Figure 14 shows which credit options those respondents chose to meet that credit. The survey results show a higher interest in very tight homes (at least 1.5 ACH50) than the permit results.

Figure 14: Air Leakage and Ventilation Choices by Survey Respondents (n = 26)



4.3.3 High Efficiency HVAC and HVAC Distribution System Options

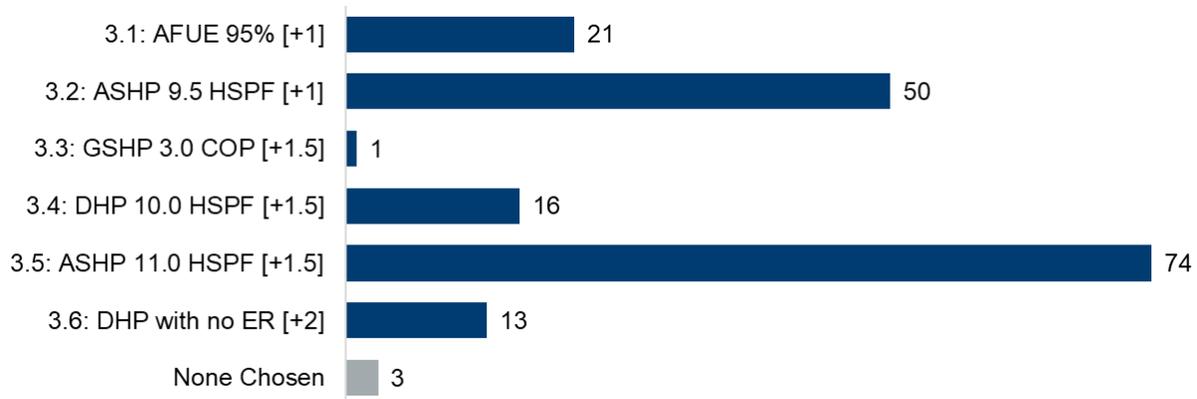
In this section we discuss two credit categories: efficient heating and cooling systems (HVAC) and options for where the ducted systems are located (if the home has a distribution system). Energy credits are awarded for HVAC systems that exceed the federal minimum manufacturing standards, regardless of the fuel type. If the HVAC is a distributed system through ductwork, a builder can choose to obtain energy credits for locating the ductwork inside the thermal boundary or deeply burying those ducts under insulation in the attic.

As shown below, high-efficiency HVAC equipment is very popular for energy credits, but interest in efficient HVAC distribution systems was moderate.

Permit Results

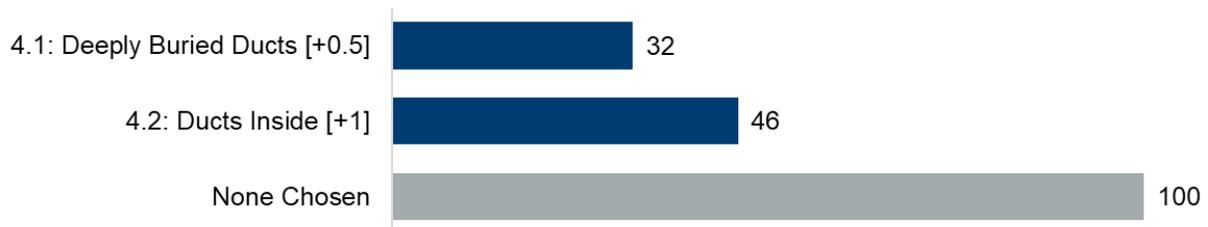
Permit results show that efficient HVAC equipment was a popular choice. The two most popular options were a 9.5 or a 11.0 HSPF ASHP. Ductless heat pumps were somewhat common, and only one permit earned credit for a ground source heat pump. Among builders that chose to heat the home with gas or propane¹³, 100% (21) of those builders chose to increase the efficiency to at least 95 annual fuel utilization efficiency (AFUE) for one energy credit.

Figure 15. Efficient HVAC Choices from Permits (n = 178)



There are additional credits for either deeply burying the ductwork in the attic or locating the ductwork completely inside the thermal envelope (referred to in the 2018 WSEC as the “HVAC distribution system” category). Based on the permit data, this category had moderate popularity for energy credits. Only 44% of builders declared energy credits in this category. When declared, the choice of bringing the ductwork inside the thermal envelope was more popular than deeply burying the ductwork.

Figure 16. HVAC Distribution System Choices (Duct Location) from Permits (n = 178)



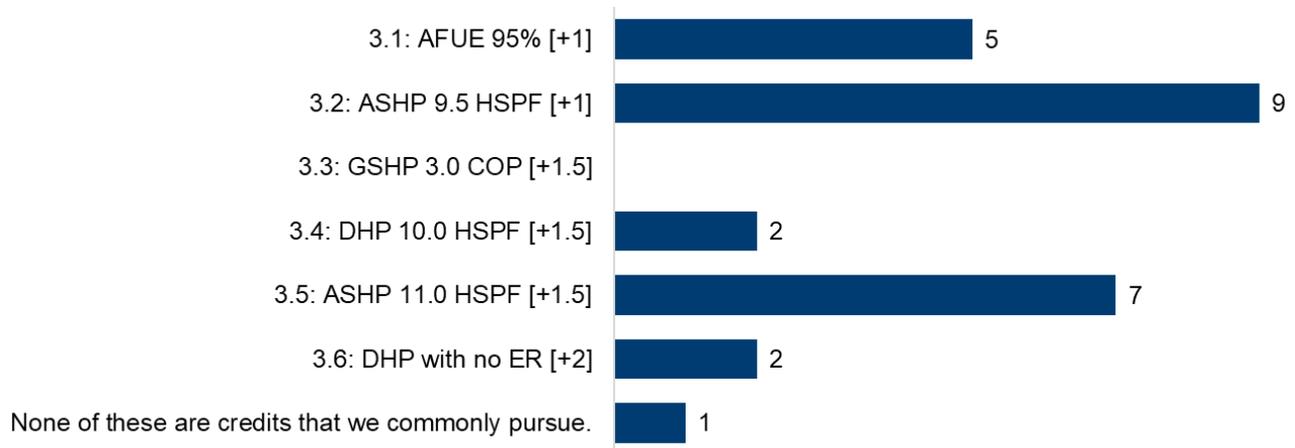
Builder Survey

Survey responses support the permit data on the popularity of high efficiency HVAC equipment regardless of fuel choice. The builder survey did not include specific questions on distribution

¹³ Data review could not determine propane versus natural gas space heating.

systems. However, in the broader credit category question, 62% of survey respondents reported that they use (or plan to use) credits from the HVAC distribution system category, and the permit results above showed this category was used 44% of the time.

Figure 17: Efficient HVAC Credit Options Chosen by Survey Respondents (n = 26)



4.3.4 Efficient Water Heating and DWHR

The 2018 WSEC offers energy credits regarding efficient water heating for any fuel type. It is the only category that allows more than one response; builders can combine the DWHR option with any one of the other options. DWHR is a device that captures heat from warm water drainpipes and utilizes that heat to reduce the amount of energy required to heat water in the home.

