July 6, 2023

REPORT #E23-467

Washington Residential Code Evaluation

Prepared For NEEA:
Meghan Bean, Sr. Market Research and Evaluation Scientist

Prepared by:
Lucy Albin, Senior Research Analyst
Marian Goebes, Director
Grant Marr, Research Analyst
Brett Close, Associate Director
Greg Lasher, Project Manager II
Brandon Faris, Project Manager II
Sean Jones, Residential Energy Efficiency Specialist
Brian Farnsworth, Outreach Specialist
Lysandra Medal, Research Associate
Smruti Srinivasan, Project Engineer III
Yolanda Beesemyer, Associate Project Manager

TRC
807 E Roy Street, Suite 301
Seattle, WA 98102

Northwest Energy Efficiency Alliance
PHONE
503-688-5400
EMAIL
info@neea.org

Table of Contents

Figures

Tables

1. Executive Summary

1.1 Introduction

On behalf of the Northwest Energy Efficiency Alliance (NEEA), TRC conducted an evaluation of the residential 2018 Washington State Energy Code (WSEC). The purpose of the study was to understand the rate of compliance with 2018 WSEC Section R406 (Additional Energy Efficiency Requirements), determine which compliance options and pathways builders are using to comply, and explore the accuracy of permit data compared to as-built conditions. The study focused on R406 requirements because of its complex structure and high contribution to the overall residential 2018 WSEC energy savings; TRC assumes this section drives the compliance profile and key builder choices across the whole code. The study also investigated the end-uses for natural gas and the fuel selection for space heating and water heating under the 2018 WSEC.

The key research objectives for this study were to:

- Calculate code compliance with Section R406 and identify what is actually constructed under the 2018 WSEC
    - Calculate compliance for single-family homes
    - Provide insight into what is actually being built – that is, installed measures, particularly for water heating and space heating equipment, renewables, and (where possible) air tightness levels achieved
    - Investigate whether the compliance rate differs across climate zones or jurisdictions with different levels of construction volume
- Investigate key project choices
    - Determine the compliance pathways builders are taking to meet the 2018 WSEC code requirements in single-family residential buildings and the fuel selection for space and water heating under the 2018 WSEC.
    - Investigate if new construction homes that claim electric appliances for water heating or space heating on permits are dual fuel system – that is, have a second system that is fossil-fuel powered
    - Investigate if and how new construction homes use natural gas for other end-uses, including stoves, dryers, and hearths, and the prevalence of gas hookups in homes with all-electric appliances
- Inform future studies
    - Investigate the accuracy of permit data
    - Assess the reasonableness of NEEA's approach of applying the single-family compliance rate to multifamily residential buildings and provide qualitative

insights on whether the compliance rate is likely lower, higher, or likely about the same for multifamily

- Assess the efficacy and replicability of using the same methodology over time and in other states in the Northwest

1.2 Approach and Methodology

To meet the objectives of this study, TRC conducted the following activities for single-family, new construction homes:

- TRC recruited residents of newly constructed homes for a virtual home audit. TRC sent 11,243 postcards and letters to roughly 7,500 residents of new homes, based on Construction Monitor data that showed the home was permitted between February 1, 2021 and February 1, 2022. A sample of jurisdictions was selected to represent the state in terms of climate zone and construction volume under WSEC 2018, and within those jurisdictions, TRC either attempted to recruit all homes or recruited a random sample of homes, depending on the number of newly constructed homes in the jurisdiction. TRC invited residents to participate in a virtual home audit (described as a "virtual home visit") in exchange for an e-gift card. During this videoconference, the resident walked through their home and showed equipment plates and other home conditions using a smart phone, and the TRC auditor collected this equipment data and other installed conditions using screenshots.
- For the audited homes, TRC collected building permits to gather data for "hidden measures" that are not visible during an audit, such as window U-value, insulation, and other envelope measures. The combination of the audit and permit data allowed us to determine whether the home complied with the 2018 WSEC Section R406 (Additional Energy Efficiency Requirements). For data points where both the permit and the audit provided data, such as heating and water heating equipment, TRC compared permit data and actual conditions to investigate the accuracy of permit (planned) data compared to installed conditions. This analysis assumed 100% compliance with the prescriptive requirements in Sections R402-R404, or the simulated performance requirements in Section R405.
- In addition, TRC analyzed code compliance for a sample of homes in the Residential Energy Services Network (RESNET) database. Similar to the audited homes, TRC collected building permits for homes TRC reviewed from RESNET to fill data gaps not in RESNET and to compare data in RESNET (which is third party verified) with the permit data.

1.3 Findings

This study found the following:

- **Approximately three-quarters (76%) of homes complied with the Additional Energy Efficiency Requirements section of 2018 WSEC.**[1] All noncompliant homes earned at least some credits in this section, with the average noncompliant home achieving 1.25 credits fewer than required. The proportion of noncompliant homes was higher for those homes in Climate Zone 5B (33%) compared with Climate Zone 4C (16%), although the difference was not statistically significant.
- **Audit results support previous study findings**[2] **demonstrating that a major shift to electric heat pump use has taken hold since the 2018 WSEC: 79% use electric heat pumps for space heating, 89% use electric heat pumps for water heating**. Homes in Climate Zone 5B were more likely to have gas water heating (17%) than homes in Climate Zone 4C (6%), although the difference was not statistically significant.
- **While most homes used electric space heating or water heating, 71% had a gas hookup, 70% had gas cooking appliances and 50% had a gas fireplace**. Of the homes with a gas hookup, 95% had a gas range for cooking. Almost half used their gas hookup for a range and one or more fireplaces.
- **Builders used a variety of pathways to comply with the 2018 WSEC**. The most popular credit categories chosen were efficient water heating, high efficiency HVAC, and fuel normalization (for electric space heating). Over half of homes targeted air leakage control and ventilation, efficient envelope, and HVAC distribution credits – for which many builders claimed duct leakage control. However, TRC found that approximately 29% of homes performed worse (leakier) during post-construction tests[3] compared to permit declarations where leakage control was estimated pre-construction. Few homes earned the renewable energy, drain water heat recovery (DWHR), and appliance package credits.
- **The RESNET database is not reliable for determining statewide compliance**. The database contains a sample of homes from relatively few builders and is likely not representative of compliance and buildings practices across the state. For the small sample of RESNET homes reviewed (21 homes), this study found a lower code compliance rate and a lower prevalence of electric heat pumps compared to the homes evaluated through virtual audits. This was surprising, since the RESNET database is primarily used for tracking homes that participate in above-code programs, such as ENERGY STAR® for Homes, while the homes sampled for virtual audits were identified through Construction Monitor which represents all permitted homes. Because the

[1] This means that 76% of homes analyzed met the minimum required energy credits based on home size as defined in Section R406, not that 76% of the savings potential of this code is achieved.

[2] The NEEA Washington Residential Post-Code Adoption Market Research Study, also conducted by TRC, found using permit reviews that 88% of homes had electric space heating and 83% had electric water heating. https://neea.org/resources/washington-residential-post-code-market-research-report

[3] While TRC did not conduct any leakage measurements, the 2018 WSEC requires builders to post leakage test results in the home as part of compliance documentation. In approximately half of the audited homes, TRC was able to work with residents to find these documents and identify the post-construction leakage results.

RESNET results are based on only 21 homes in six subdivisions, these findings may not apply to all homes in the RESNET database.

- **TRC estimates compliance rates would be at least as high for multifamily.** While this study collected data from single-family homes, most of the credits that were popular for single-family homes could be achieved in multifamily units with a similar level of feasibility. The exception is the credit for heat pump water heaters, which is more challenging for multifamily units due to space constraints. However, multifamily units need to earn 4.5 credits, instead of the six credits required for medium-sized single-family homes. Consequently, TRC estimates that multifamily units would have a compliance rate at least as high as what this study found for single-family: 76%.
- **Permits generally represented installed equipment but were less reliable for leakage test results.** TRC found that the permits were generally consistent with the installed condition of appliances and other equipment found in virtual audits. However, as noted above, 29% of the post-construction whole house leakage test results found in on-site compliance documentation showed leakier homes than represented in pre-construction permit declarations. As NEEA continues to consider data collection options for code compliance studies, TRC recommends that they consider using permits for verifying equipment but requiring verification of any field test results.

2 Introduction

This study gathered market data on compliance with the 2018 Washington State Energy Code (WSEC) Section R406 and other building choices made in new construction single-family homes. The goal for this study was to collect findings that were representative of 2018 WSEC adoption across the state of Washington. The study looked at primary space and water heating fuel selection, how homes earned credits, and other characteristics including envelope, heating and cooling, ventilation, and water heating choices.

2.1 Washington State Climate Zones

Washington primarily comprises two climate zones: 4C—a more moderate, marine climate, and 5B—a climate that is dryer and more extreme in terms of temperature (hotter summers and colder winters).[4]

The two climate zones in Washington represent different heating and cooling demands, different demographics, and possibly different building styles. TRC ensured the sampled jurisdictions represented a mix of both of the state's climate zones, using the approach outlined in Section 3.1.1. A map of Washington's climate zones can also be found in this section.

2.2 Changes in 2018 WSEC

The 2018 WSEC includes Sections R402-R404 with prescriptive requirements; R405 with a simulated performance alternative to the prescriptive requirements; and Section R406, Additional Energy Efficiency Requirements, which requires homes to earn a minimum number of credits based on the home size and provides a menu of credit options. All homes must meet Section R406 in addition to meeting either the prescriptive (R402-R404) or simulated performance (R405) requirements.

The 2018 WSEC[5] 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 according to the size of the new home.
- Section R406 of 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

[4] There is a small area in the Puget Sound Area that is Climate Zone 5C and a small area in northeast Washington that is Climate Zone 6B. Since these areas represent a small portion of Washington's housing stock, in the sections of the WSEC where requirements depend on climate zone (such as the R402 prescriptive requirements), the code assigns any counties in 5C to 4C requirements and any counties in 6B to 5B requirements. The energy credit requirements in R406, which was the focus of this study, are not climate zone dependent. However, to align with how the broader WSEC handles climate zones and to simplify research, TRC used the same categorization and treated homes in climate zone 5C as 4C and homes in climate zone 6B as 5B.

[5] https://sbcc.wa.gov/sites/default/files/2021-01/2018%20WSEC_R%20Final%20package2.pdf

required 3.5 energy credits. A copy of Section R406 is available in APPENDIX A: 2018 WSEC, Section R406.

- 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."[6] The table offers five options for primary heating source across all possible heating fuel choices: gas, heat pump, electric resistance, heat pump with electric resistance, other fuel sources. The builder must declare fuel choices, and the fuel normalization table assigns a number of energy credits based on the selection, which counts towards the required total 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 higher efficiencies in the 2018 WSEC.

2.3 NEEA Post-Code Adoption Market Research Study Summary

This section provides highlights of the 2018 Washington Residential Post-Code Adoption Market Research Study[7], which TRC conducted on behalf of NEEA in 2022. The purpose of that study was to investigate how builders were responding or planned to respond to the new code shortly after it went into effect. The Post-Code Adoption Market Research Study used builder surveys and permit reviews and did not include any onsite (or virtual) data collection. TRC includes a summary of findings from the previous report to provide a comparison between a permit-only data collection approach and the methodology used in the present study (as-built conditions and permits for hidden measures).

Highlights of the 2018 Washington Residential Post-Code Adoption Market Research Study findings include:

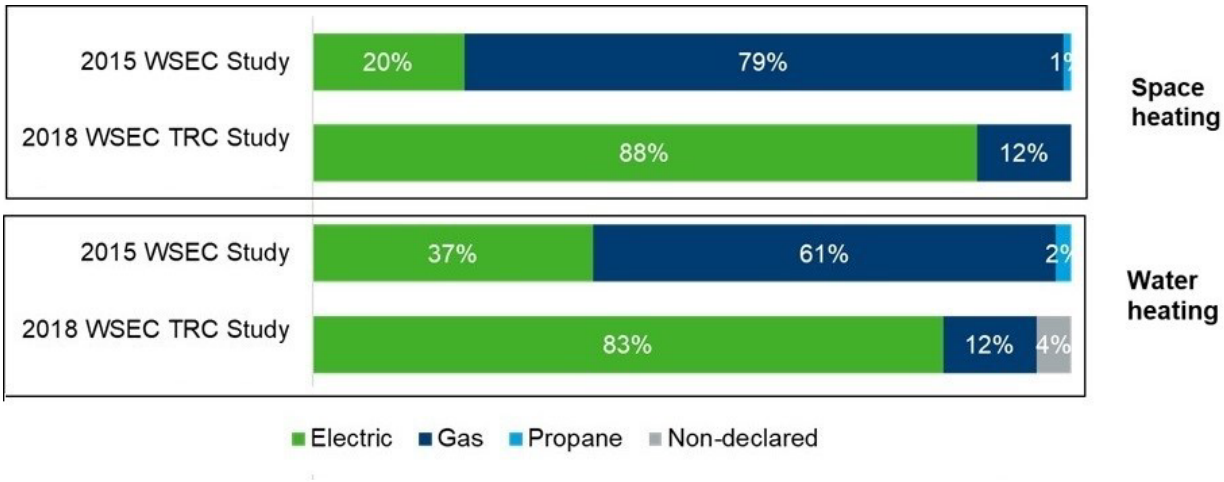
- Permit review showed 100% compliance with the 2018 WSEC—that is, all homes were complying with the code based on the permit data.

[6] 2018 WSEC R406.2 Carbon emission equalization

[7] https://neea.org/resources/washington-residential-post-code-market-research-report

- Builder surveys and permit review indicated a big shift from gas to electric space heating and water heating appliances compared to a 2015 WSEC code study[8], as indicted in Figure 1 below.

Figure 1. Fuel Choice for Space Heating and Water Heating (Source: NEEA Washington Residential Post-Code Adoption Market Research Study, 2022)

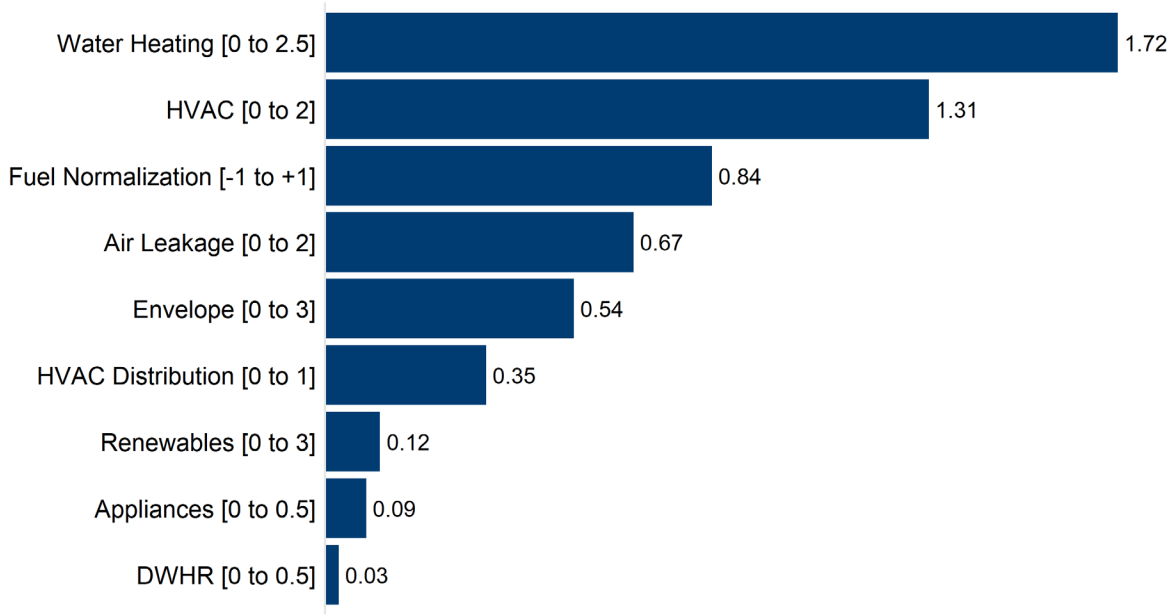


As shown in Figure 2, the Post-Code Adoption Market Research Study found that:

- The most credits claimed per home based on the permit review were in the Water Heating and Heating, Ventilation, and Air Conditioning (HVAC) categories.
- Fuel normalization (which provides credit for electric space heating equipment), Air Leakage (for reduced leakage as measured by a blower door), Envelope, and HVAC Distribution (for reduced duct leakage or ducts in conditioned space) accounted for a moderate amount of credits claimed per home based on permit review.
- Renewables (solar photovoltaic (PV)), appliances, which includes ENERGY STAR kitchen appliances and an ENERGY STAR dryer with an efficiency rating that only heat pump dryers can meet, and drain water heat recovery (DWHR) accounted for a fairly low number of credits claimed per home based on permit data.

[8] https://neea.org/resources/2019-2020-washington-residential-new-construction-code-study

Figure 2. Average Credits Achieved from Each Credit Category from Permits (n=178) (Source: NEEA Washington Residential Post-Code Adoption Market Research Study, 2022



The Post-Code Adoption Market Research Study also found that, for the most part, builders made similar energy credit choices across climate zones. One of the few differences by climate zone was that builders in Climate Zone 5B were slightly more likely to pursue Air Leakage and Ventilation—that is, a tighter envelope and heat recovery ventilator/energy recovery ventilator (HRV/ERV)—compared to homes in Climate Zone 4C.