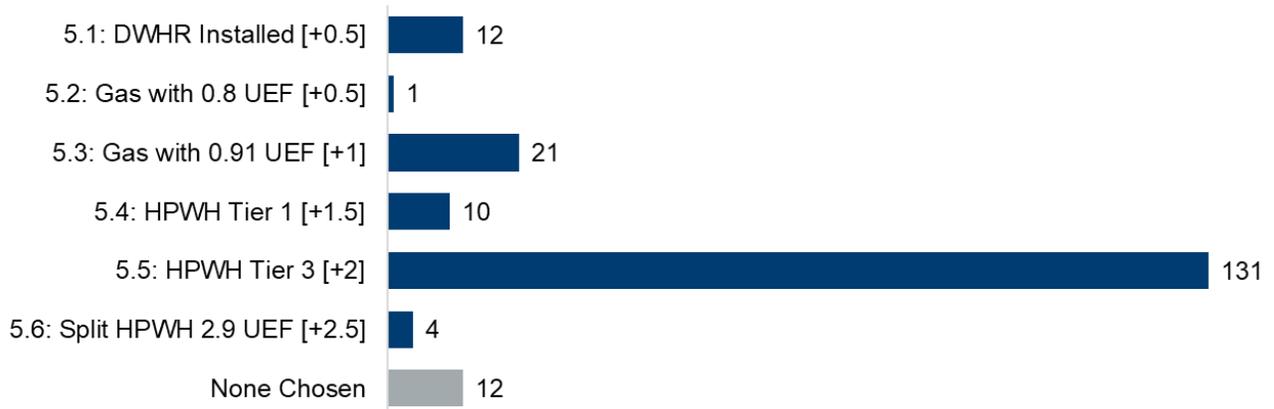
As shown below, heat pump water heaters topped all individual credit options in the study for popularity and credit impact, but DWHR showed low interest.

Permit Results

Permit results from this research study show the water heating category to be very popular and impactful in its contribution to the required energy credits. A Tier 3 heat pump water heater (HPWH) was the single most popular option, with 73% of the permits reviewed claiming this measure. With a contribution of two energy credits, HPWH was also impactful towards the total required energy credits, which presumably contributed to its popularity.

Despite both the 2015 and 2018 WSEC offering credit for DWHR, it was not popular with only 12 declarations out of the 178 permits in this study. However, 6 builders out of 10 from the Redmond jurisdiction declared DWHR systems for energy credits. TRC inquired with the jurisdiction about this finding, but the permit office did not reply.

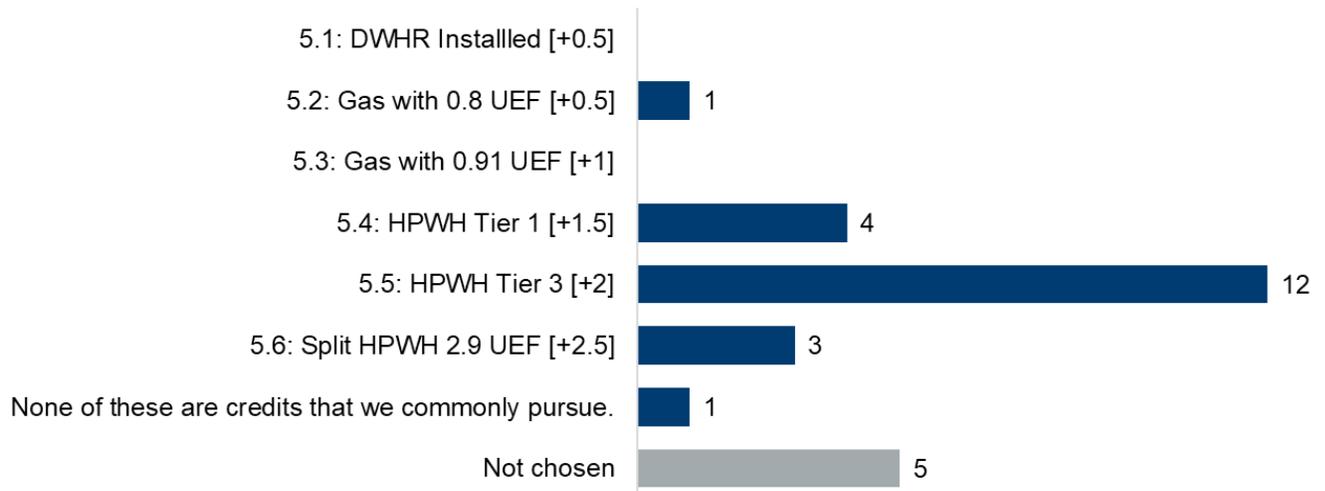
Figure 18. Efficient Water Heating Choices from Permits (n = 178)



Builder Survey

The survey responses also reflect the popularity of heat pump water heaters and the unpopularity of all other options, including DWHR, similar to the permit results for this category.

Figure 19: Efficient Water Heating Choices by Survey Respondents (n = 26)



4.3.5 Renewable Electric Energy Options

The renewable energy category for the 2018 WSEC allows one to three energy credits for electrical generation from either on-site wind or solar equipment. The capacity of the system is based on the minimum annual power generation.

As shown below, most builders are not pursuing credits in the renewable energy category.

Permit Results

The permits showed solar panels to be the exclusive type of renewable electric energy generation declared for energy credits. While only 6% of builders chose this category, the relative impact was larger. This is because roughly a third of the homes choosing solar panels received three credits, a high impact on the total amount required for a single category.

Figure 20. Renewables Choices from Permits (n = 178)



Builder Survey

Survey results indicated that renewable energy credits are unpopular. Only one respondent found compliance with renewable energy credits to be easy.

4.3.6 Appliance Package Options

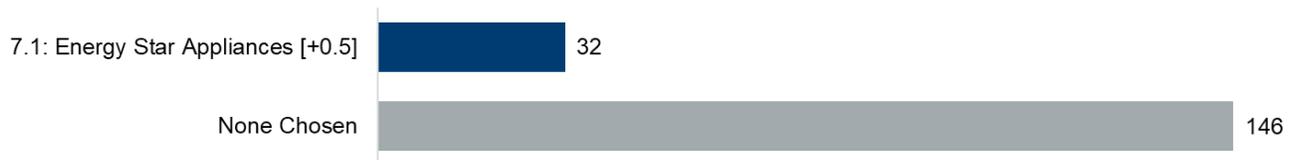
The final category of energy credits from table R406.3 allows 0.5 energy credits for new ENERGY STAR appliances installed in the home. To claim the credit for appliances all four appliances must be installed: dishwasher, refrigerator, washing machine, and clothes dryer. The dryer required is an ENERGY STAR rated ventless dryer with a minimum CEF rating of 5.2.

As shown below, most builders do not select ENERGY STAR appliance packages for energy credits.