Section 4 includes comparisons of the findings from the Post-Code Adoption Market Research Study with the findings from the present Code Evaluation study. Except for these comparisons, the remainder of this report presents the methodology and findings only from the Code Evaluation study.

3 Methodology

For this Code Evaluation study, TRC collected data through a variety of sources, including:

- Virtual audits of 56 single-family homes built under 2018 WSEC from a sample of Washington jurisdictions, which represented the state's varied climate zones and the volume of residential new construction building permits pulled under 2018 WSEC for the first year of the new code's implementation. The audits provided data for the fuel choice of equipment and provided most of the data for determining code compliance.
- Review of building permit documents approved while the 2018 WSEC was in effect. TRC gathered permits for homes that were audited and for homes analyzed from the Residential Energy Services Network (RESNET) database (described below). Used in conjunction with audit data, the permits provided the remaining data for determining code compliance, since it provided "hidden measures" such as envelope conditions not visible in the audit. Permit data also indicated how a builder reported they would comply with the 2018 WSEC to support comparison to as-built conditions found in the audits.
- Reviews of 21 homes within the RESNET database that were permitted while the 2018 WSEC was in effect from a sample of Washington jurisdictions. TRC initially planned to use this data set to supplement the audit data for determining trends (code compliance and fuel selection). However, the RESNET database appeared to be skewed to a few builders and did not appear representative of the state. Consequently, TRC presents the results for audited homes separately from RESNET results, and (except in the section describing RESNET results) TRC's data for compliance and fuel selection only reflects results of audited homes.

This section describes each of these efforts. Section 3.3 describes which data source TRC used to determine code compliance for each credit category.

3.1 Virtual Home Audits

3.1.1 Sampling Plan for Virtual Audits

This study used two levels of sampling for virtual home audits: one for selecting jurisdictions within the state of Washington to study, and one for selecting homes within each selected jurisdiction. These two levels of sampling are described in this section.

3.1.1.1 Jurisdiction Sampling Plan for Virtual Audits

To ensure representative data collection across the state while streamlining resources for data collection, TRC identified a sample of jurisdictions in the state of Washington for virtual audits. Our overall sampling approach was as follows:

- TRC analyzed jurisdiction construction permit volume using recent data from Construction Monitor and identified three categories: low, medium, and high construction volume jurisdictions, defined as <220 permits, 220-469 permits, and >469 permits per

year, respectively. These designations split the jurisdictions into three categories with approximately 6,000 new construction permits each. TRC used a similar approach as previous studies (the Post-Code Adoption Market Research Study and a 2015 WSEC study[9]) by categorizing jurisdictions in this manner, but TRC developed new thresholds of low, medium, and high so that each would include roughly the same number of permits. Compared to the previous studies, TRC also updated the categorization of jurisdictions (for example, reclassified a low construction volume jurisdiction as medium) based on permit data from February 2021 to February 2022, to account for current construction volume trends.

- TRC included jurisdictions that had been included in the Post-Code Adoption Market Research Study to streamline outreach and used a randomized approach to add jurisdictions as necessary for representation. TRC stratified the sample by the jurisdiction's level of construction volume under WSEC 2018, with initial strata samples sizes of 10 low, nine medium, and eight high construction volume jurisdictions, respectively.
- TRC ensured the sampled jurisdictions represented a mix of both of the state's climate zones, with 11 jurisdictions in Climate Zone 5B and 16 jurisdictions in Climate Zone 4C. While there were fewer sampled jurisdictions in Climate Zone 5B, TRC oversampled Climate Zone 5B relative to their total permits (see Table 2) to ensure sufficient representation of both climate zones in the sample of audited homes.
- After initial outreach and data collection, TRC adjusted the initial sample because some jurisdictions that were sampled do not keep permits after 90 days; therefore, many homes could not be fully analyzed for code compliance. In addition, TRC added 10 jurisdictions that were low or medium construction volume jurisdictions from Climate Zone 5B to increase audit completions from these areas.

A breakdown of all Washington jurisdictions available in Construction Monitor, by permit volume from 2/1/21 to 2/1/22, and by climate zone, can be found in Table 1 and Table 2, respectively.

Table 1. WA Jurisdiction Breakdown by Permit Volume

Jurisdiction Permit Volume	Number of Jurisdictions	Total Permits in Database	Average Permits per Jurisdiction
Low volume: <220 permits	104	5,989	58
Medium volume: 220-469 permits	20	6,028	301
High volume: >469 permits	8	6,399	800
Total	132	18,416	140

[9] https://neea.org/resources/2019-2020-washington-residential-new-construction-code-study

Table 2. WA Jurisdiction Breakdown by Climate Zone

Climate Zone	Number of Jurisdictions	Total Permits in Database
4C	98	12,962
5B	34	5,454
Total	132	18,416

The breakdown of the study's initially selected and ultimately selected jurisdictions by permit volume category is summarized in Table 3. Note that some jurisdictions were targeted for audits (2nd set of columns) but are not represented in the completed audit (3rd set of columns). This is because some jurisdictions did not have any residents that completed audits (that is, recruitment was zero). Since the overall recruitment rate for completed audits was approximately 0.8%[10], there were several low construction volume jurisdictions that fell into this category.

Table 3. Proposed Sample Jurisdictions Breakdown by Permit Volume

	Initially Targeted for Study		Ultimately Targeted for Study		Represented in Completed Audits	
Jurisdiction Permit Volume	Number of Jurisdictions	Total Permits in Database	Number of Jurisdictions	Total Permits in Database	Number of Jurisdictions	Total Homes Audited
Low volume	10	1,110	19	1,810	7	10
Medium volume	9	2,787	10	3,128	7	18
High volume	8	6,399	8	6,399	7	28
Total	27	10,296	37	11,337	21	56

The breakdown of selected jurisdictions by climate zone is summarized in Table 4. Total permits in database are based on Construction Monitor totals from 2/1/21 to 2/1/22.

Table 4. Proposed Sample Jurisdictions Breakdown by Climate Zone

	Initially Targeted for Study		Ultimately Targeted for Study		Represented in Completed Audits	
Climate Zone	Number of Jurisdictions	Total Permits in Database	Number of Jurisdictions	Total Permits in Database	Number of Jurisdictions	Total Homes Audited
4C	16	7,028	16	7,028	11	32
5B	11	3,268	21	4,309	10	24
Total	27	10,296	37	11,337	21	56

[10] As explained in Section 3.1.2, the overall recruitment rate was low for a few reasons, including that TRC could only contact customers through the mail.

One disadvantage of this approach is that not all jurisdictions report permits to Construction Monitor. However, most new construction is reflected in this database.[11] Data from the Census Building Permits Survey (BPS)[12] indicates there were roughly 25,000 permits for new single-unit homes in Washington during this time period, and Construction Monitor lists nearly 19,000 with the same criteria. There are some differences with how each source defines the type of home; for example, the census groups homes by the number of housing units per structure, and Construction Monitor has over 500 descriptions for residential homes (including "New Home", "Demo and Rebuild Home", "Townhome", and "Cottage Residential", to name a few). But TRC estimated that at least 75% of new construction homes are represented in Construction Monitor. This resource also provided other valuable data (for example., permit date, home address, and jurisdiction) that TRC leveraged for data collection.

3.1.1.2 Sampling of Homes Within Each Jurisdiction

Within each sampled jurisdiction, TRC sampled homes for recruitment.

- In low and medium construction volume jurisdictions, because of the smaller number of homes in each jurisdiction, TRC attempted to recruit all newly constructed homes (that is, attempted a census).
- In high construction volume jurisdictions, TRC developed a random sample of newly constructed homes for recruitment. TRC aimed to sample approximately 500 homes from each high construction volumpe jurisdiction. However, this number could be lower or higher depending on the groups already represented (within the jurisdiction itself, or within the permit volume or climate zone categories) at the time of recruitment or whether the jurisdiction included homes eligible for utility co-branded materials, which is discussed in Section 3.1.2. Sampling in high construction volume jurisdictions ranged from 188 to 884 homes, with an average of 471 homes contacted per jurisdiction.

There were 11,337 total permits in Construction Monitor for sampled jurisdictions. Due to the sampling approach used for homes in high construction volume jurisdictions, TRC ultimately contacted 7,457 homes to participate in a virtual audit.

3.1.1.3 Homes Audited by County and Climate Zone

In total, TRC conducted 56 audits across the state of Washington.[13] The map in Figure 3 below shows the distribution of completed audits across the two climate zones, where Climate Zone 4C counties are shown in green, and Climate Zone 5B counties are shown in blue.

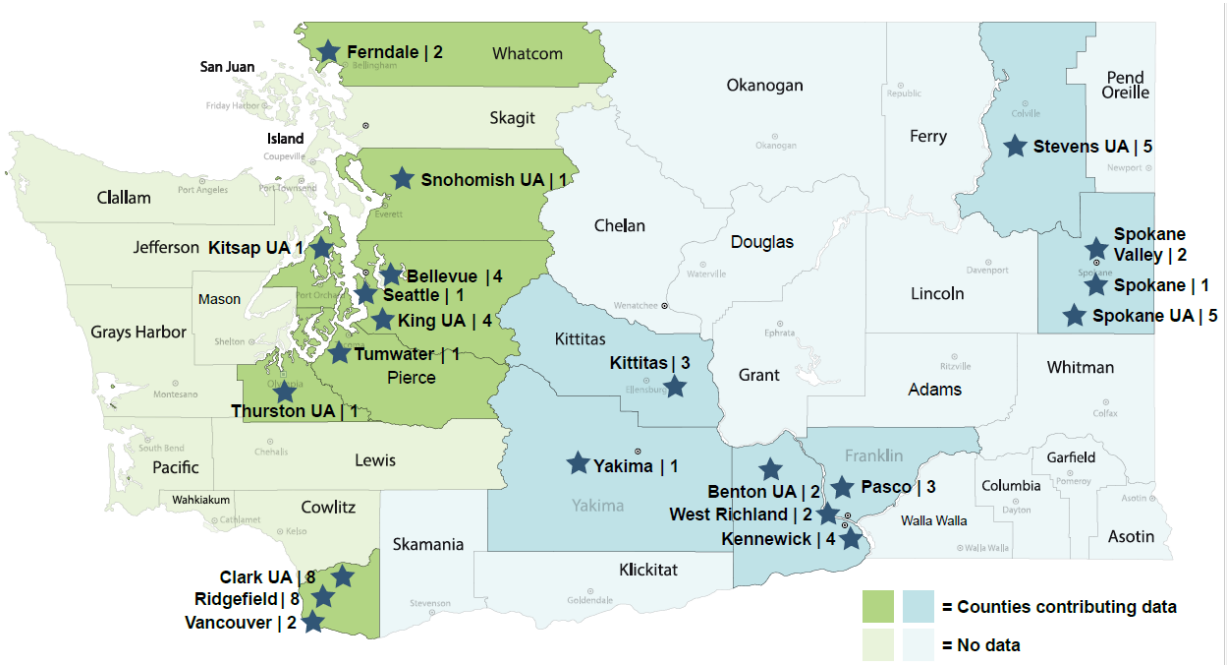
---

[11] Construction Monitor is limited to jurisdictions that have made some basic permit data publicly available online. This includes permit dates, not just full permits (which few jurisdictions publish online). A few jurisdictions either use only paper or do not make any permit data available to the public. Construction Monitor does not estimate the fraction of jurisdictions missing from their data, however TRC believes it is a small number of small rural jurisdictions. To compensate for this data gap, TRC specifically recruited homes in low and medium construction volume jurisdictions in Climate Zone 5B that were in the Construction Monitor data.

[12] https://www.census.gov/construction/bps/current.html

[13] TRC also conducted a few audits of homes that were later determined (after receiving the permit) to be built under the 2015 WSEC. Results from these 2015 WSEC audits are not included.

Figure 3. Audits Conducted by Climate Zone

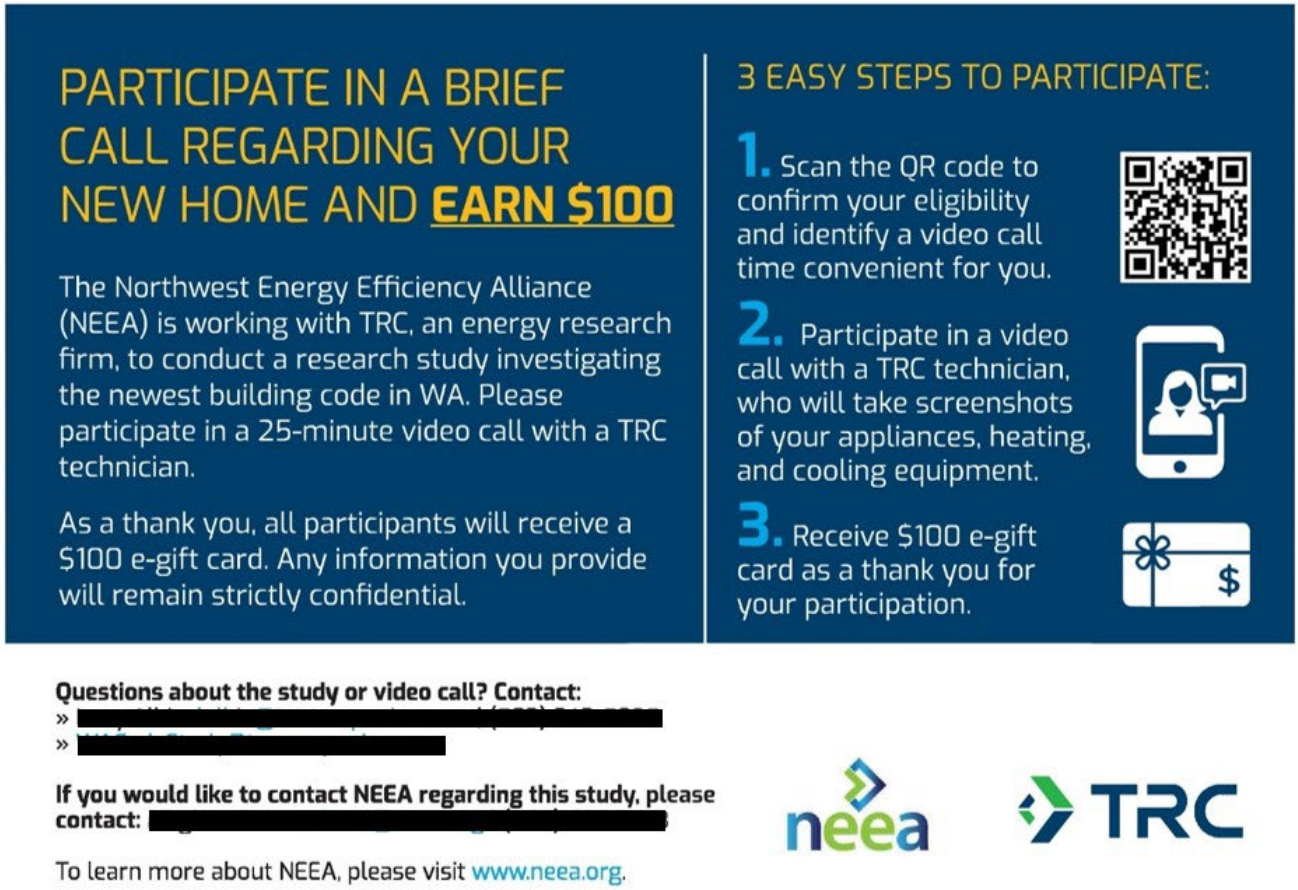


3.1.2 Virtual Audit Recruitment

To recruit participants for the virtual home audits, TRC pulled addresses for homes in Construction Monitor that had single-family new construction building permits approved between 2/1/2021-2/1/2022 in the sampled jurisdictions. TRC used this timeframe to ensure that the homes were built under the 2018 WSEC code (which applies to all homes with permits pulled after 2/1/2021) and to include a buffer of several months to allow time for the homes to be constructed and occupied before the audits were conducted, which began in summer 2022.

Home address was the only available contact information for the residents of homes identified in Construction Monitor, so recruitment was conducted via mail. TRC chose to test two different formats for recruitment: a postcard (see Figure 4) and a letter (see APPENDIX B: Virtual Audit Recruitment Letter), both of which included contact information for TRC and NEEA staff. Relevant research on which of these would yield a higher success rate was not available, so TRC chose to send postcards to roughly half the homes and letters to roughly half the homes. Subsequent rounds of outreach to a home that was already contacted would use the other method. For example, if a home initially received a postcard, TRC would send a letter a few weeks later if the home had not responded and TRC was still targeting this jurisdiction for audits.

Figure 4. Virtual Audit Recruitment Postcard



During data collection, TRC made the following changes to the recruitment strategy:

- After the team faced difficulties obtaining permits from certain jurisdictions (described as part of Section 4.9), TRC contacted homes for which the team had already collected permits as part of the Washington Residential Post-Code Adoption Market Research Study, even if they were not in the original jurisdiction sample.[14]
- TRC and NEEA increased the incentive from $75 to $100 per home to improve the recruitment rate. The higher incentive rate was advertised beginning with the fourth round of recruitment, which was mailed in late October 2022.
- TRC and NEEA partnered with one local utility to co-brand recruitment materials in an effort to improve recruitment rates in jurisdiction types that were under-represented in the initial responses. This included low and medium construction volume jurisdictions, and jurisdictions in Climate Zone 5B. TRC sent co-branded recruitment materials during the fourth round of recruitment, sent in early January 2023.

[14] Note that one single-family attached home was audited because the permit was available from the Post-Code Adoption Market Research Study. All other audits were of single-family detached homes.

In all, TRC sent 11,243 mailers to a total of 7,457 homes. TRC contacted 3,722 homes once, 3,684 homes twice, and 51 homes three times. The response rate was 2% overall. The highest response rate was from the first attempt, with 2.5% of recipients responding after receiving the first postcard or letter. For homes where TRC sent a second mailer (or a third), only 1.5% responded.

Table 5 summarizes recruitment results. Note that not all homes that responded completed an audit, either due to ineligibility or lack of further response.

Table 5. Response Rate by Number of Outreach Attempts per Home

Number of Outreach Attempts per Home	Number of Homes Contacted	Number of Responses	Response Rate
1 attempt	3,722	94	2.5%
2 or more attempts	3,735	56	1.5%
Total	**7,457**	**150**	**2.0%**

TRC sent both postcards and letters to a roughly equal number of homes. This enabled TRC to evaluate the success of the two types of recruitment mailers. As shown in Table 6, the letter was found to be more effective than the postcard, with the highest response rate of 3.4% for a letter alone, and the second highest response rate of 2.1% for a postcard followed by a letter. Combinations of recruitment mailers other than the top four, including a letter followed by a second letter, and instances where three types were sent, are grouped together in the below above under “Other combinations.”

Table 6. Response Rate by Mailer Type

Recruitment Mailer Type	Number of Homes Contacted	Number of Responses	Response Rate
Letter	1,901	65	3.4%
Postcard	1,821	29	1.6%
Letter, then Postcard	1,872	17	0.9%
Postcard, then Letter	1,811	38	2.1%
Other combinations	52	1	1.9%
Total	**7,457**	**150**	**2.0%**

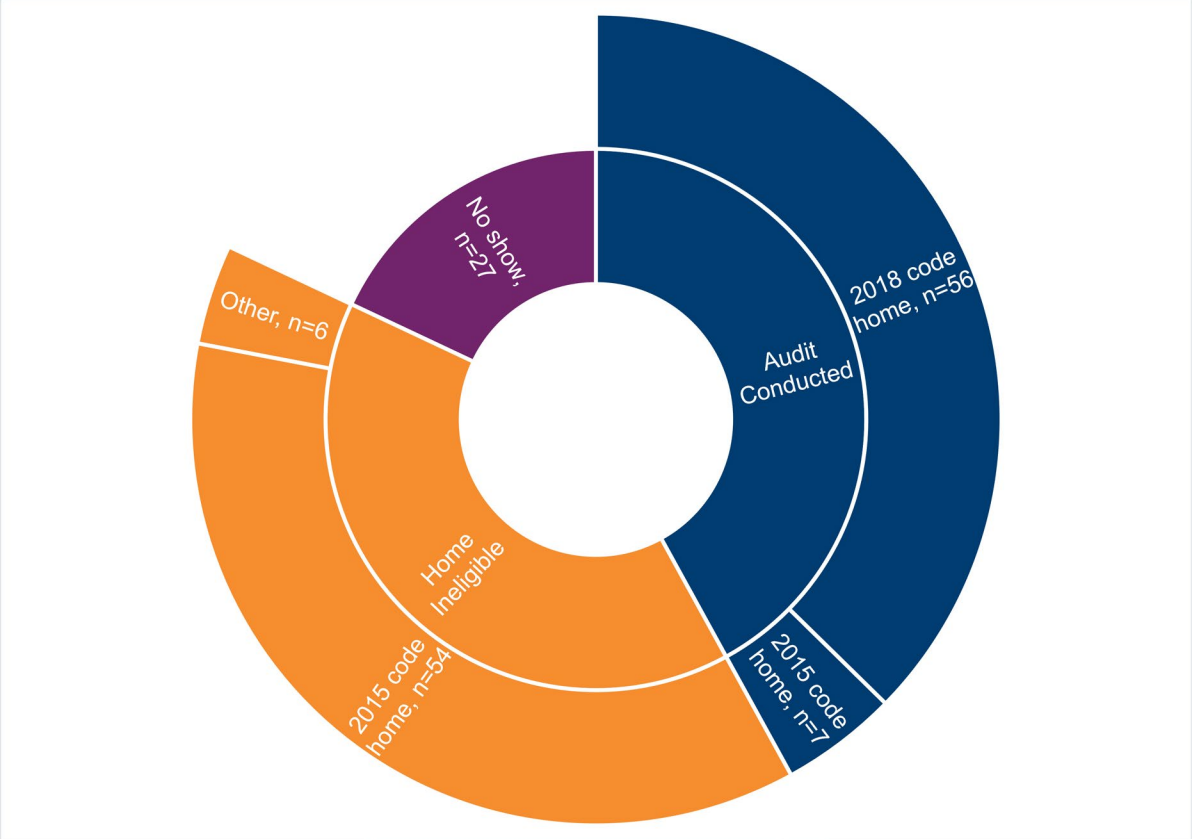
TRC noted the higher success of the letter over the postcard partway through recruitment, which is why some homes received two letters. It is possible that the postcards received fewer responses because they may have looked like junk mail to some residents. Additionally, the majority of recruitment was conducted in the fall of 2022, coinciding with political mailers sent out prior to November 2023 elections. It is possible that customers overlooked postcards amidst the high volume of mail they were receiving.

Of the 150 people that responded, approximately one-third (56 homes) resulted in a completed audit of a 2018 WSEC home. One-third of respondents were ineligible. This was primarily because, while Construction Monitor data indicated the homes were permitted after February 1, 2021 (under the 2018 WSEC), online permit information from the jurisdiction showed the homes

were permitted before this date (under the 2015 WSEC). Approximately one-fifth (27 homes) of respondents scheduled audits but did not call in at the appointed time. While TRC attempted to reschedule these, some never responded. Finally, TRC audited a few homes that were later determined to be constructed under the 2015 WSEC, so they were out of scope of this research and their data were not analyzed.

The overall recruitment rate of completed 2018 WSEC audits compared to number of homes that received recruitment materials was 0.8%.

Figure 5. Responses vs. Completed Audits of 2018 WSEC Homes



3.1.3 Demographics of Residents Participating in Audits

The recruitment materials (letters and postcards) directed interested participants to a Microsoft Forms® questionnaire. This three-minute online questionnaire asked for some basic information about their home (including address), provided scheduling options for virtual audits that the participant could select, and asked two demographic questions: one regarding household income and one regarding the race(s) of household members. This section provides the results of the demographic questions for residents that completed audits, compared to census data.

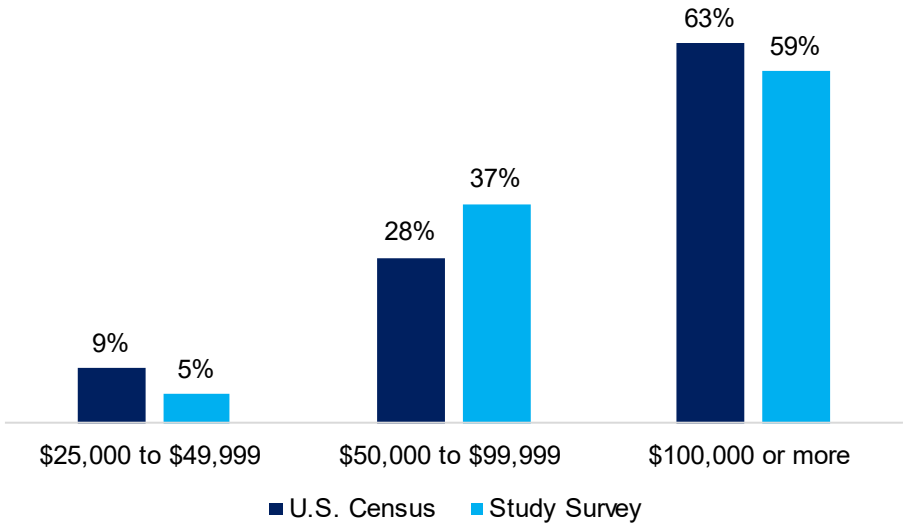
The purpose of the two demographic questions was to explore whether the residents captured in the audits represented the general population of single-family residents in Washington. In particular, if the participating residents had a much higher income level than single-family residents, this could indicate a skewed sample, such as high-end homes that may be more

likely to have high-end appliances. Both demographic questions were optional and included a *decline to state* option.

TRC compared income responses for census data for Washington homeowners with mortgages for at least $25,000. This comparison point was chosen because census data was not available for income of single-family residents in Washington, nor for single-family home owners in the state. Because the majority of single-family home residents are owners, and most homeowners have mortgages, the data point from the census of homeowners with mortgages was the closest TRC could identify to characterize the income levels of single-family home residents.

Out of the 56 participants in the study, 15 declined to state their income. The majority of the 41 participants who reported their income (59%) had an annual income of $100,000 or more, while only two homes (5%) had an annual income between $25,000 and $50,000. Another 15 homes (37%) reported an annual income between $50,000 and $100,000. The income distribution of survey participants aligns fairly closely with the U.S. census data in 2021 for homes with a mortgage in Washington.

Figure 6. Homeowners Income – 2021 U.S. Census Washington State Income Data and Self-Reported Data from Survey Respondents



When asked about their own and their household members' races or ethnicities, respondents reported their households were White (56%), Asian/Pacific Islander (19%), or Hispanic/Latino (8%), or a combination of those three races/ethnicities (17%). No respondents reported they were Black/African American or Native American. Census data is not available for race/ethnicities of mortgage holders in Washington, but the demographics of all Washington residents is 66% White, 10% Asian/Pacific Islander, 14% Hispanic/Latino, 5% two or more races, 4.5% Black/African American, and 2% Native American.[15] Eight participants declined to state their racial identity.

[15] https://www.census.gov/quickfacts/WA. Results sum to greater than 100% because Latinos / Hispanics may be any race so can be included in multiple categories.

3.1.4 Virtual Audit Process

This section describes the process TRC took to conduct a virtual audit.

TRC obtained access to homes by connecting with residents at a prescheduled time through a video communications platform, with the resident joining on their smartphone. The audit primarily consisted of the auditor asking the resident to show them various parts of the home through the video, as the auditor took screenshots of equipment nameplates, model numbers, built conditions, and compliance documentation, if available. The auditor also asked the resident questions about the home and its equipment, such as the primary method that the household uses for space heating, if there was additional equipment that is not safely accessible (such as in a crawlspace or unfinished attic), and whether the home has a solar PV system. When asking for compliance documentation, the auditor asked the resident if they were aware of a compliance certificate or worksheet with test results, and the auditor suggested areas of the home for the resident to look for this documentation. As explained further in Section 4.5, builders are required by code to post a compliance certificate in the home with any applicable air leakage test results and other relevant details, but these are not always posted, and those that are posted are not always complete.

The virtual audit took approximately 25 minutes for the resident, and a few minutes of this was typically spent looking for compliance documentation.

3.2 Permit Review

3.2.1 Collection of Permit Data

To obtain permits from jurisdictions in Washington, TRC reached out directly to jurisdiction offices by email and by telephone. TRC 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. Of the 56 homes audited, TRC was able to obtain complete permits for 44 homes (79%). For the remainder of homes (21%), the jurisdictions reported they did not have permit data, with most of those jurisdictions reporting they do not keep permits beyond 90 days.

TRC was able to determine compliance for an additional five homes with incomplete permit information; these included some small homes (<1500 sf) that only needed three credits for compliance and that earned at least three credits based on the appliances found in the audits.

In addition, TRC collected permits for homes that TRC analyzed from the RESNET database.

3.2.2 Data Collected from Permits

In reviewing permits, TRC documented the measures that could not be determined through virtual audits, such as envelope measures (where test results were not posted in compliance documentation at the home), air leakage, and duct leakage results. TRC also documented all credits targeted and compared permit data (planned measures) with installed conditions (actual measures). TRC developed an Excel® workbook to capture information for each home audited.

This workbook included fields for basic information about the home (for example, location, home size), detailed information of each energy credit earned, and the source of this information (audit or permit data).

Section 3.4 describes the permit data that TRC analyzed for homes studied from the RESNET database.

3.3 Determination of Code Compliance

TRC evaluated compliance with the R406 energy credit requirements for each home and assumed 100% compliance with the prescriptive minimum requirements in Sections R402-R404 or the simulated performance requirements in Section R405. To determine code compliance for each audited home, TRC needed a combination of audit data and permit data. Some credit category data was available from audits, some only in permits, and some categories had data available from both sources. Some audited homes also had a compliance certificate available with post-construction test results, described in further detail in Section 4.5. Where data was available from both sources, TRC used audit data because this reflected as-built conditions. Table 7 shows a breakdown of the available data for each credit category, which source was used, and how the determination was made.

Table 7. Data Source for Determining Code Compliance

Credit Category	Data Source for Determining Code Compliance	Comment
Fuel Normalization	Audit data	Audit data of the installed HVAC systems was the most representative of as-built conditions.
Efficient Building Envelope Options	Permit data	Insulation is hidden and not available for visual inspection during an audit. For safety reasons TRC did not ask residents to confirm the attic insulation measure, and window stickers would have been removed prior to occupancy. Note: some compliance certificates found in audits had insulation information entered. This was not used unless the home did not have complete permit information with credits claimed available. For example, if R-38 insulation floor insulation over a crawlspace was declared, TRC assumed the home met the 1.3 credit.[16]
Air Leakage Control and Efficient Ventilation Options	Audit or permit data or mix, depending on data available during the audit	Audit data was used when available, but many residents did not know what type of ventilation system they had. ACH50 values were reported on some but not all compliance certificates, and residents could not always locate a compliance certificate. If data from audits were not available, permit declarations were used. Of the 56 homes audited, 27 homes had ACH50 values in compliance documentation found in the audit.

[16] Because most builders will insulate floors over crawlspaces to R-30, if R-38 was present in the crawlspace it is reasonable to assume that energy credit 1.3 was utilized.

Credit Category	Data Source for Determining Code Compliance	Comment
		Of the 49 homes analyzed for code compliance, TRC verified compliance using permit data for 26 homes and compliance documentation found in audits for 23 homes.
High Efficiency HVAC	Audit data	Auditors captured the HVAC system based on screenshots of equipment plates. Audit data showed as-built conditions. Because HVAC model specifications often list a range of heating seasonal performance factors (HSPF), which sometimes spanned multiple credit categories, TRC sometimes relied on the credit category in the permit to identify which HSPF the project targeted. If the range covered the efficiency claimed in the permit, TRC would assign what was claimed.
HVAC Distribution System	Permit data TRC verified credit 4.1 (which sets a maximum duct leakage value) with compliance documents from the audit when available	If the permit claimed credit 4.1, TRC would look for the duct leakage test out value in the compliance certificate in homes where TRC could find compliance certificates. 20 total homes had duct leakage results available from the audit. When permit data was not available and audit data indicated the 4.1 credit met the duct leakage requirement, the 4.1 credit was awarded. For 4.2 (ducts in conditioned space), TRC relied on permit data.
DWHR	Permit data	Permit data was used for the DHWR credit because this system cannot be visually verified in an audit.
Efficient Water Heating	Audit data	Auditors captured the water heating system based on screenshots of equipment plates. Audit data showed as-built conditions.
Renewable Electric Energy Options	Combination: Audit to confirm presence of solar PV. If solar PV was installed, TRC used the permit to verify the number of credits claimed	In addition to asking residents, TRC considered using Google Maps to verify the presence of solar PV. But because these are new homes, many were not visible in current satellite imagery.
Appliance Package Options	Audit data	TRC started with looking up the dryer model number on the ENERGY STAR database to verify it is qualified, ventless, and meets the minimum CEF rating. This step was conducted first because a heat pump dryer (which is needed to meet the efficiency rating requirement) is uncommon. Next, TRC would check the dishwasher, refrigerator, and washing machine on the ENERGY STAR database to confirm qualification, if necessary.
Home Size	Audit data, permit data, and online data sources	TRC would collect this information from the permit and confirm with Zillow or Redfin. TRC also asked residents for their home size during the audit.

3.4 RESNET Analysis

In addition to collecting data on audited homes, TRC explored the RESNET database as a source to determine residential new construction compliance under 2018 WSEC and compare permit data to as-built conditions. The RESNET database includes homes that receive a home energy rating, which is typically done for participation in a green building or energy-efficiency home program such as ENERGY STAR for Homes. Third-party raters upload data in the RESNET database based on their in-field observations and leakage tests. The advantage of using RESNET data is it leverages existing data of as-built conditions. A major disadvantage is most homes are not listed in the RESNET database, because RESNET registry is required by some voluntary programs but not by code.