Permit Results

This category was not popular. Of the permits reviewed, 17% declared the builder would install a full set of ENERGY STAR appliances. The permit review indicated that the ENERGY STAR clothes dryer efficiency rating required a heat pump dryer instead of the traditional electric resistance or gas-heated dryers, in addition to the dishwasher, refrigerator, and washing machines that are more commonly available.

Figure 21. Appliance Package Choices from Permits (n = 178)



Builder Survey

Not many survey respondents reported that they choose to use the appliance credit, ranking it the third least popular choice. About one-third (31%) of respondents said that they believed that it was easiest to comply with the appliance credit.

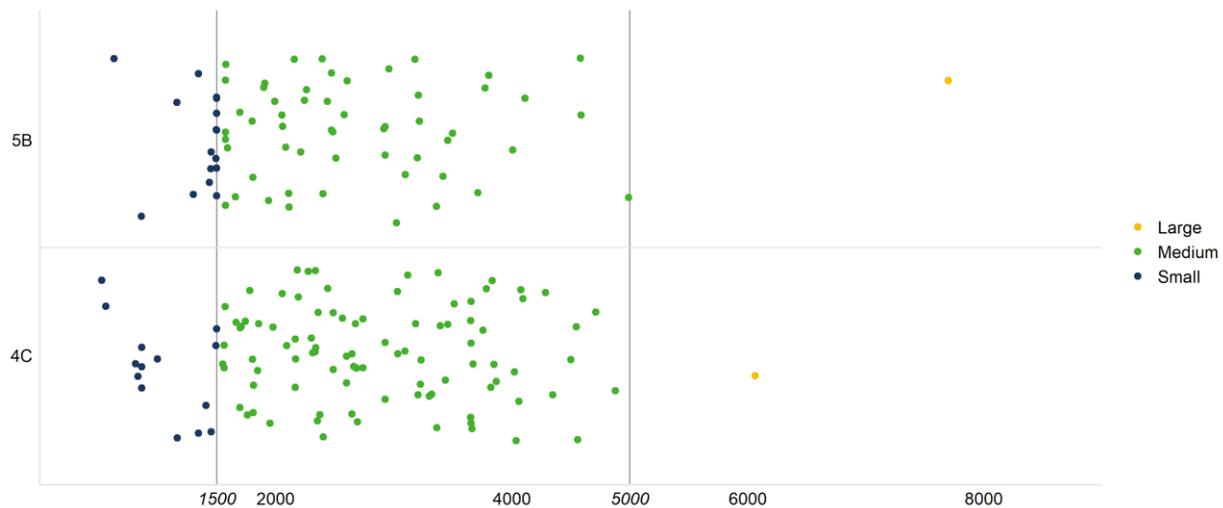
4.3.7 Home Size

As stated earlier, the 2018 WSEC requires builders to select a combination of energy credits based on the size of the home. Small homes (under 1,500 sf) require three credits, medium (between 1,500 and 5,000 sf) six credits, and large homes (above 5,000 sf) seven credits. Builders can make a choice to build smaller homes and potentially save a substantial cost to comply with the 2018 WSEC.

Figure 22 below shows a scatter plot of all of the homes in the permit results organized by size on the horizontal axis and by climate zone on the vertical axis. There are 30 small homes, 146 medium, and 2 large. The 2018 WSEC size delineations are provided on the figure to show the division between the energy credit requirements. As shown, most homes (82%) are medium, a small percent (17%) are small, and almost no homes (1%) are large.

TRC visually reviewed the data to investigate whether there are clusters of homes just below the 1,500 sf mark or the 5,000 sf mark. That would indicate some builders may be designing homes to be just under the next size cutoff to avoid the jump in energy credit requirements. There are several homes just below 1,500 sf, but there are also other clusters of homes in the data, so it is not clear if builders are designing home size to reduce energy credit requirements. If the size delineations from WSEC significantly impacted the builders' choices, we would expect to see far more homes just under 1,500 sf and very few homes just above that line. The builder survey responses showed the choice to build smaller as fairly unpopular. Builders should be familiar with these size categories and their impact on energy credits, since the same size categories were used in 2015 WSEC. In sum, the data collected for this study do not indicate that builders are choosing to build smaller homes to avoid increases in energy credits required for larger homes.

Figure 22. Scatter Plot of Permit Results by Home Size and Climate Zone



4.4 Common Compliance Pathways

There are a multitude of possible combinations a builder can choose to meet the required number of energy credits. Builders can choose from 32 energy credit options with anywhere from 0.5 to 3.0 energy credits from each. TRC found that six combinations of credits contributed 41% of all the permits analyzed. Although this suggests some conformity, the 2015 WSEC code study (CLEARResult 2020) found that the top six pathways contributed 92% of the permits from 17 energy credits options. In the 2020 study, CLEARResult found 30 total combinations, while TRC found 81 different combinations in this study in 2022. **The increase in the number of options and the required number of credits has diversified the common approaches to energy code compliance in Washington.**

The five most common pathways used electric space heating, while the sixth most common pathway used gas space heating. The choices combined with the gas primary heat are unique among the popular pathways: triple pane 0.20 u-factor windows, 2.5 ACH50 air leakage, and ducts fully inside the thermal envelope. Heat pump water heaters appear in all the most popular pathways regardless of space heating fuel type.

It should be noted that the top six most common pathways to energy credit compliance are all for medium size homes requiring six credits, which make up 82% of the homes in the permit data sample. Analyzing the pathways for the other two categories, small and large, were inconclusive. With only two large homes, no conclusions could be made. For the small category, there is less data on builders' approaches because only three credits are required. For example, most small homes had no data on water heating fuel type¹⁴ because they did not need to pursue efficient water heating credits.

¹⁴ Six of the eight permits with no data on water heating fuel type were small homes. Water heating fuel type is not a required declaration on the Fuel Normalization table R406.2

Figure 23. Most Common Pathways taken to Earn Energy Credits

Combination	Measure 1	Measure 2	Measure 3	Measure 4	Measure 5	Measure 6	Total	Percent Contribution
Option Combination A	FN 2	1.3	2.1	3.5	4.1	5.5	19	11%
Option Combination B	FN 2	1.3		3.5	4.2	5.5	18	10%
Option Combination C	FN 2	1.3	2.3	3.2		5.5	16	9%
Option Combination D	FN 2	1.3	2.1	3.2	4.2	5.5	11	6%
Option Combination E	FN 2	1.2	2.1	3.5		5.5	6	3%
Option Combination F	FN 1	1.2	2.2	3.1	4.2	5.5	4	2%