To begin, NEEA provided TRC with a download of RESNET data for single-family homes in Washington registered in 2021 and 2022 (up to the date of data collection). TRC first identified single-family homes verified in 2021 or later (since the 2018 WSEC took effect on February 1, 2021). TRC also filtered this list for homes in the same sample of jurisdictions that were targeted for virtual audits to reduce the number of jurisdictions for which TRC needed to coordinate permit requests. TRC also removed homes in jurisdictions where permits could not be obtained or that did not have a complete dataset for the fields collected, as key fields were not reported for some homes. Using this filtered list, TRC checked each home address against Construction Monitor data to verify that permit was filed on or after February 1, 2021 (under 2018 WSEC). While there are thousands in the RESNET database for Washington for 2021 to 2022, these filters reduced the list to approximately 70 homes.

TRC planned to collect RESNET data for around 40 homes. However, after beginning the analysis for the remaining list of homes, we determined that many of the homes were in the same subdivisions with the same builders and that many used the same building practices. TRC chose to limit the number of homes per subdivision to avoid duplicating results, which left fewer homes than anticipated. TRC also broadened the sample to include jurisdictions added to the audit sample, and we investigated other jurisdictions with permit data available online, but we were ultimately not able to find a sample of 40 homes with unique data (that is, representing different subdivisions or custom homes). **Ultimately, TRC analyzed 21 homes in six subdivisions from the RESNET database**.

To determine compliance of the homes in the RESNET analysis, TRC used a similar approach to the code compliance determination of audited homes. However, the availability of data from the RESNET database differed from what was available to collect during virtual audits. Most notably, TRC did not have the equipment model numbers for RESNET homes and had to rely on the information directly reported in RESNET. For some equipment, this includes efficiency ratings, but some include only basic information such as fuel type and system type. The data sources used to determine code compliance for homes in the RESNET analysis are summarized in Table 8.

Table 8. Data Source for RESNET Analysis

Credit category	Data source for determining Code Compliance	Comment
Fuel Normalization	RESNET data	HVAC fuel type reported in RESNET was used, since this is the most representative of as-built conditions.
Efficient Building Envelope Options	RESNET data	RESNET reports window U-value, and insulation R-values for walls, attics, and floors, which was used to determine the credit category achieved.
Air Leakage Control and Efficient Ventilation Options	RESNET data	RESNET reports ACH50 result and ventilation type, which was used to determine the credit category achieved.
High Efficiency HVAC	RESNET data	RESNET reports the space heating fuel type, system type, and efficiency, which was used to determine the credit category achieved.
HVAC Distribution System	Combination of permit data and RESNET data	To verify this credit, TRC first looked at what was claimed in the permit. If the permit claimed credit 4.1, TRC would take the duct leakage test result from RESNET and calculate the cfm/100 sf to determine whether the requirement was met. If the permit claimed credit 4.2, TRC would verify that the % of ducts in conditioned space reported in RESNET was >95% in order to award the 4.2 credit.
DWHR	Permit data	Permit data was used for the DHWR credit because this system is not reported in RESNET.
Efficient Water Heating	Combination of permit data and RESNET data	RESNET reports the water heating fuel type and system type, but not the efficiency. Given this, TRC began by looking at the credit claimed in the permit. If the fuel and system type in RESNET matched, TRC used the credit from the permit. If the RESNET water heating system and fuel type did not match the credit claimed in the permit, TRC awarded no credit.
Renewable Electric Energy Options	Combination of permit data and RESNET data	First, TRC checked the credit claimed in the permit. If a credit was claimed, TRC would confirm PV installation with the RESNET data and use the number of points from the permit. If no PV was reported in RESNET, TRC would award no credit.
Appliance Package Options	Combination of permit data and RESNET data	First, TRC checked the credit claimed in the permit. If the credit was claimed, TRC would check the dryer fuel type from RESNET. If electric, TRC would award the credit. If gas, TRC would not. No other appliance information is available in RESNET.
Home Size	Permit and RESNET data	This information is reported in RESNET and would be verified against the permit documents.

TRC also used data from the RESNET database to determine fuel choice for space heating and water heating.

A full list of the data fields collected from the RESNET database for homes used in this analysis is provided in APPENDIX C: RESNET Data Fields.

4 Results

4.1 Code Compliance

4.1.1 Statewide Compliance

TRC completed 56 virtual audits with residents of homes built under the 2018 WSEC code and was able to determine compliance for 49 homes based on complete permit documentation or assumptions for homes with incomplete permit information, as explained in Section 3.3. TRC found that **37 homes (76%) complied with 2018 WSEC energy credit requirements,** with a 90% confidence interval of +/- 10%. More information on the 12 (24%) homes that failed to comply, including how their permit data compared with installed conditions, can be found in Section 4.1.4.

After the 2018 WSEC went into effect, the Washington State Building Code Council (SBCC) passed an emergency rule in June 2022[17] that, due to limited product availability, would allow a temporary efficiency reduction for homes that claimed the 11.0 HSPF credit for 1.5 points to meet the requirement with a 10.0 HSPF heat pump.[18] TRC analyzed the dataset to see how this ruling affects the compliance rate and found that it would only push one home from noncompliance into compliance. This home's permit was issued in 2021, however, so it is unlikely that the rule would have been in effect during the home's inspection. There were other homes where this rule might have applied, but it would not have affected these homes' compliance—that is, they needed more than 0.5 credit to comply.

On the other hand, there were three homes that TRC audited that likely did not comply with the 2018 WSEC unless they met the requirements for the DWHR credit and/or used the emergency rule for a heat pump. One home could comply with just one of these requirements, while two homes would need both credits to comply. The permits for all three homes were completed after the emergency ruling was passed. TRC audited these three homes and collected partial compliance documentation from the resident (described in Section 4.5) including air leakage test results and envelope conditions, but TRC was unable to obtain a full permit that would have shown whether the builder targeted the DWHR credit. If the homes met the DWHR credit, they would comply; if not, they would be noncompliant. As described in Section 4.4.4, only 9% of homes with complete information met the DWHR credit. While it is unlikely that the homes met the credit, it is possible that at least one did, so TRC did not include these homes in the code compliance results. If TRC had declared these homes as noncompliant, then the compliance rate would be as low as 71%. The value of 71% is within the 10% precision level for the estimate of 76%, so this difference is not statistically significant.

The compliance rates found here are lower than in past studies of residential energy code compliance. A review of residential code compliance rates by ACEEE 2023[19] provides

[17] https://sbcc.wa.gov/sites/default/files/2022-12/sm06292022C_ah.pdf

[18] https://sbcc.wa.gov/sites/default/files/2022-06/WAACAA%20SBCC%20PROPOSAL%2060922.pdf

[19] https://database.aceee.org/state/compliance. Results are updated continuously, and TRC reviewed results in March 2023.

compliance rates based on previous studies for many states and found that most states have compliance rates at or above 90%. A 2013 study[20] of residential code compliance in Washington found a 96-97% compliance rate. Code compliance studies use different methods, so it is not possible to make an apples-to-apples comparison across studies. For example, many code compliance evaluations have coordinated with builders to gain access to homes. This method allows for diagnostic testing, such as air leakage (blower door) and duct leakage tests, but it introduces a bias since some builders do not allow evaluators on-site. TRC's method was to recruit residents directly, thereby bypassing builders. While TRC was not able to conduct leakage testing, the results should be less biased since builders could not decline to participate or show the auditors only a select set of homes. Another possible reason for the difference in compliance is that the 2018 WSEC may be more challenging for builders to meet or for code officials to enforce compared to the 2015 WSEC or codes in other states. Many of the energy credits in the 2018 WSEC exceed requirements in the International Energy Conservation Code (IECC), the model code followed by most states. Furthermore, many states adopt older versions of the IECC, such as the 2009, 2012, or 2015 IECC, which have lower efficiency requirements than the 2018 IECC.[21]

Our estimated compliance rate of 76% is likely an overestimate. As described in Section 4.1.4, the most common reason why homes did not comply was because compliance certificate data found during the audit showed they did not meet the leakage values (air leakage or duct leakage) targeted in permit declarations. TRC found leakage test results in compliance certificates (see Section 4.5) for about half of homes and assumed permit values for remaining homes. It is likely that some of the homes where permit data was used for leakage results might not have complied if actual test results had been available.

4.1.2 Compliance by Climate Zone

TRC also ran analysis by climate zone to determine if 2018 WSEC compliance differed in the two zones.

Of the approximately one quarter of homes that did not comply with the 2018 WSEC, the proportion was higher for those homes in Climate Zone 5B, where one third of homes did not comply. The compliance rates statewide and by climate zone are shown in Figure 7.

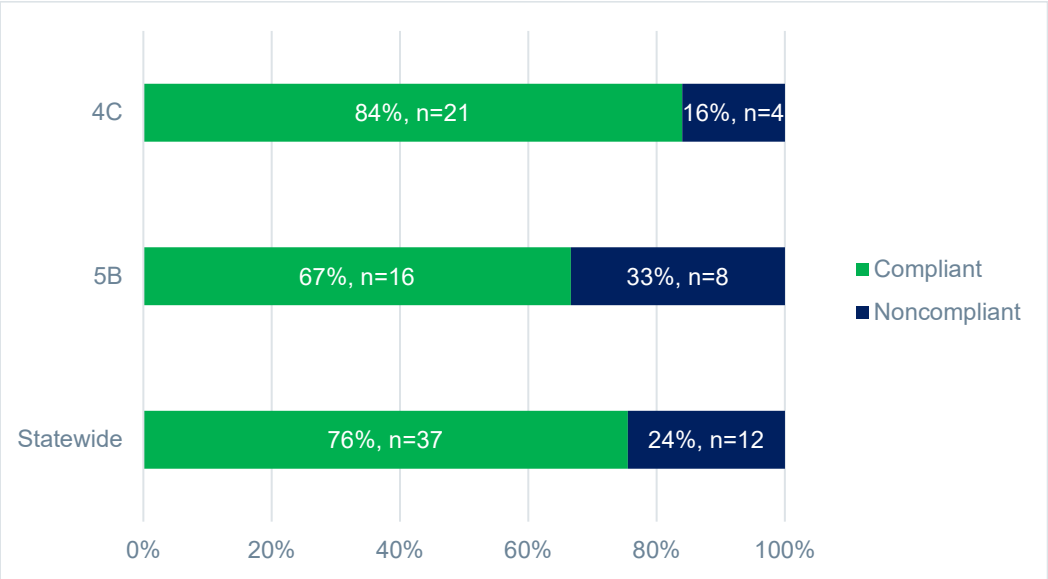
Climate Zone 5B has a compliance rate of 67 +/- 16% compared to the Climate Zone 4C's compliance rate of 84 +/- 13%. While this may appear to be a substantial difference for categories with a similar number of audits, this difference is not statistically significant with 90% confidence.[22]

[20] Northwest Energy Efficiency Alliance (NEEA), "Washington Residential Energy Code Compliance." https://neea.org/resources/washington-residential-energy-code-compliance

[21] https://www.energycodes.gov/infographics

[22] The two-sided t-test on the 5B and 4C compliance rates being equal has a p-value of about 0.17, which is greater than the threshold of 0.1 for 90% confidence. The 90% confidence interval on their difference is -38% to 3% (that is, 5B is 38% lower to 4C is 3% higher); if the test were statistically significant then this interval would not include zero.

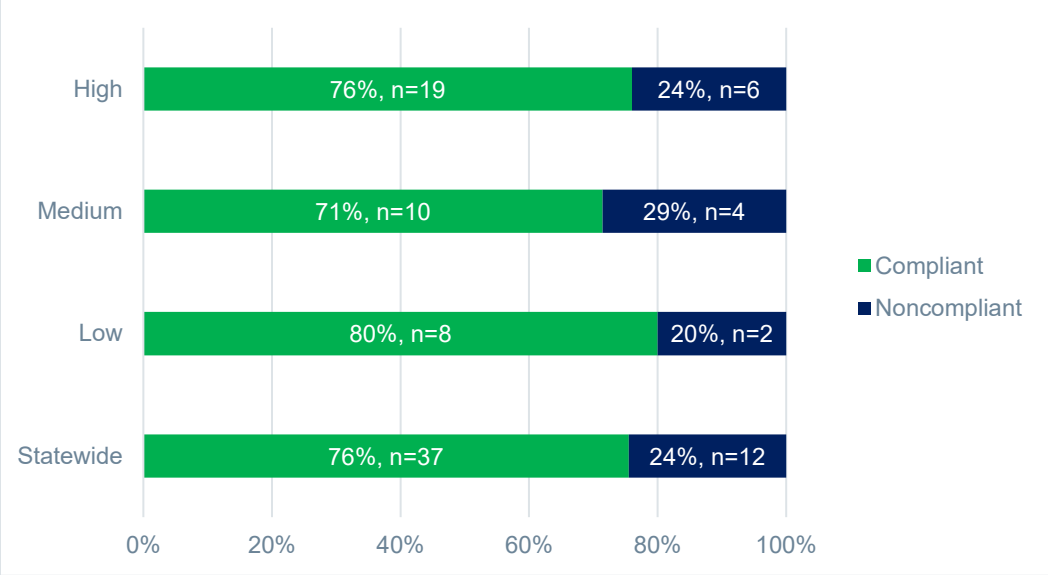
Figure 7. Statewide and Climate Zone Compliance



4.1.3 Compliance by Jurisdiction Permit Volume

TRC conducted analysis by jurisdiction permit volume to determine if the 2018 WSEC compliance differed between jurisdictions of different permit volumes. With a 90% confidence interval, TRC found that 2018 WSEC compliance was 80 +/- 23% for low construction volume, 71 +/- 21% for medium construction volume, and 76 +/- 15% for high construction volume jurisdictions. The difference in results is not statistically significant. The compliance rates by jurisdiction volume are shown in Figure 8.

Figure 8. Compliance by Jurisdiction Volume



4.1.4 Reasons for Noncompliance

As discussed in Section 4.1.1, of the 49 homes for which TRC was able to determine compliance, 12 homes (24%) did not comply with the 2018 WSEC energy credit requirements. These homes fell short of their required number of credits by 0.5 to 3.5 points, with an average of 1.25 points. All noncompliant homes were medium size (between 1,500 and 5,000 sf), requiring six energy credits. The reasons for noncompliance are summarized in Table 9.

Table 9. Summary of Reasons for Noncompliance

Reason for Noncompliance		Number of Homes
Failing test results	ACH50 requirement in the air leakage and ventilation category only	3
	Duct leakage requirement in the HVAC distribution category only	1
	Both the duct leakage and ACH50 requirements	2
Used 2015 WSEC checklist in permit documentation		3
Could not isolate reasons[23]		1
Different fuel type		1
Heat pump did not meet required HSPF		1

Six homes were noncompliant because the test results found in compliance documentation found during the audit did not meet the requirements of the credits declared in the permit. As described in Section 4.5, while TRC did not conduct leakage tests (air leakage tests or duct leakage tests); instead, auditors would ask the resident if they could find a copy of compliance documentation, which often showed these test results. As detailed in Section 3.3, TRC was able to find compliance documentation with these test results in approximately half of the audited homes. As described below, the test results were often worse (leakier) than the permit declarations, and this led to noncompliance with code:

- Three homes failed only the ACH50 requirement in the air leakage and ventilation category:

[23] This home did not have complete permit documentation. However even if all categories that could not be verified were given the most credits possible, the home would not comply. Without a permit declaration for comparison, a single reason for failure could not be determined.

    - Two claimed credit 2.3 (1.5 ACH50) but met 2.1 (3.0 ACH50).
    - One claimed credit 2.1 (3.0 AH50) but met no credits in this category.
    - One of these homes also did not meet the HSPF rating for the declared HVAC credit; however even if the emergency rule was used and points were awarded for the credit declared in the permit, the home would be 0.5 points short of compliance.
- Two homes failed both the duct leakage and ACH50 requirements:
    - One claimed credit 2.1 (3.0 AH50) but met no credits in this category. This home also claimed credit 4.1, but it did not meet the duct leakage target.
    - The other claimed credit 2.2 (2.0 ACH50) but met 2.1 (3.0 AH50). This home also claimed credit 4.1, but it did not meet the duct leakage target. This home also did not meet the HSPF rating for the declared HVAC credit; however, even if the emergency rule was used and points were awarded for the credit declared in the permit, the home would be 0.5 points short of compliance.
- One home failed only the duct leakage requirement in the HVAC distribution category:
    - Credit 4.1 was claimed but was not met.

Three of the homes found to be noncompliant used the 2015 WSEC checklist in the permit documentation, claiming 3.5 points for a medium size home (rather than six). These were all submitted after the implementation deadline (submitted to the relevant jurisdictions on 2/10/21, 2/12/21, and 6/4/21); therefore, they should have been evaluated against the 2018 WSEC code. TRC contacted the two relevant jurisdictions and asked if they instituted a grace period when implementing the new code but did not receive any responses.

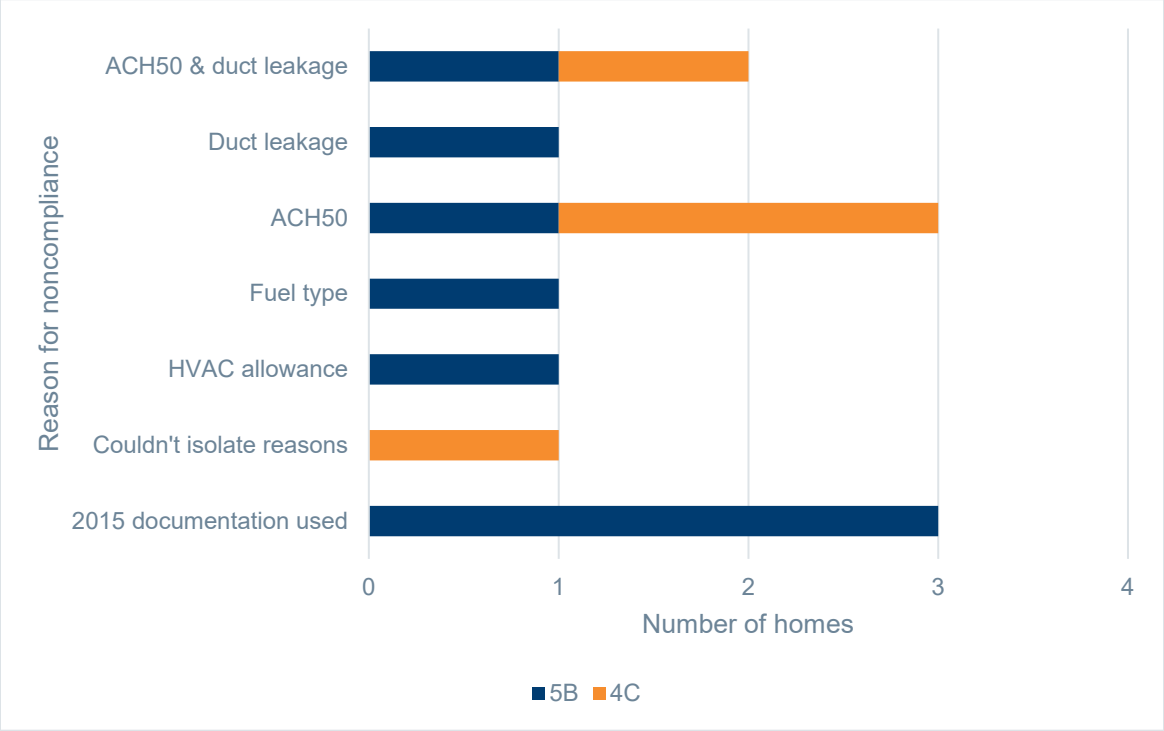
One home did not have complete permit information available, so TRC could not determine which credit(s) differed between the permit declarations and audit findings. However the home only earned a maximum of 3.5 credits given the categories confirmed in the audit and assuming the best case scenarios for the remaining credit categories that could not be verified (short of the 6 minimum credits). It is also possible that this home used the 2015 WSEC checklist to declare 3.5 credits for a medium home, despite its submission date of 3/8/21.

One of the noncompliant homes claimed a different fuel type for space heating and water heating compared to what was found in the audit. This home claimed a fuel normalization and HVAC credit for a heat pump, but it uses a gas furnace (credit 3.2 was claimed, and credit 3.1 was awarded with no fuel normalization credit). The water heater was also declared to be a heat pump water heater, but the audit found a gas water heater (credit 5.5 was claimed, and credit 5.3 was awarded). The home claimed credits in the envelope, air leakage and ventilation, HVAC distribution, and DWHR categories. TRC could not verify these credits in the audit, but we awarded these credits. We also awarded the appliance credit based on audit findings, although the credit was not claimed in the permit. However, the home was still short of compliance by two credits.

One of the noncompliant homes did not meet the required HSPF rating for the declared HVAC credit but would pass using the temporary efficiency reduction emergency ruling as described in Section 4.1.1. However, the home was sold in 2021, which was prior to the emergency ruling taking effect (in June 2022), so the home did not comply with the code at the time.

These results are presented by climate zone in Figure 9.

Figure 9. Reasons for Noncompliance by Climate Zone



Individual credits that are failed most often will be explored further in Section 4.4.

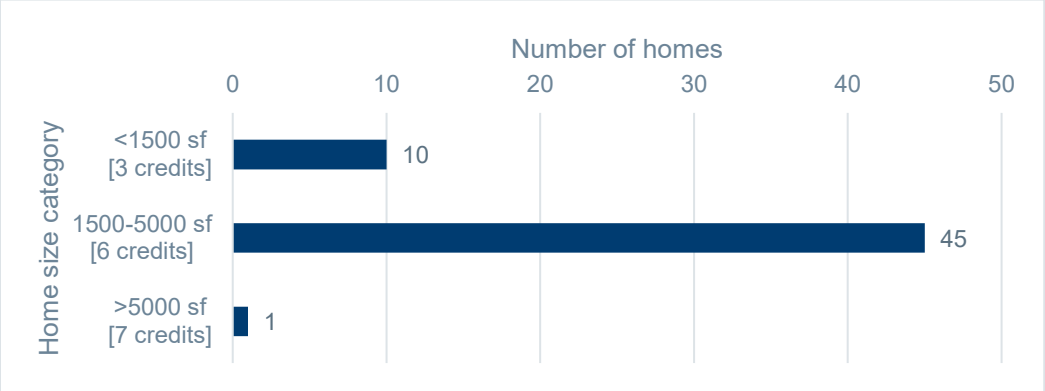
4.1.5 Credits Needed and Common Compliance Pathways

4.1.5.1 Home Size and Credits Needed

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 2018 WSEC.

Of 56 audited homes, 10 were small (18%), 45 were medium (85%), and 1 was large (2%), as shown in Figure 10.

Figure 10. Audited Homes by Size Category (n=56)



4.1.5.2 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 most common combinations of credits (described in Figure 11 below) contributed 41% of all the homes analyzed, which is the same result found in the Post-Code Adoption Market Research Study. Although this suggests conformity, the top six pathways represent 15 of the 37 homes determined to comply with the 2018 WSEC code, while the remaining 22 homes all used a unique combination of credits to determine compliance, for a total of 28 pathways. The 2015 WSEC code study[24] found that the top six pathways contributed 92% of the permits from 17 energy credits options. **The increase in the number of options and the required number of credits has diversified the approaches that builders use to comply with the energy code in Washington**.

Five of the most common pathways used electric space heating, while the sixth most common pathway used gas space heating. This sixth pathway combined gas primary heat with the following choices: triple pane 0.20 u-factor windows, 2.0 ACH50 air leakage, and ducts fully inside the thermal envelope. This is shown in Figure 11 below, along with the other most common pathways that utilize electric space heating. Heat pump water heaters appear in all of the most popular pathways regardless of space heating fuel type.

It should be noted that five of the top six most common pathways to energy credit compliance are all for medium size homes requiring six credits, which comprise 70% of the homes analyzed. The other common pathway is for a small size home requiring three credits, which comprise 27% of the homes in the data sample. Of the remaining pathways that were only used for one home in the sample, eight were for small homes, 13 were for medium homes, and one was for a large home. With only one large home requiring seven credits, or 3%, no conclusions could be made.

[24] https://neea.org/resources/2019-2020-washington-residential-new-construction-code-study

Figure 11. Most Common Pathways taken to Earn Energy Credits

Combination	Measure 1	Measure 2	Measure 3	Measure 4	Measure 5	Measure 6	Total Homes	Percent Contribution	Home Size
Option Combination A	FN 2	1.3	2.1	3.5	4.1	5.5	4	11%	Medium
Option Combination B	FN 2	1.3	2.3	3.2		5.5	3	8%	Medium
Option Combination C	FN 2			3.5		5.5	2	5%	Small
Option Combination D	FN 2	1.1	2.1	3.5	4.1	5.5	2	5%	Medium
Option Combination E	FN 2	1.3	2.1	3.2	4.2	5.6	2	5%	Medium
Option Combination F	FN 1	1.2	2.2	3.1	4.2	5.5	2	5%	Medium

FN 1= Gas primary heat
FN 2= Heat Pump primary heat
1.1= U=0.24 windows
1.2= U=0.20 windows
1.3=U=0.28 windows, Floor R-38
2.1=3.0 ACH50
2.2=2.0 ACH50
2.3=1.5 ACH50
3.1=Gas 95% AFUE
3.2=ASHP 9.5 HSPF
3.5=ASHP 11.0 HSPF
4.1=Deeply Buried
4.2=Ducts Inside
5.5= NEEA Tier III Heat Pump WH
5.6= Heat Pump WH 2.9 UEF

Where AFUE = annual fuel utilization efficiency, ASHP = air source heat pump, HSPF = heating seasonal performance factor, WH = water heater, and UEF = uniform energy factor

4.2 Fuel Choice

This section provides data on how new single-family homes in Washington are using different fuel types.

4.2.1 Space Heating and Water Heating

The 2018 WSEC provides a credit for electric space heating through a fuel normalization credit, and provides it credits for electric heat pumps used for water heating or space heating. This section provides audit results of fuel choice for those end uses.

Of 56 homes audited, 79% with a 90% confidence interval of +/- 9% used electric space heating as their primary space heating type. All of these were primarily served by heat pumps, although some also included secondary electric resistance heating, as described in Section 4.4.3. As shown in Figure 14, this proportion is similar to the proportion among the 37 code-compliant homes, of which 78% used electric space heating primarily; this difference is not statistically significant from audited homes as a whole. Of the 12 homes that did not comply with the 2018 WSEC, 75% used electric space heating primarily. There were also seven homes that were audited but for which compliance could not be determined because of lack of permit data; of these, 86% used electric space heating. There were not enough noncompliant homes to calculate whether the differences in electric space heating prevalence among code-compliant and noncompliant homes are statistically significant. The prevalence of electric space heating is also similar to results from the Residential Post-Code Adoption Market Research Study (88%), although the present research did find slightly more gas systems than the Post-Code Adoption Market Research Study, as shown in Figure 12.

Of the 44 audited homes with electric primary space heating, four (or 9%) were found to have a gas furnace as a backup or secondary system, which was not considered a primary heating source and is not reflected in Figure 12 or Figure 16. These secondary gas systems may have been undercounted, as gas backup systems are not always visible or easily noticed, and (when asked during the audits) residents often did not know whether they had a backup system.

Of 56 homes audited, 89% used electric water heating with a 90% confidence interval of +/- 7%. As shown in Figure 15, this proportion is similar to the proportion of the 37 code-compliant homes audited, of which 92% used electric water heating; this difference is not statistically significant from audited homes. Of the 12 homes that did not comply with the WSEC, 75% used electric water heating. Of the 7 homes that were audited but for which compliance could not be determined because of lack of permit data, 100% used electric water heating. There were not enough noncompliant homes to calculate whether the differences in electric water heating prevalence among code-compliant and noncompliant homes are statistically significant. The prevalence of electric water heating is also in line with the Residential Post-Code Adoption Market Research Study results from permit data (83%), although the audit data did find slightly more electric systems than the Post-Code Adoption Market Research Study, as shown in Figure 13.

Figure 12. Fuel Choice for Primary Space Heating

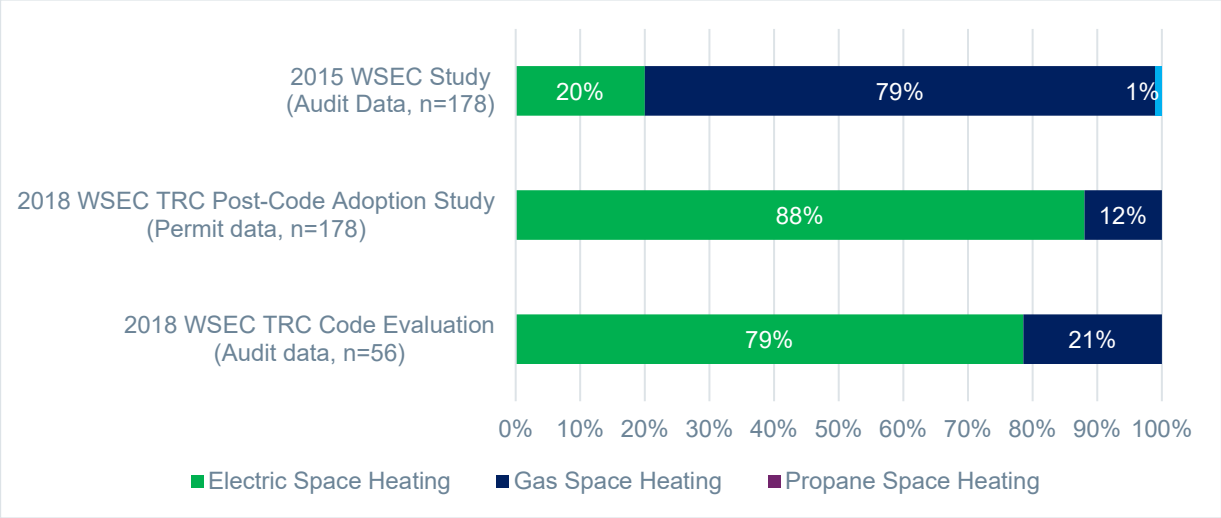


Figure 13. Fuel Choice for Water Heating

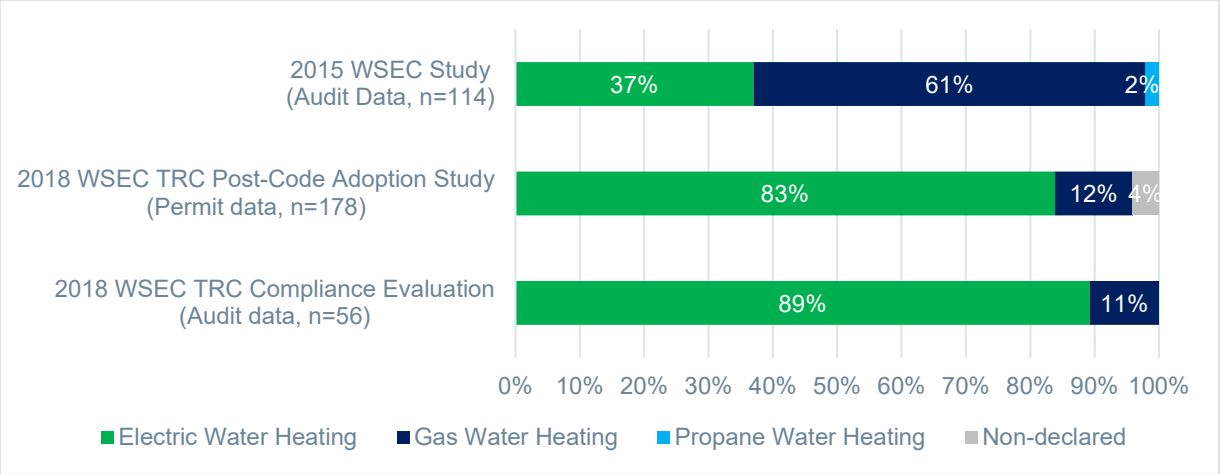


Figure 14. Primary Space Heating Fuel by WSEC Compliance

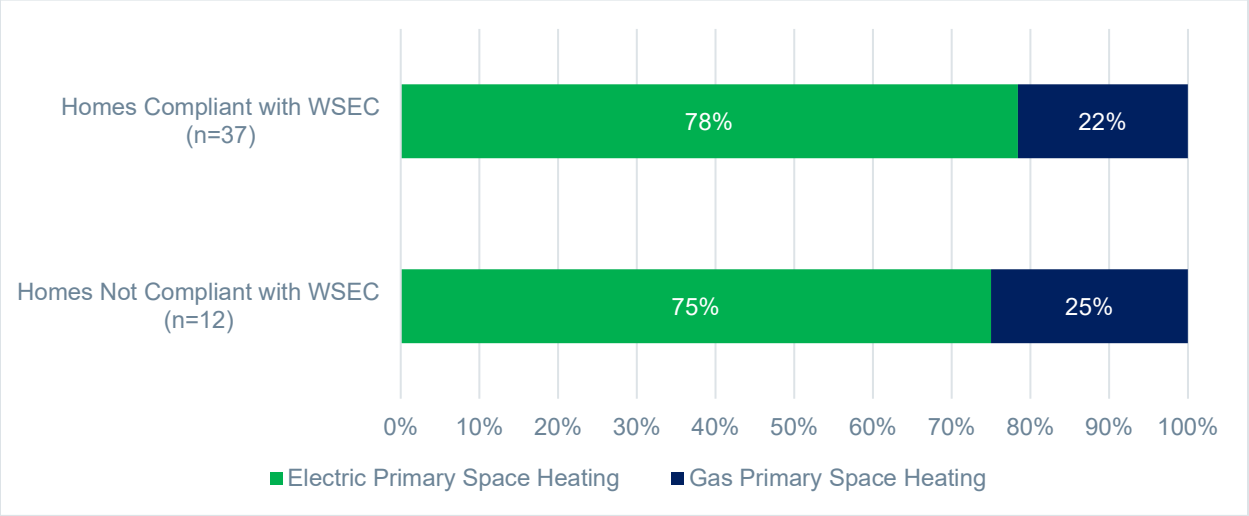
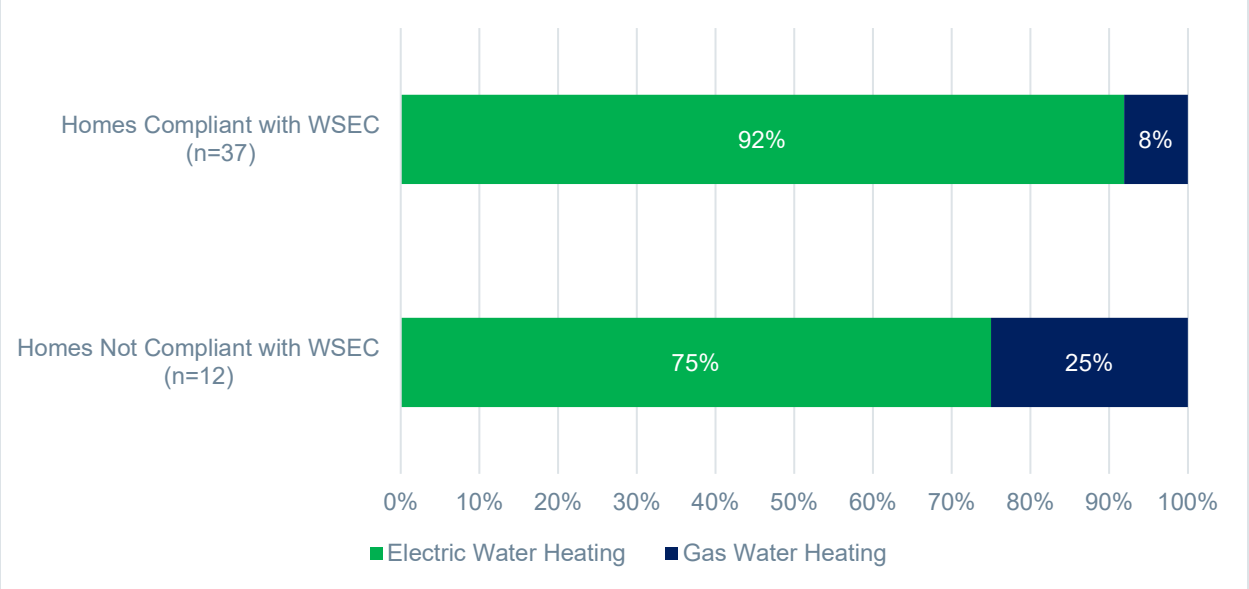