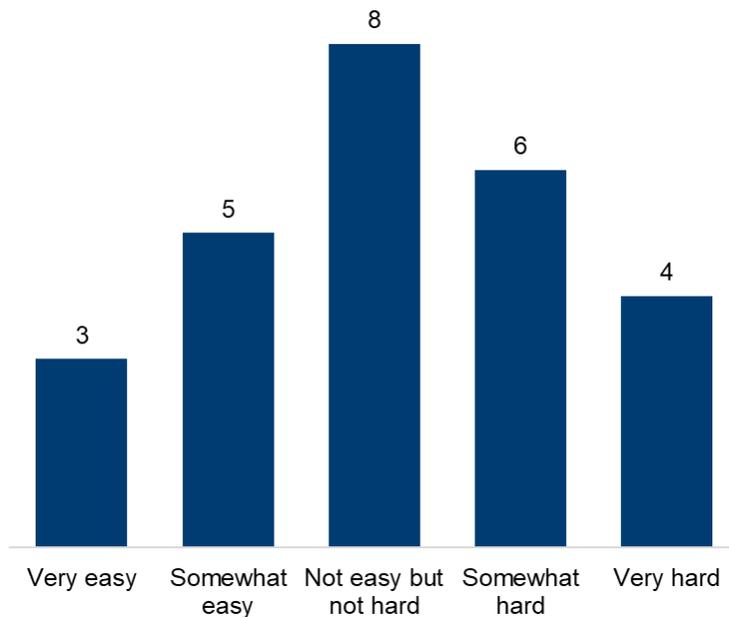
FN 1= Gas primary heat 2.1=3.0 ACH50 3.2=ASHP 9.5 HSPF 5.5= Heat Pump WH
 FN 2= Heat Pump primary heat 2.2=2.0 ACH50 3.5=ASHP 11.0 HSPF
 1.2= U=0.20 windows 2.3=1.5 ACH50 4.1=Deeply Buried
 1.3=U=0.28 windows, Floor R-38 3.1=Gas 95% AFUE 4.2=Ducts Inside

4.5 Feedback on the 2018 WSEC

4.5.1 Builder Feedback on Difficulty and Cost of the 2018 WSEC

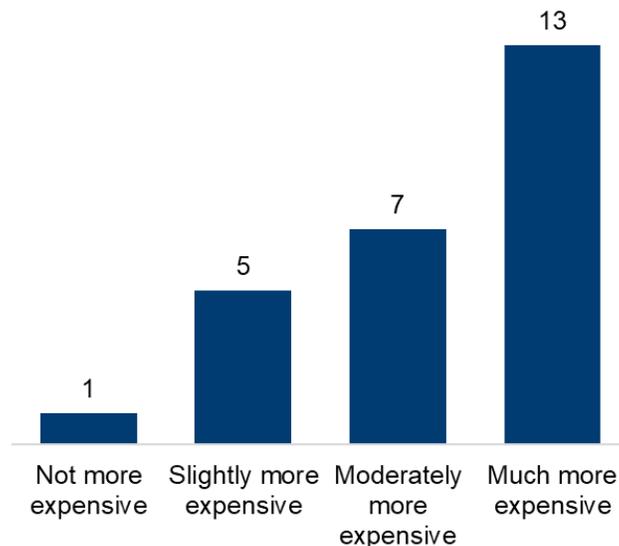
As part of the survey, TRC asked builders how difficult it is to meet the 2018 WSEC, setting aside costs. Respondents provided mixed views, with the largest number of respondents reporting it was not easy, but not hard. For the remaining builders, slightly more said it was somewhat hard or very hard, compared to very easy or somewhat easy.

Figure 24. Builder Responses to Question: How difficult do you think it is to meet the 2018 WSEC from a technical standpoint, compared to the 2015 WSEC? (n = 26)



In another survey question, TRC asked builders how expensive it is to meet the 2018 WSEC code, compared to the 2015 WSEC. Almost all builders reported it is more expensive, with “much more expensive” the most common response chosen.

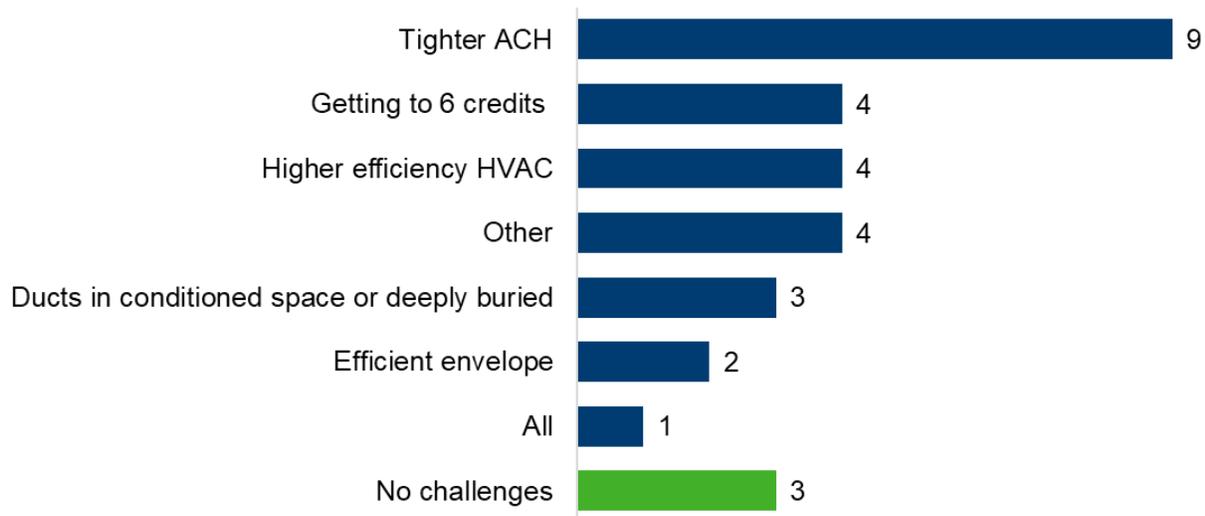
Figure 25. Builder Responses to Question: How expensive do you think it is to meet the 2018 WSEC from a technical standpoint, compared to the 2015 WSEC? (n = 26)



Taken together, these results highlight that builders find the 2018 WSEC to be more expensive, but not significantly more technically challenging. This finding is also reinforced by the results indicating that—at least for now—builders are primarily choosing to install higher efficiency equipment, rather than changing construction techniques (See Section 4.2.2). It is possible that practices may change as builders gain more experience with the new code.

In an open-ended question, the survey asked builders which is the most challenging credit they are targeting. TRC grouped the responses by category and present results in Figure 26. As shown, builders most frequently reported that a lower ACH is the most challenging measure they are targeting, followed by achieving six credits and higher efficiency HVAC. Another common challenge relates to locating ducts in conditioned space or deeply buried. The tighter ACH may be more challenging because this requires an improvement to construction techniques and potentially tighter management of labor (staff or subcontractors), rather than simply purchasing more expensive equipment.