Figure 15. Water Heating Fuel by WSEC Compliance



As shown in Figure 16, homes audited in Climate Zone 4C had almost the same proportion of gas primary space heating (22%) compared to those in Climate Zone 5B (21%). As shown in Figure 17, homes audited in 5B had a higher proportion of gas water heating (17%) than those in 4C (6%), although the difference is not statistically significant.

Figure 16. Primary Space Heating Fuel by Climate Zone

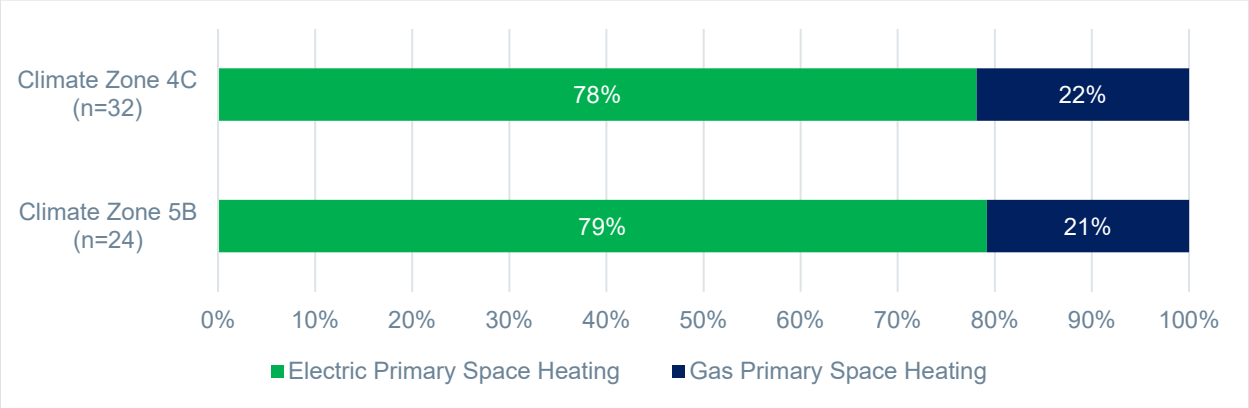
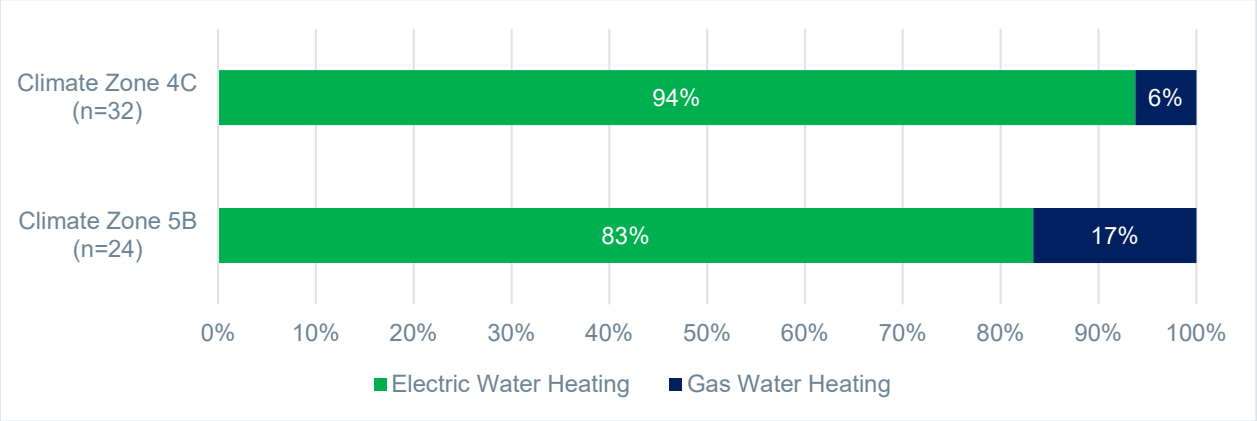


Figure 17. Water Heating Fuel by Climate Zone



As shown in Figure 18, high construction volume jurisdictions had a lower proportion of electric primary space heating than medium or low construction volume jurisdictions. High construction volume jurisdictions also had the lowest proportion of electric water heating, as shown in Figure 19, although the difference was not as great as with space heating.

Figure 18. Primary Space Heating Fuel by Jurisdiction Volume

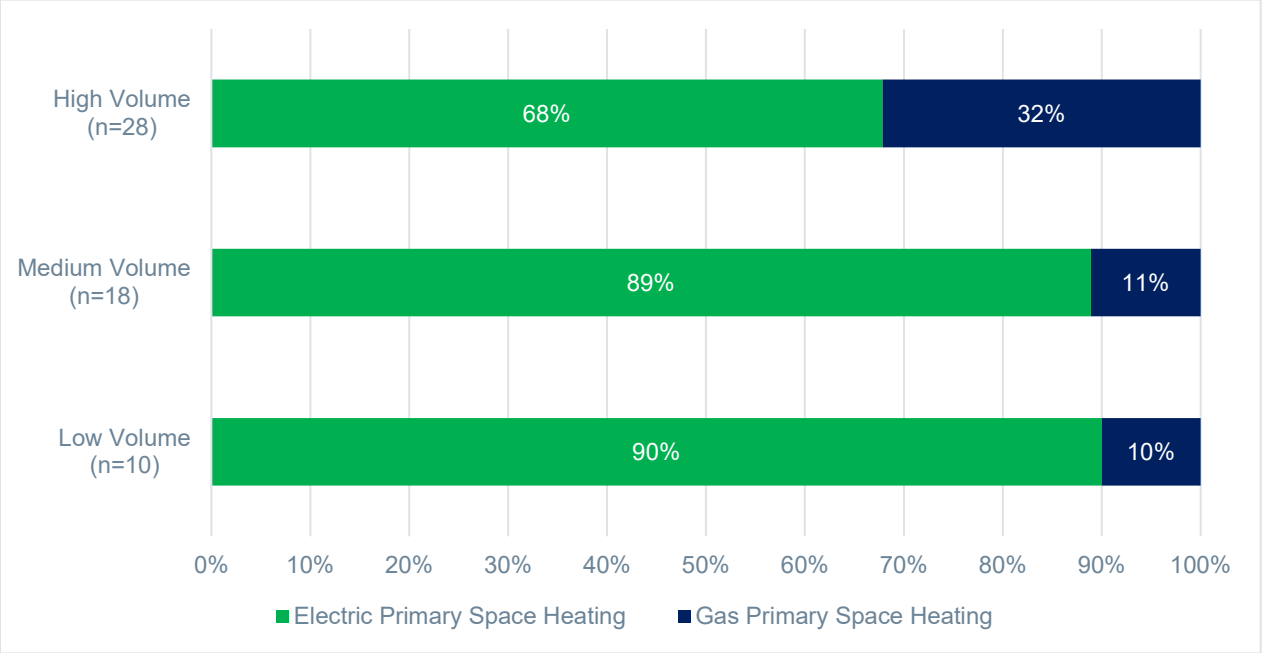
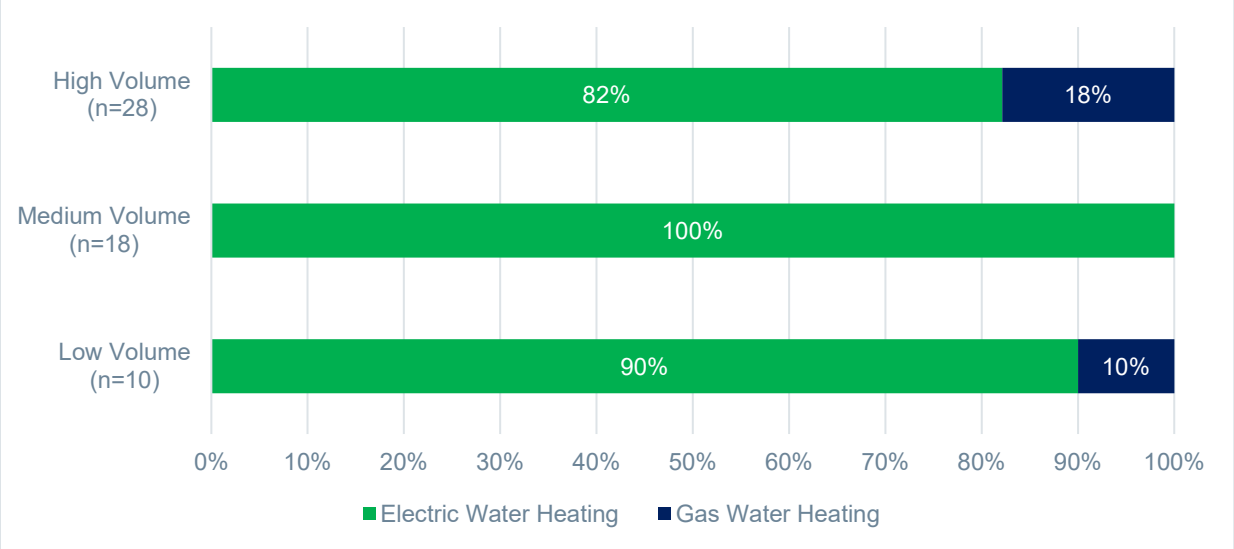


Figure 19. Water Heating Fuel by Jurisdiction Volume



4.2.2 Other Uses of Natural Gas

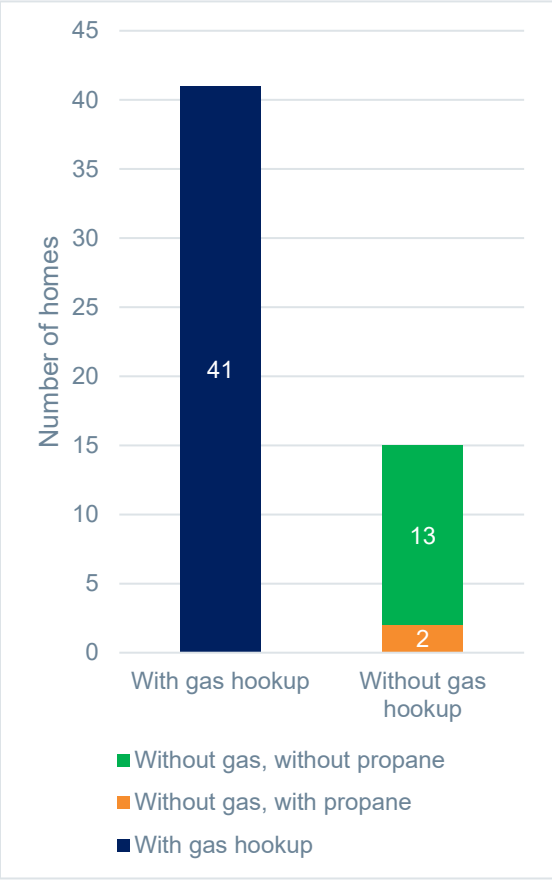
This section shows the prevalence of a gas hookup and (for those with a hookup) other appliances that were found to use natural gas in homes.

Seventy-three percent of audited homes, or 41 homes, had a gas hookup. Of these, one was an all-electric home with no gas appliances found in the audit but with a visible gas meter.

Additionally, two homes without a natural gas hookup used propane in some capacity, as shown in Figure 20.

In Climate Zone 4C, 81% of homes (26 of 32) had a gas hookup, while in Climate Zone 5B, only 63% (15 of 24) did. This difference is not statistically significant at the 10% precision level.[25]

Figure 20. Audited Homes with and without Natural Gas Hookup (n=56)



A detailed look at the homes with a gas hookup and the number of natural gas uses in each home is shown in Figure 21. Most homes with a gas hookup had only two documented gas uses[26]; these homes are shown in more detail in Figure 16. Among homes with a gas hookup:

- A total of 39 homes, or 70% of homes audited, had a natural gas range (stove). This was 95% of homes with a gas hookup.
- A total of 28 homes, or 50% of homes audited, had a natural gas fireplace or hearth. This was 63% of homes with a gas hookup.
- A total of eight homes, or 14% of homes audited, had an outdoor natural gas tap, two of which were currently being used with a barbecue. This may have been undercounted, as

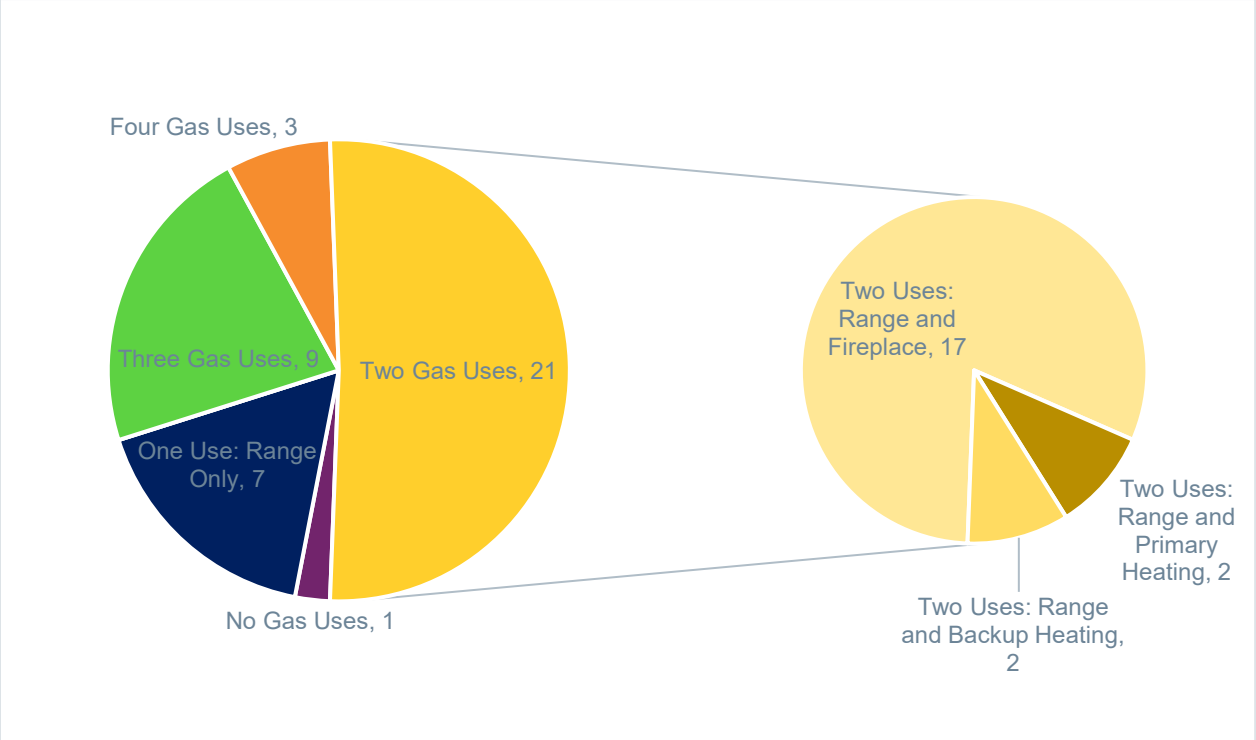
[25] The t-statistic is 1.55 and it would need to be 1.681. The p-value is 0.127 and it would need to be below 0.10 to be significant at the 10% level with 90% confidence.