Figure 26. Most Challenging Credit Builders Are Targeting (n = 26, Multiple Responses Allowed)

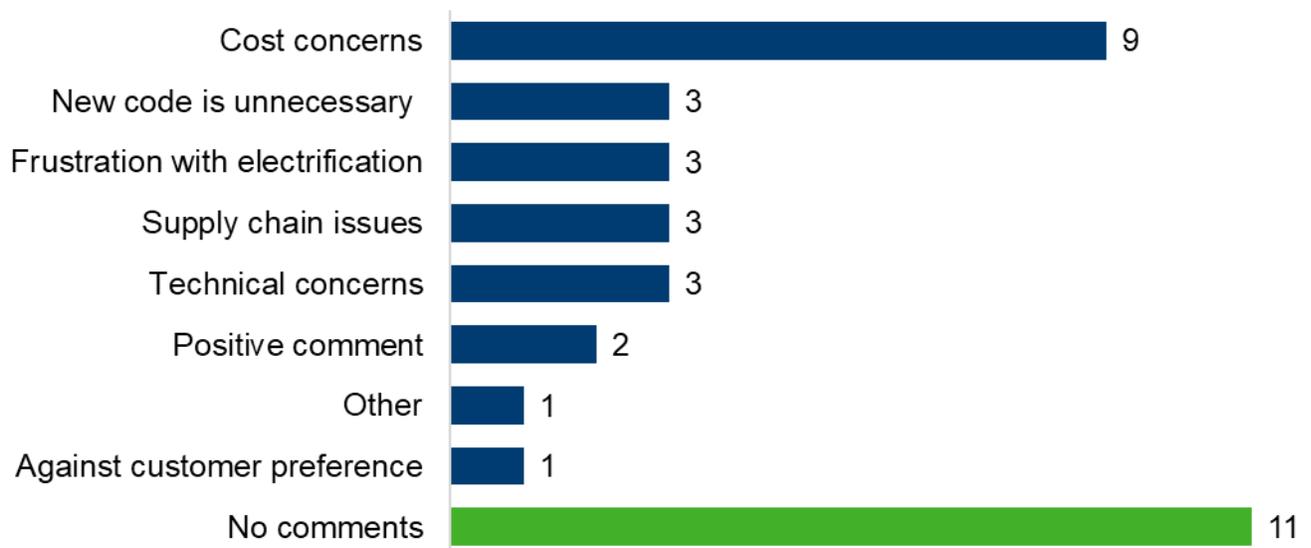


4.5.2 Open-ended Feedback from Builders on the 2018 WSEC

One of the last questions in the survey asked builders to provide any final comments about the 2018 WSEC. The response was open-ended, so builders could enter any information they wished. **Most builder open-ended feedback on the 2018 WSEC was negative, and cost was by far the largest concern.**

Figure 27 shows comments grouped by topic. Some comments fell into multiple topics. For example, one comment that discusses both cost and supply chain issues would count under both of those topics.

Figure 27. Open-Ended Feedback on the 2018 WSEC (n = 26; Multiple Responses Allowed)



As shown in Figure 27, respondents most frequently commented that the 2018 WSEC is increasing costs. These include concerns that the 2018 WSEC is making homes less affordable, and the requirements are not cost-effective given Washington's relatively mild climate. Other common topics included technical concerns, supply chain issues, frustration with electrification, and consumer preferences for technologies now discouraged by the code.

Some example comments include:

- "I think the new code is not necessary for our climate. I feel the cost is hard to recover for the customer."
- "This is extremely counterproductive to producing affordable housing. Pick what your priority is and stick with it."
- "With the increase in (minimum) code compliance, getting the necessary equipment and materials is becoming a serious challenge with the shipping and increased costs."
- "The phasing out of natural gas is a difficult problem for us, many of our clients prefer it."
- "Solar is the easiest [credit], but it's also the stupidest. I can throw four panels on a home that is surrounded by trees or that is on a north-east facing roofline and I'll get credits, but won't do the homeowner a bit of good."

A few respondents had positive comments, which came from custom builders that reported to build above code homes.

- "We are building all electric net zero energy homes for the same price other builders build old fashioned homes. We are happy to share our designs."
- "Keeping the costs down requires promoting insulation and energy efficiency as "bling". Then, those other items promoted by the builder magazines can be eliminated and the money saved buys the HRV and the added insulation."

The survey also asked builders what topics they would like training on. Frequently cited topics included:

- Air leakage control and ventilation
- Ducts in conditioned space or deeply buried
- Fuel normalization: selecting affordable and effective space heating
- High-efficiency equipment
- Renewables credit (solar)
- High-efficiency envelope

The Washington State University Extension Program (WSUEP) provides a free builder hotline and code trainings, both sponsored by NEEA. WSUEP could cover some of these topics in builder trainings.

4.6 Climate Zone Analysis

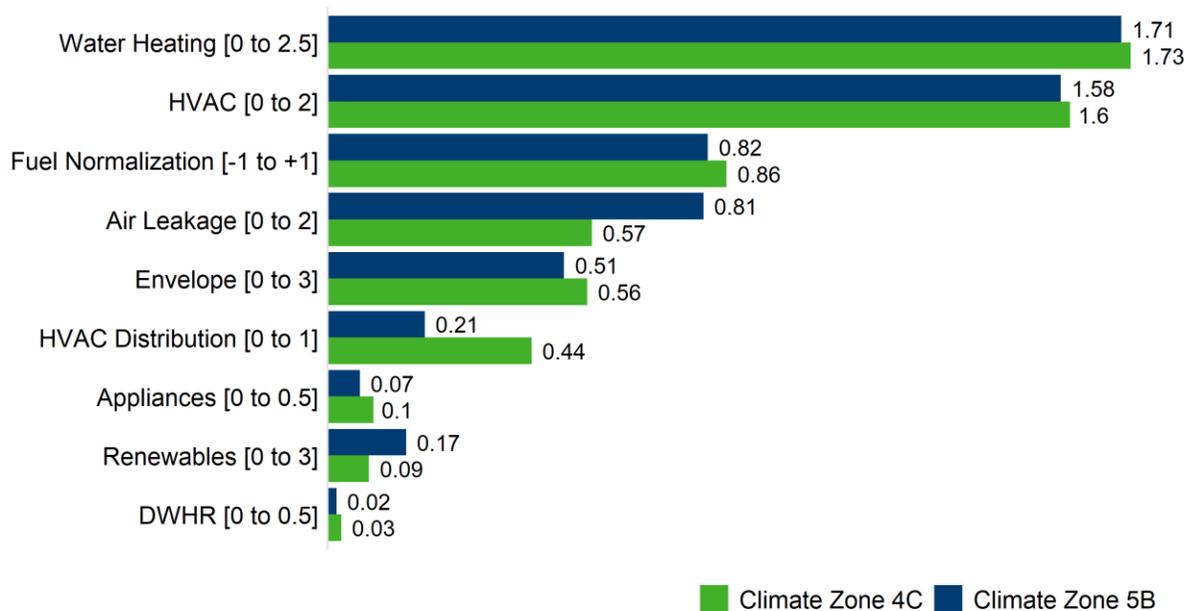
Washington primarily comprises two climate zones¹⁵: 4C—a more moderate, marine climate, and 5B—a more extreme (and dryer) hot and cold climate. The two climate zones in Washington represent different heating and cooling demands, different demographics, and possibly different building styles. TRC ran analysis splitting the data by climate zone to determine if the 2018 WSEC choices differed in the two zones.