[26] This does not include barbeque taps, since TRC added a question midway through data collection on these taps.

the audit team added a more explicit question regarding these taps midway through data collection, after recognizing their prevalence. Because this study did not track barbeque taps consistently, they are not included in the gas uses shown in Figure 21.

- No homes audited had a gas clothes dryer, gas pool heater, or gas spa heater.
- As shown in Figure 21, of the 41 homes with a gas hookup, 17 homes (46%) used it only for their range and one or more fireplaces, and 8 homes (17%) used the gas only for their range.

Figure 21. Audited Homes with Gas Hookup, by Number and Type of Gas Uses (n=41)



4.3 Confidence and Precision of Results

Table 10 below summarizes the compliance and fuel type results from audit homes, along with the calculated rates and precision estimates at 90% confidence. The “Result” column is a fraction where the numerator indicates how many homes met the designation in the first set of columns, and the denominator is the total number of homes where TRC had data to evaluate this question. Using the first row as an example: 37 homes compiled with the code statewide out of the 49 homes evaluated for compliance. As shown in the “Absolute Precision” column, TRC achieved 10% precision or better (at the 90% confidence level) for Statewide Compliance and space heating fuel type for compliant homes. TRC had less precision for groups where TRC had fewer homes in each category.

Table 10. Audit Results with Precision Estimates[27]

	Category	Result	Rate	Absolute Precision	CI* Lower Limit	CI Upper Limit
Code Compliance	Statewide	37/49	76%	10%	65%	86%
	Climate Zone 5B	16/24	67%	16%	50%	83%
	Climate Zone 4C	21/25	84%	13%	71%	97%
	Low volume	8/10	80%	23%	57%	100%
	Medium volume	10/14	71%	21%	50%	93%
	High volume	19/25	76%	15%	61%	91%
Space heating fuel type	Electric	44/56	79%	9%	69%	88%
	Gas	12/56	21%	9%	12%	31%
Space heating fuel type – compliant homes	Electric	29/37	78%	11%	67%	90%
	Gas	8/37	22%	11%	10%	33%
Water heating fuel type	Electric	50/56	89%	7%	82%	96%
	Gas	6/56	11%	7%	4%	18%
Water heating fuel type – compliant homes	Electric	34/37	92%	8%	84%	99%
	Gas	3/37	8%	8%	1%	16%

*CI = confidence interval

4.4 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 is discussed first, followed by a comparison to the audit results, when applicable. TRC views the audit data as more accurate, because it represents actual (installed) conditions.

4.4.1 Efficient Building Envelope Options

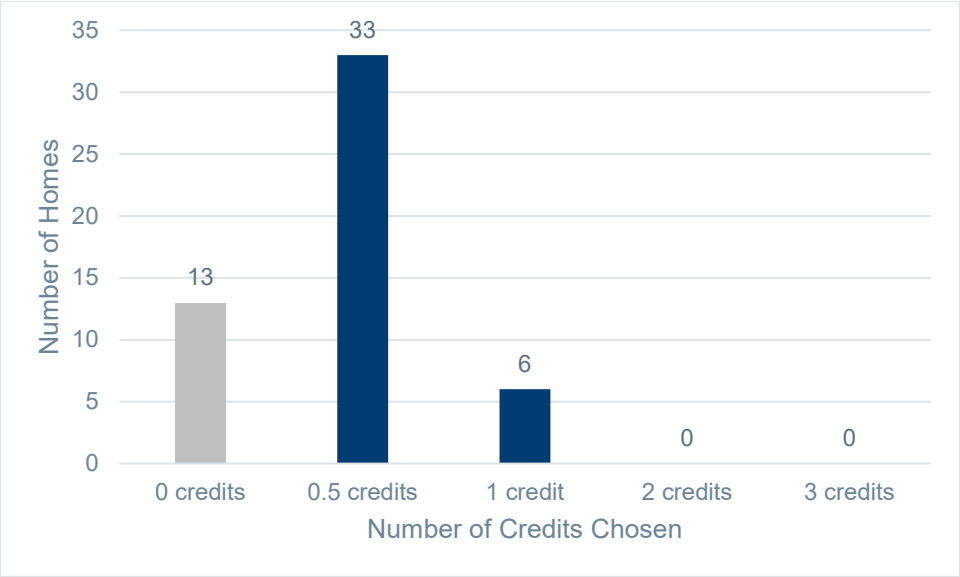
This category offers builders options to improve the envelope of a home beyond the prescriptive requirements. This includes more efficient windows, walls, floors, attics, raised heel trusses, and advanced framing. Fenestration products have a U-value, where a lower U-value means less heat passes through the product. Similarly, insulation products and envelope assemblies have an R-value, where a higher R-value means less heat passes through the product. Envelope products are not visible once the home is completed, because drywall hides insulation and builders remove window stickers prior to home sale. Consequently, data in this section is based on permits.

[27] The confidence interval for all calculations in this table is 90%.

Builders can only choose one selection in this category. As shown below, for efficient building envelopes, most builders (63%) are choosing a slight improvement worth 0.5 energy credits and are avoiding exterior continuous insulation.

For homes with applicable permit data (n=52), the mean number of credits was 0.43 for this category, with the most popular option being 0.5 credits, as shown in Figure 22.

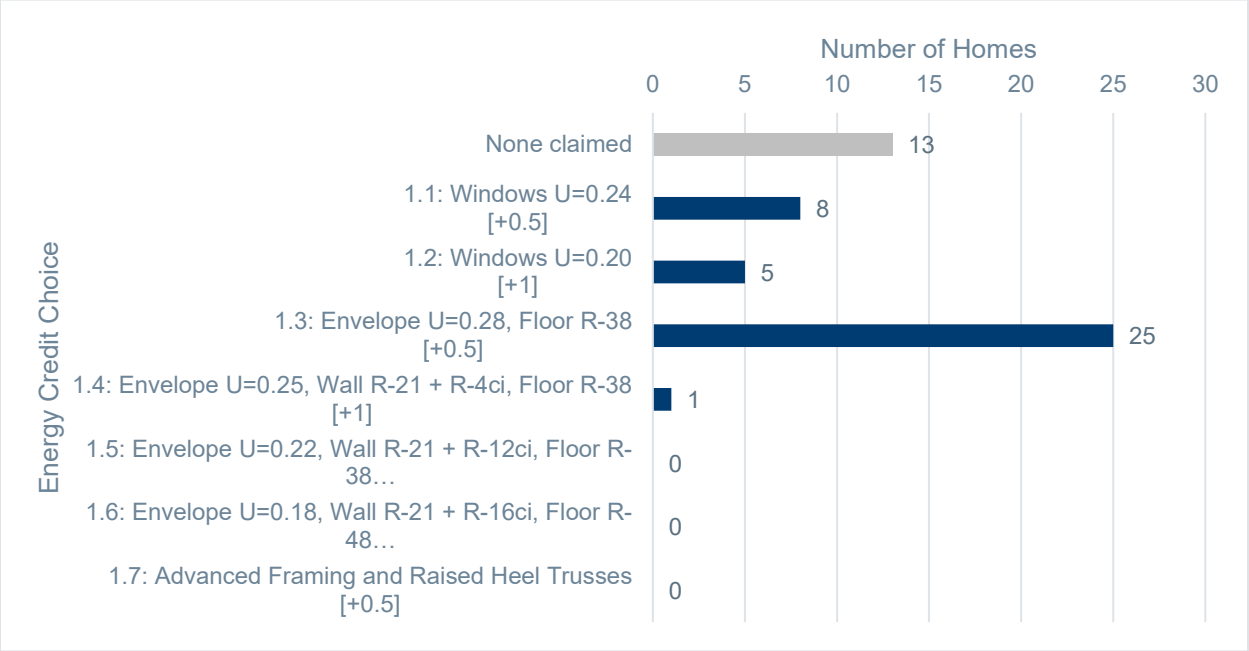
Figure 22. Number of Envelope Credits Chosen (n=52)



More detail on specific envelope credit options chosen is shown in Figure 23. The most common 0.5-credit option, and also the most common option overall, was credit option 1.3, which requires one of the following two sets of requirements:

- Vertical fenestration U = 0.28, Floor R-38, and R-10 perimeter and under entire slab for a slab on grade foundation, or
- Compliance based on Section R402.1.4: Reduce the total conductive UA by 5%.

Figure 23. Envelope Credit Options Claimed (n=52)



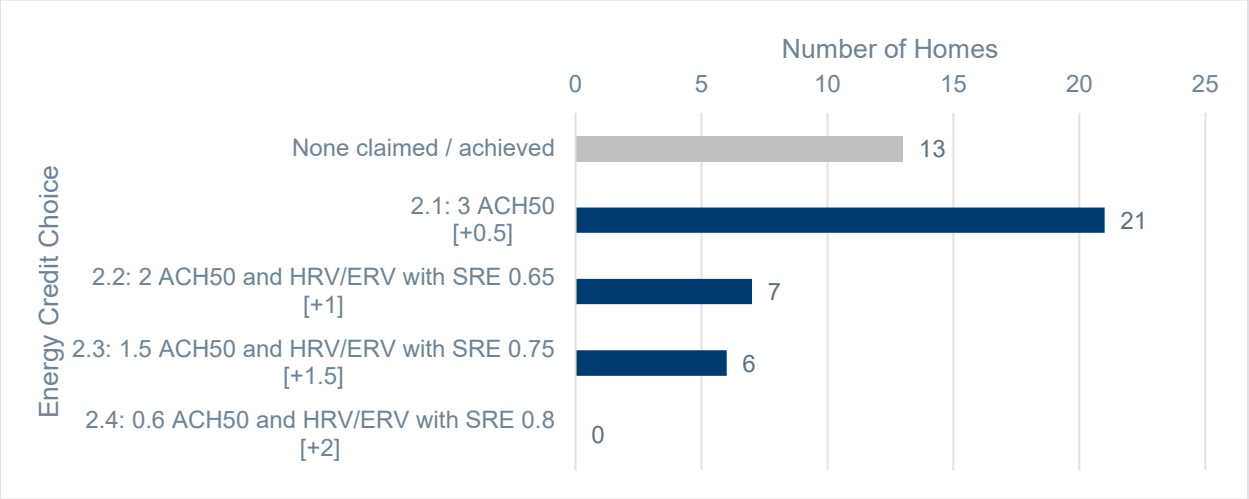
4.4.2 Air Leakage Control and Efficient Ventilation Options

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. Air leakage is measured with a blower door test and expressed as air changes per hour at 50 Pascals (ACH50). Air leakage tighter than three ACH50 requires an HRV. To gather data for this credit, TRC used air leakage test-out values if the resident was able to locate a compliance certificate with this value, and asked the resident if they were aware of their ventilation system type. If either data point was not available using these methods, TRC used permit data.

As shown in Figure 24, almost half of builders (43%) pursued the lowest credit option (0.5 credits) for air leakage control and ventilation, which requires 3.0 ACH50 and no HRV.

- Of homes with applicable permit and/or audit data (n=53), audit data was used for the 27 homes (51%) where infiltration testing results and/or ventilation information was found during the audit.
- For these 53 homes, the mean number of credits was 0.52 for this category, with the most popular option being option 2.1, worth 0.5 credits, as shown in Figure 24. This option requires tested air leakage to be a maximum of 3.0 ACH50.
- One-quarter (28%) of homes pursued credit 2.2 or 2.3, which requires a tighter envelope (1.5 or 2 ACH50) and an HRV. The remaining one-quarter (28%) did not pursue any credits in this category.

Figure 24. Air Leakage and Ventilation Options Claimed or Achieved (n=46)*



*** Figure 24 uses "claimed" to refer to credit results based on permits, and "achieved" to refer to credit results based on compliance certificates found in the audits.**

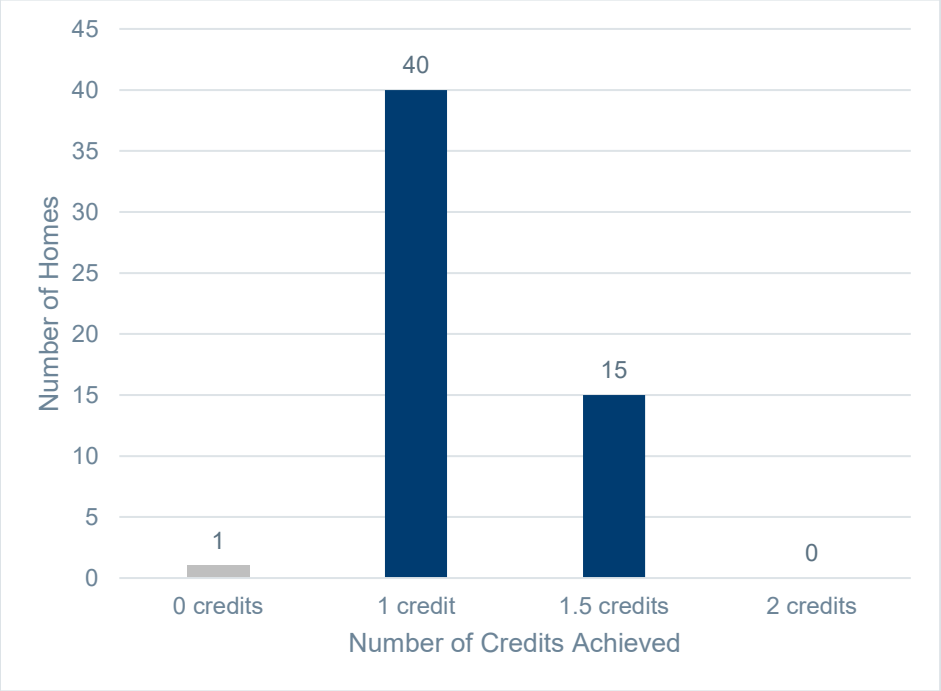
4.4.3 High Efficiency HVAC and HVAC Distribution System Options

This section provides findings for two related 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. TRC gathered data for the HVAC system credits from audits. Data for the HVAC distribution credits are primarily based on permit data unless the home was pursuing tight ducts and the resident was able to locate a compliance certificate with the duct leakage test-out value.

As shown below, all but one home (98%) installed high-efficiency HVAC equipment, and approximately half of homes are earning credits for an efficient HVAC distribution system.

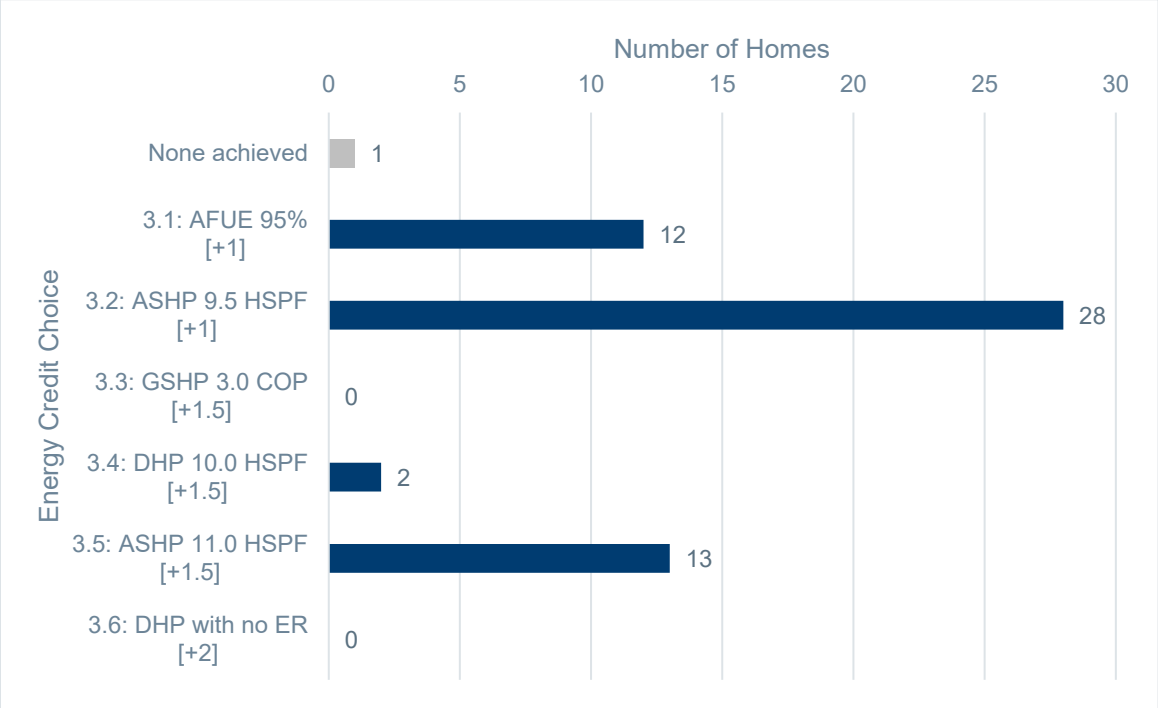
Of 56 audited homes, the mean credits earned for High Efficiency HVAC was 1.12 points. Most commonly, one point was achieved as shown in Figure 25.