For the most part, builders made similar energy credit choices across climate zones.

Figure 28 below show the average energy credits from efficient water heating, HVAC, envelope, appliances, renewables, and DWHR categories to be very similar.

One of the few differences by climate zone was that permits from 5B, on average, had slightly more credits in the air leakage control and ventilation category. Builders in Climate Zone 5B were slightly more likely to choose a more aggressive credit worth more points (that is, pursue a tighter envelope and HRV/ERV) compared to homes in Climate Zone 4C. Zone 5B had about 5% more gas heated homes than 4C, enough to lower the impact of fuel normalization in 5B. Finally, builders in Climate Zone 4C chose efficient HVAC distribution more often, either choosing to deeply bury ductwork more often or bring the ductwork inside the thermal envelope.

Figure 28. Average Energy Credits by Category in Climate Zone 4C and 5B from Permits (n = 178)



¹⁵ There is a very small area in the Puget Sound Area that is Climate Zone 5C. However, since it is extremely small, none of the permits reviewed came from 5C, so TRC did not analyze data from this climate zone.

5 Overall Findings and Potential Opportunities

5.1 Findings

Findings from this research indicate that the impact of the 2018 WSEC on single-family homes is significant. One major impact is the shift to electric space heating and water heating compared to builders' choices under the 2015 WSEC. With 178 approved permits analyzed, the incidence of electric primary space heating is 88% in this study of the 2018 WSEC; the 2015 WSEC study (CLEAResult 2020) recorded a 20% incidence of electric primary space heating for comparison. Water heating fuel is also showing significant changes. This study of the 2018 WSEC shows 87% electric water heating, while the 2015 WSEC study (CLEAResult 2020) recorded 44% electric water heating.

The results also indicate that the 2018 WSEC is changing how builders construct homes. The findings suggest that builders are primarily choosing more efficient equipment and installing electric space heating and water heating equipment more frequently, rather than changing construction techniques (such as tightening the building envelope and redesigning homes to bring HVAC inside the thermal envelope).

Building homes tighter and placing HVAC systems in conditioned spaces imposes challenges on multiple phases of the design and building process. These changes differ from fuel selection in that they require more than selecting gas equipment instead of electric. The changes involve different building procedures and new skills for the trades. This is particularly true for the most popularly declared challenge in the builder survey, which is building tighter envelopes.

The increase in the number of energy credit options and the required number of credits has diversified the common approaches to energy code compliance in Washington. For the most part, builders made similar energy credit choices by climate zone, although there may be a slight preference towards more aggressive air tightness and ventilation (ERV/HRV) credits in Climate Zone 5B and a slight preference towards efficient HVAC distribution credits in Climate Zone 4C.

Significant takeaways from each of the energy credit categories include:

- For efficient building envelopes, most builders chose a slight improvement worth 0.5 energy credit and avoided exterior continuous insulation.
- Most builders pursued the lowest credit option for air leakage control and ventilation, which requires 3.0 ACH50 and no HRV.
- High-efficiency HVAC equipment was a very popular selection for energy credits, but builder interest in efficient HVAC distribution systems was moderate.
- Heat pump water heaters topped all individual credit options in the study for popularity and credit impact, while DWHR was very unpopular.
- Most builders were not pursuing credits in the renewable energy category.

- Most builders did not choose ENERGY STAR appliance packages for energy credits.

Most builder open-ended feedback on the 2018 WSEC was negative, and by far the largest concern was the cost increase. Comments range from a fundamental disagreement in the direction the code has taken, to the expense and difficulty of implementing the changes. Some responses mention the difficulties presented by supply chain issues, and other responses indicate confusion and disagreement as to the purpose of the code changes.

Overall, the study found that the 2018 WSEC is changing builder practices in various ways, including by pushing more builders towards electric space heating and water heating and to selecting more efficient equipment.

6 APPENDIX: 2018 WSEC, Section R406

SECTION R406

ADDITIONAL ENERGY EFFICIENCY REQUIREMENTS

R406.1 Scope. This section establishes additional energy efficiency requirements for all new construction covered by this code, including additions subject to Section R502 and change of occupancy or use subject to Section R505 unless specifically exempted in Section R406. Credit from both Sections R406.2 and R406.3 are required.

R406.2 Carbon emission equalization. This section establishes a base equalization between fuels used to define the equivalent carbon emissions of the options specified. The permit shall define the base fuel selection to be used and the points specified in Table R406.2 shall be used to modify the requirements in Section R406.3. The sum of credits from Tables R406.2 and R406.3 shall meet the requirements of Section R406.3.

R406.3 Additional energy efficiency requirements. Each dwelling unit in a residential building shall comply with sufficient options from Table R406.2 so as to achieve the following minimum number of credits:

1. Small Dwelling Unit: 3.0 credits
 Dwelling units less than 1500 square feet in conditioned floor area with less than 300 square feet of fenestration area. Additions to existing building greater than 500 square feet of heated floor area but less than 1500 square feet.
2. Medium Dwelling Unit: 6.0 credits
 All dwelling units that are not included in #1, #3 or #4.
3. Large Dwelling Unit: 7.0 credits
 Dwelling units exceeding 5000 square feet of conditioned floor area.
4. Dwelling units serving R-2 occupancies: 4.5 credits
5. Additions less than or equal to 500 square feet: 1.5 credits

The drawings included with the building permit application shall identify which options have been selected and the point value of each option, regardless of whether separate mechanical, plumbing, electrical, or other permits are utilized for the project.

**TABLE R406.2
 FUEL NORMALIZATION CREDITS**

System Type	Description of Primary Heating Source	Credits	
		All Other	Group R-2
1	Combustion heating equipment meeting minimum federal efficiency standards for the equipment listed in Table C403.3.2(4) or C403.3.2(5)	0	0
2	For an initial heating system using a heat pump that meets federal standards for the equipment listed in Table C403.3.2(1)C or C403.3.2(2) or Air to water heat pump units that are configured to provide both heating and cooling and are rated in accordance with AHRI 550/590	1.0	1.0

6 APPENDIX: 2018 WSEC, Section R406

3	For heating system based on electric resistance only (either forced air or Zonal)	-1.0	-1.0
4	For heating system based on electric resistance with a ductless mini-split heat pump system in accordance with Section R403.7.1 including the exception	0.5	N/A
5	All other heating systems	-1	-0.5

**TABLE 406.3
 ENERGY CREDITS**

OPTION	DESCRIPTION	CREDIT(S)	
		All Other	Group R-2
1. EFFICIENT BUILDING ENVELOPE OPTIONS			
Only one option from Items 1.1 through 1.7 may be selected in this category. Compliance with the conductive UA targets is demonstrated using Section R402.1.4, Total UA alternative, where [1-(Proposed UA/Target UA)] > the required %UA reduction			
1.1	Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.24.	0.5	0.5
1.2	Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.20.	1.0	1.0
1.3	Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.28 Floor R-38 Slab on grade R-10 perimeter and under entire slab Below grade slab R-10 perimeter and under entire slab or Compliance based on Section R402.1.4: Reduce the Total conductive UA by 5%.	0.5	N/A
1.4	Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.25 Wall R-21 plus R-4 ci Floor R-38 Basement wall R-21 int plus R-5 ci Slab on grade R-10 perimeter and under entire slab Below grade slab R-10 perimeter and under entire slab or Compliance based on Section R402.1.4: Reduce the Total conductive UA by 15%.	1.0	1.0
1.5	Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.22 Ceiling and single-rafter or joist-vaulted R-49 advanced Wood frame wall R-21 int plus R-12 ci Floor R-38 Basement wall R-21 int plus R-12 ci Slab on grade R-10 perimeter and under entire slab Below grade slab R-10 perimeter and under entire slab or Compliance based on Section R402.1.4: Reduce the Total conductive UA by 30%.	2.0	1.5

**TABLE 406.3 (continued)
 ENERGY CREDITS**

OPTION	DESCRIPTION	CREDIT(S)	
		All Other	Group R-2
1.6	Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.18 Ceiling and single-rafter or joist-vaulted R-60 advanced Wood frame wall R-21 int plus R-16 ci Floor R-48 Basement wall R-21 int plus R-16 ci Slab on grade R-20 perimeter and under entire slab Below grade slab R-20 perimeter and under entire slab or Compliance based on Section R402.1.4: Reduce the Total conductive UA by 40%.	3.0	2.0
1.7	Advanced framing and raised heel trusses or rafters Vertical Glazing U-0.28 R-49 Advanced (U-0.020) as listed in Section A102.2.1, <i>Ceilings below a vented attic</i> and R-49 vaulted ceilings with full height of uncompressed insulation extending over the wall top plate at the eaves.	0.5	0.5
2. AIR LEAKAGE CONTROL AND EFFICIENT VENTILATION OPTIONS Only one option from Items 2.1 through 2.4 may be selected in this category.			
2.1	Compliance based on R402.4.1.2: Reduce the tested air leakage to 3.0 air changes per hour maximum at 50 Pascals or For R-2 Occupancies, optional compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.3 cfm/ft ² maximum at 50 Pascals and All whole house ventilation requirements as determined by Section M1507.3 of the <i>International Residential Code</i> or Section 403.8 of the <i>International Mechanical Code</i> shall be met with a high efficiency fan(s) (maximum 0.35 watts/cfm), not interlocked with the furnace fan (if present). Ventilation systems using a furnace including an ECM motor are allowed, provided that they are controlled to operate at low speed in ventilation only mode. To qualify to claim this credit, the building permit drawings shall specify the option being selected, the maximum tested building air leakage, and shall show the qualifying ventilation system and its control sequence of operation.	0.5	1.0

TABLE 406.3 (continued)
ENERGY CREDITS

OPTION	DESCRIPTION	CREDIT(S)	
		All Other	Group R-2
2.2	<p>Compliance based on Section R402.4.1.2: Reduce the tested air leakage to 2.0 air changes per hour maximum at 50 Pascals</p> <p>or</p> <p>For R-2 Occupancies, optional compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.25 cfm/ft² maximum at 50 Pascals</p> <p>and</p> <p>All whole house ventilation requirements as determined by Section M1507.3 of the <i>International Residential Code</i> or Section 403.8 of the <i>International Mechanical Code</i> shall be met with a heat recovery ventilation system with minimum sensible heat recovery efficiency of 0.65.</p> <p>To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the maximum tested building air leakage and shall show the heat recovery ventilation system.</p>	1.0	1.5
2.3	<p>Compliance based on Section R402.4.1.2: Reduce the tested air leakage to 1.5 air changes per hour maximum at 50 Pascals</p> <p>or</p> <p>For R-2 Occupancies, optional compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.25 cfm/ft² maximum at 50 Pascals</p> <p>and</p> <p>All whole house ventilation requirements as determined by Section M1507.3 of the <i>International Residential Code</i> or Section 403.8 of the <i>International Mechanical Code</i> shall be met with a heat recovery ventilation system with minimum sensible heat recovery efficiency of 0.75.</p> <p>To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the maximum tested building air leakage and shall show the heat recovery ventilation system.</p>	1.5	2.0
2.4	<p>Compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.6 air changes per hour maximum at 50 Pascals</p> <p>or</p> <p>For R-2 Occupancies, optional compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.15 cfm/ft² maximum at 50 Pascals</p> <p>and</p> <p>All whole house ventilation requirements as determined by Section M1507.3 of the <i>International Residential Code</i> or Section 403.8 of the <i>International Mechanical Code</i> shall be met with a heat recovery ventilation system with minimum sensible heat recovery efficiency of 0.80. Duct installation shall comply with Section R403.3.7.</p> <p>To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the maximum tested building air leakage and shall show the heat recovery ventilation system.</p>	2.0	2.5

**TABLE 406.3 (continued)
 ENERGY CREDITS**

OPTION	DESCRIPTION	CREDIT(S)	
		All Other	Group R-2
3. HIGH EFFICIENCY HVAC EQUIPMENT OPTIONS			
Only one option from Items 3.1 through 3.6 may be selected in this category.			
3.1 ^a	ENERGY STAR rated (U.S. North) Gas or propane furnace with minimum AFUE of 95% or ENERGY STAR rated (U.S. North) Gas or propane boiler with minimum AFUE of 90%. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and the minimum equipment efficiency.	1.0	1.0
3.2 ^a	Air-source centrally ducted heat pump with minimum HSPF of 9.5. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and the minimum equipment efficiency.	1.0	N/A
3.3 ^a	Closed-loop ground source heat pump; with a minimum COP of 3.3 or Open loop water source heat pump with a maximum pumping hydraulic head of 150 feet and minimum COP of 3.6. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and the minimum equipment efficiency.	1.5	1.0
3.4	Ductless mini-split heat pump system, zonal control: In homes where the primary space heating system is zonal electric heating, a ductless mini-split heat pump system with a minimum HSPF of 10.0 shall be installed and provide heating to the largest zone of the housing unit. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and the minimum equipment efficiency.	1.5	2.0
3.5 ^a	Air-source, centrally ducted heat pump with minimum HSPF of 11.0. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and the minimum equipment efficiency.	1.5	N/A
3.6 ^a	Ductless split system heat pumps with no electric resistance heating in the primary living areas. A ductless heat pump system with a minimum HSPF of 10 shall be sized and installed to provide heat to entire dwelling unit at the design outdoor air temperature. To qualify to claim this credit, the building permit drawings shall specify the option being selected, the heated floor area calculation, the heating equipment type(s), the minimum equipment efficiency, and total installed heat capacity (by equipment type).	2.0	3.0

**TABLE 406.3 (continued)
 ENERGY CREDITS**

OPTION	DESCRIPTION	CREDIT(S)	
		All Other	Group R-2
4. HIGH EFFICIENCY HVAC DISTRIBUTION SYSTEM OPTIONS			
4.1	<p>All supply and return ducts located in an unconditioned attic shall be deeply buried in ceiling insulation in accordance with Section R403.3.7.</p> <p>For mechanical equipment located outside the conditioned space, a maximum of 10 linear feet of return duct and 5 linear feet of supply duct connections to the equipment may be outside the deeply buried insulation. All metallic ducts located outside the conditioned space must have both transverse and longitudinal joints sealed with mastic. If flex ducts are used, they cannot contain splices.</p> <p>Duct leakage shall be limited to 3 cfm per 100 square feet of conditioned floor area.</p> <p>Air handler(s) shall be located within the conditioned space.</p>	0.5	0.5
4.2	<p>HVAC equipment and associated duct system(s) installation shall comply with the requirements of Section R403.3.7.</p> <p>Locating system components in conditioned crawl spaces is not permitted under this option.</p> <p>Electric resistance heat and ductless heat pumps are not permitted under this option.</p> <p>Direct combustion heating equipment with AFUE less than 80% is not permitted under this option.</p> <p>To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and shall show the location of the heating and cooling equipment and all the ductwork.</p>	1.0	N/A
5. EFFICIENT WATER HEATING OPTIONS			
Only one option from Items 5.2 through 5.6 may be selected in this category. Item 5.1 may be combined with any option.			
5.1	<p>A drain water heat recovery unit(s) shall be installed, which captures waste water heat from all and only the showers, and has a minimum efficiency of 40% if installed for equal flow or a minimum efficiency of 54% if installed for unequal flow. Such units shall be rated in accordance with CSA B55.1 or IAPMO IGC 346-2017 and be so labeled.</p> <p>To qualify to claim this credit, the building permit drawings shall include a plumbing diagram that specifies the drain water heat recovery units and the plumbing layout needed to install it. Labels or other documentation shall be provided that demonstrates that the unit complies with the standard.</p>	0.5	0.5
5.2	<p>Water heating system shall include one of the following: ENERGY STAR rated gas or propane water heater with a minimum UEF of 0.80.</p> <p>To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the water heater equipment type and the minimum equipment efficiency.</p>	0.5	0.5

**TABLE 406.3 (continued)
 ENERGY CREDITS**

OPTION	DESCRIPTION	CREDIT(S)	
		All Other	Group R-2
5.3	<p>Water heating system shall include one of the following: ENERGY STAR rated gas or propane water heater with a minimum UEF of 0.91</p> <p>or</p> <p>Solar water heating supplementing a minimum standard water heater. Solar water heating will provide a rated minimum savings of 85 therms or 2000 kWh based on the Solar Rating and Certification Corporation (SRCC) Annual Performance of OG-300 Certified Solar Water Heating Systems</p> <p>or</p> <p>Water heater heated by ground source heat pump meeting the requirements of Option 3.3.</p> <p>To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the water heater equipment type and the minimum equipment efficiency and, for solar water heating systems, the calculation of the minimum energy savings.</p>	1.0	1.0
5.4	<p>Water heating system shall include one of the following: Electric heat pump water heater meeting the standards for Tier I of NEEA's advanced water heating specification</p> <p>or</p> <p>For R-2 Occupancy, electric heat pump water heater(s), meeting the standards for Tier I of NEEA's advanced water heating specification, shall supply domestic hot water to all units. If one water heater is serving more than one dwelling unit, all hot water supply and recirculation piping shall be insulated with R-8 minimum pipe insulation.</p> <p>To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the water heater equipment type and the minimum equipment efficiency.</p>	1.5	2.0
5.5	<p>Water heating system shall include one of the following: Electric heat pump water heater meeting the standards for Tier III of NEEA's advanced water heating specification</p> <p>or</p> <p>For R-2 Occupancy, electric heat pump water heater(s), meeting the standards for Tier III of NEEA's advanced water heating specification, shall supply domestic hot water to all units. If one water heater is serving more than one dwelling unit, all hot water supply and recirculation piping shall be insulated with R-8 minimum pipe insulation.</p> <p>To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the water heater equipment type and the minimum equipment efficiency.</p>	2.0	2.5

**TABLE 406.3 (continued)
 ENERGY CREDITS**

OPTION	DESCRIPTION	CREDIT(S)	
		All Other	Group R-2
5.6	<p>Water heating system shall include one of the following:</p> <p>Electric heat pump water heater with a minimum UEF of 2.9 and utilizing a split system configuration with the air-to-refrigerant heat exchanger located outdoors. Equipment shall meet Section 4, requirements for all units, of the NEEA standard <i>Advanced Water Heating Specification</i> with the UEF noted above</p> <p>or</p> <p>For R-2 Occupancy, electric heat pump water heater(s), meeting the standards for Tier III of NEEA's advanced water heating specification and utilizing a split system configuration with the air-to-refrigerant heat exchanger located outdoors, shall supply domestic hot water to all units. If one water heater is serving more than one dwelling unit, all hot water supply and recirculation piping shall be insulated with R-8 minimum pipe insulation.</p> <p>To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the water heater equipment type and the minimum equipment efficiency.</p>	2.5	3.0
6. RENEWABLE ELECTRIC ENERGY OPTION			
6.1	<p>For each 1200 kWh of electrical generation per housing unit provided annually by on-site wind or solar equipment a 1.0 credit shall be allowed, up to 3 credits. Generation shall be calculated as follows:</p> <p>For solar electric systems, the design shall be demonstrated to meet this requirement using the National Renewable Energy Laboratory calculator PVWATTS or approved alternate by the code official.</p> <p>Documentation noting solar access shall be included on the plans.</p> <p>For wind generation projects designs shall document annual power generation based on the following factors:</p> <p>The wind turbine power curve; average annual wind speed at the site; frequency distribution of the wind speed at the site and height of the tower.</p> <p>To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall show the photovoltaic or wind turbine equipment type, provide documentation of solar and wind access, and include a calculation of the minimum annual energy power production.</p>	1.0	1.0
7. APPLIANCE PACKAGE OPTION			
7.1	<p>All of the following appliances shall be new and installed in the dwelling unit and shall meet the following standards:</p> <p>Dishwasher – ENERGY STAR rated</p> <p>Refrigerator (if provided) – ENERGY STAR rated</p> <p>Washing machine – ENERGY STAR rated</p> <p>Dryer – ENERGY STAR rated, ventless dryer with a minimum CEF rating of 5.2.</p> <p>To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall show the appliance type and provide documentation of ENERGY STAR compliance. At the time of inspection, all appliances shall be installed and connected to utilities. Dryer ducts and exterior dryer vent caps are not permitted to be installed in the dwelling unit.</p>	0.5	1.5

- a. An alternative heating source sized at a maximum of 0.5 Watts/ft² (equivalent) of heated floor area or 500 Watts, whichever is bigger, may be installed in the dwelling unit.