Figure 25. Number of High Efficiency HVAC Credits Achieved (n=56)



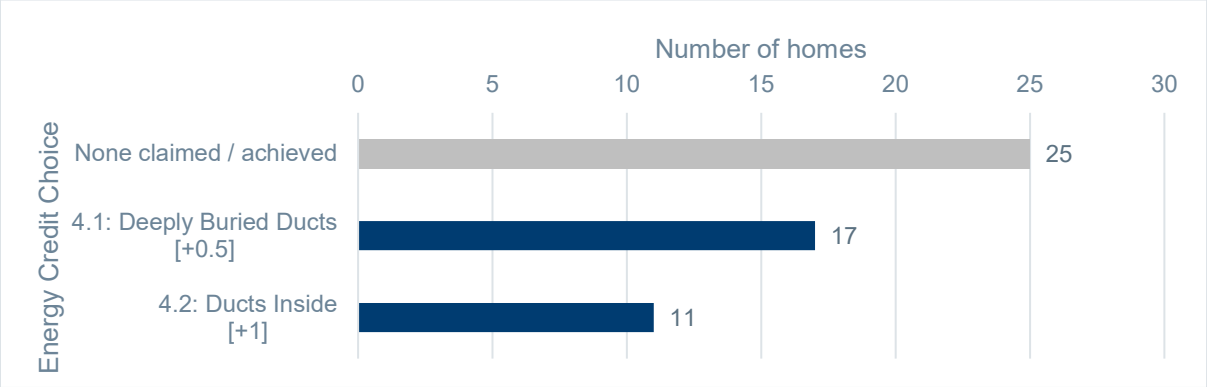
As shown in Figure 26, the more common of the two 1-credit options for High Efficiency HVAC, and the most commonly achieved credit option overall, was option 3.2, which requires an air-source centrally ducted heat pump with minimum HSPF of 9.5.

Figure 26. High Efficiency HVAC Credits Achieved (n=56)



- For the HVAC Distribution credit category, of homes with applicable permit and/or audit data (n=53), audit data was used for the 20 homes (38%) where documented duct leakage testing results were found during the audit. For the remaining 33 homes, permit data was used to evaluate this credit category.
- For these 53 homes, the mean number of credits was 0.37 for this category, with 25 of 53 homes (47%) having no option chosen or achieved. As shown in Figure 27, the most common option worth credits was option 4.1 (0.5 credits), which requires deeply buried ducts and a maximum amount of tested duct leakage.

Figure 27. Efficient HVAC Distribution Credits Achieved (n=53)



4.4.4 Efficient Water Heating and DWHR

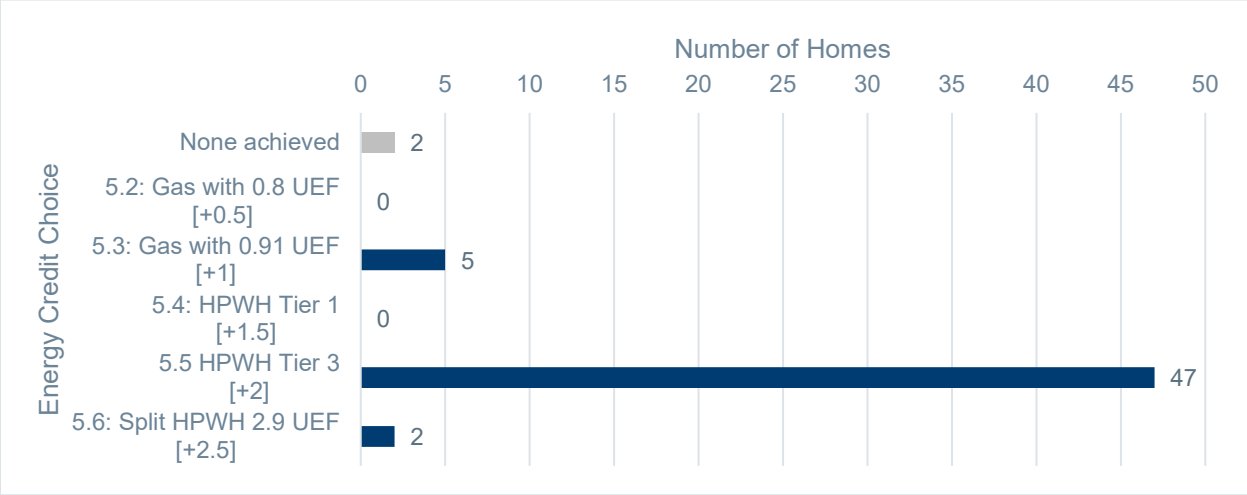
2018 WSEC offers energy credits regarding efficient water heating for any fuel type. It is the only category that allows more than one response; builders can combine the DWHR option with any one of the other options. DWHR is a device that captures heat from warm water drainpipes and utilizes that heat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

As shown below, 96% of homes earned credits for efficient water heating, but only 9% of homes earned the DWHR credit.

Of 56 audited homes, the mean number of credits achieved for Efficient Water Heating was 1.86. As shown in Figure 28, the most commonly achieved credit option by far was 5.5, worth two credits, achieved by 84% of homes. This option requires an electric heat pump water heater meeting NEEA's Tier 3 standards. Note that while Tier 3 heat pump water heaters require "minimal use of resistance heating elements," they can still utilize some electric resistance water heating as a backup, which is less efficient than heat pump water heating.[28] A minority of homes had gas water heaters, but those systems typically earned one credit for having a Unit Energy Factor (UEF) of 0.91 or higher.

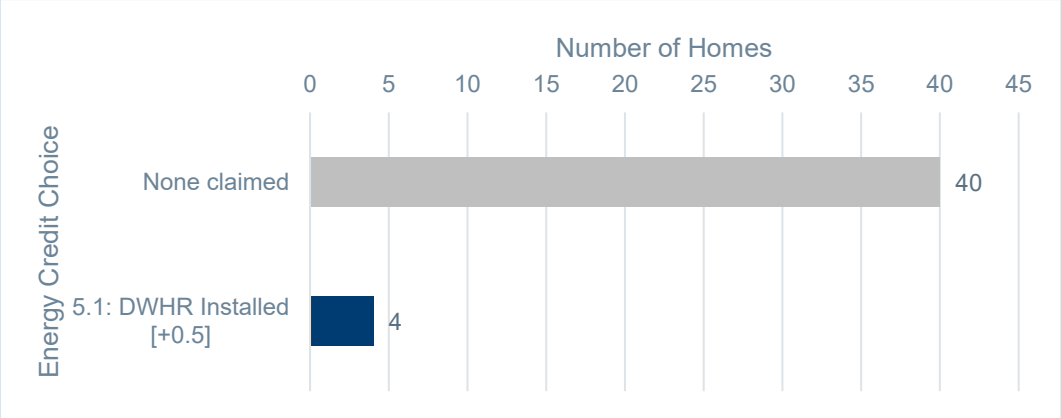
[28] Northwest Energy Efficiency Alliance, March 1, 2022, A Specification for Residential, Commercial – Multifamily, and Industrial Water Heaters and Heating Systems - Advanced Water Heating Specifications - Version 8.0, https://neea.org/img/documents/Advanced-Water-Heating-Specification.pdf

Figure 28. Efficient Water Heating Credits Achieved (n=56)



Of 44 homes with applicable permit data, only four homes (9%) claimed the DHWR credit option worth 0.5 credits, as shown in Figure 29.

Figure 29. DWHR Credits Achieved (n=56)



4.4.5 Renewable Electric Energy Options

The renewable energy category for 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. For data collection for this credit category, TRC asked the resident if they had a renewable energy system, such as solar PV system. If so, TRC used the number of credits claimed in the permit for this credit category.

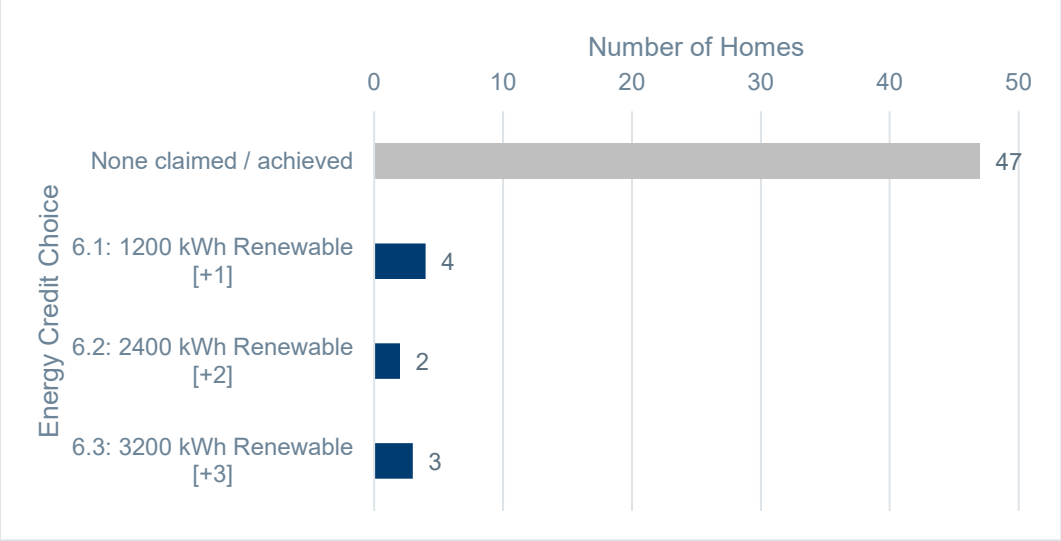
As shown below, a minority of homes (16%) have a renewable energy system (solar PV).

Of 56 audited homes, the mean number of credits achieved for Renewable Electric Energy was 0.30. As shown in Figure 30, 47 homes (84%) did not have a renewable energy system. All nine

homes that achieved credits in this category did so through a solar PV system (solar PV), as opposed to wind.

Homes with gas furnaces were more likely to achieve credits in this category. Of the 12 homes found to have a gas furnace through audits, four of them (33%) achieved credits in the renewable energy category with the presence of solar PV, close to three times the proportion of homes primarily served by heat pump HVAC systems that had solar PV (11%).

Figure 30. Renewable Electric Energy Credits Achieved (n=56)



4.4.6 Appliance Package Options

The final category of energy credits allows 0.5 energy credits for new ENERGY STAR appliances. To claim the credit, the following four ENERGY STAR appliances must be installed: dishwasher, refrigerator, washing machine, and clothes dryer. In addition, the dryer is required to be a ventless dryer with a minimum combined energy factor (CEF) rating of 5.2. This is a very high CEF rating that most dryers do not meet. While a heat pump dryer is capable of achieving this CEF, many dryers that use traditional heating technologies, including many ENERGY STAR rated dryers, have a CEF lower than 5.2. TRC used audit data to verify this credit by capturing equipment plates of each appliance and looking up specifications.

As shown below, very few builders install ENERGY STAR appliance packages for energy credits.

- Of the 44 homes with permit data, two claimed the appliance package credit option, but audit data showed that neither of these actually achieved the requirements of this credit option. However, another home that did not claim this credit did achieve all of the requirements with the necessary appliances, as shown in Figure 31. Of the 56 homes audited, this was the only home with a dryer that met the CEF requirements.
- Many audited homes met the credit requirements for their refrigerator, dishwasher, and clothes washer but did not meet the efficiency requirements for the clothes dryer.

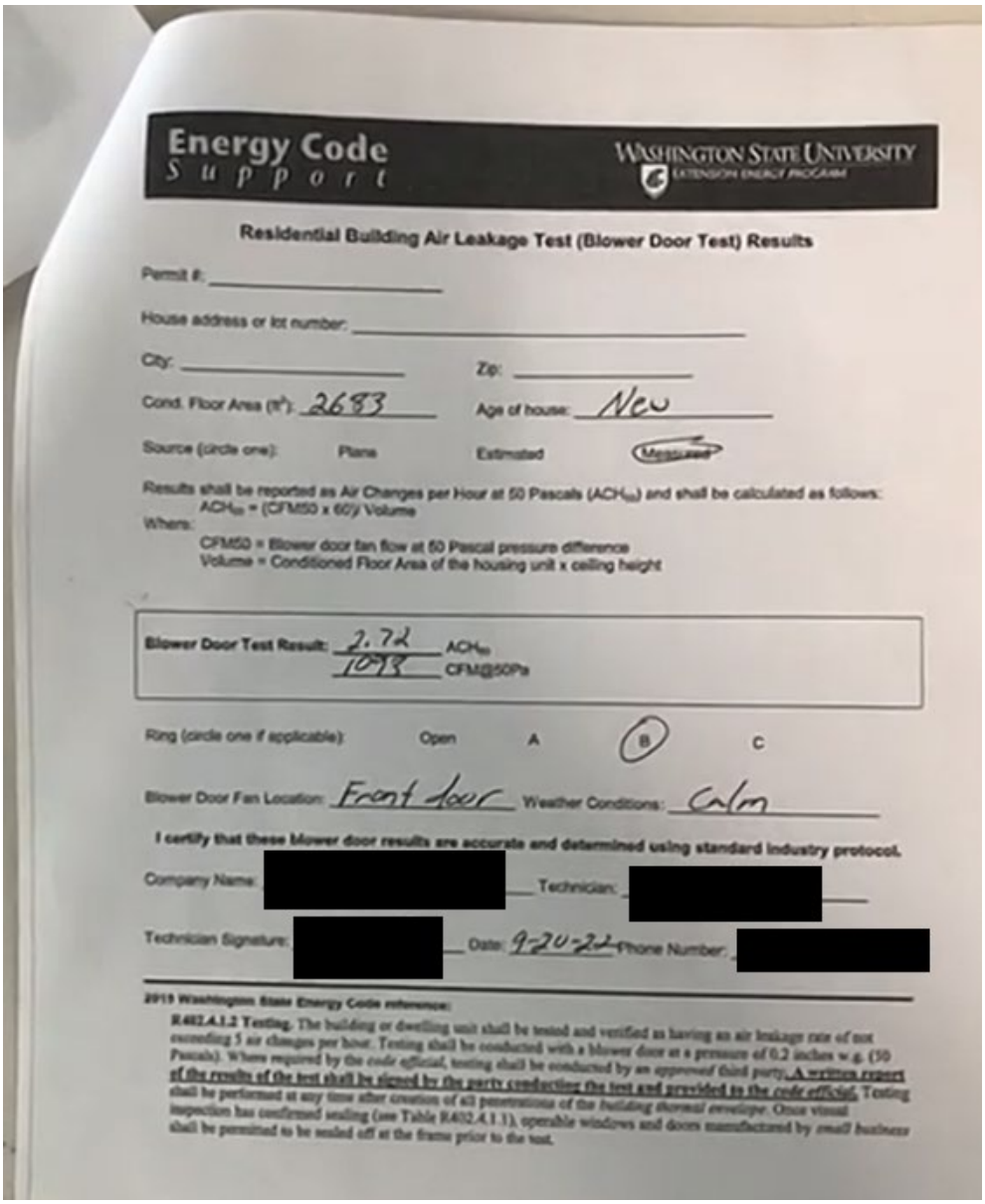
Figure 31. Appliance Package Energy Credits Achieved (n=56)

4.5 Compliance Certificate Findings

Builders are required by code to post a permanent compliance certificate in the new home, showing that the home meets the 2018 WSEC. However, compliance with this requirement does not affect the 2018 WSEC compliance credit calculation. Among the required certificate details are the home's envelope air leakage test-out (post-construction) results as well as any duct testing required, insulation values, and other mechanical aspects of the home. To assist with this step, the Washington State University Extension program has developed a one-page worksheet that builders can provide to residents.

Of 56 audited homes, the TRC auditor was able to work with the resident to locate some type of compliance documentation in 34 (61%) of the homes through the audit. This includes all homes with any type of compliance documentation found, including homes that only had building blower door test results or duct air leakage test results, but many other blank fields. The blower door and duct leakage results were sometimes posted on air handlers or were found in house manual binders. Figure 32 shows an example of a building air leakage test (blower door test) form found through a home audit.

Figure 32. Residential Building Air Leakage Test Example



Energy Code Support

WASHINGTON STATE UNIVERSITY
EXTENSION ENERGY PROGRAM

Residential Building Air Leakage Test (Blower Door Test) Results

Permit #: _____

House address or lot number: _____

City: _____ Zip: _____

Cond. Floor Area (ft²): 2683 Age of house: New

Source (circle one): Plans Estimated Measured

Results shall be reported as Air Changes per Hour at 50 Pascals (ACH_{50}) and shall be calculated as follows:
ACH_{50} = (CFM50 x 60)/ Volume
Where:
CFM50 = Blower door fan flow at 50 Pascal pressure difference
Volume = Conditioned Floor Area of the housing unit x ceiling height

Blower Door Test Result: 2.72 ACH_{50}
1093 CFM@50Pa

Ring (circle one if applicable): Open A (B) C

Blower Door Fan Location: Front door Weather Conditions: Calm

I certify that these blower door results are accurate and determined using standard industry protocol.

Company Name: [redacted] Technician: [redacted]

Technician Signature: [redacted] Date: 9-20-22 Phone Number: [redacted]

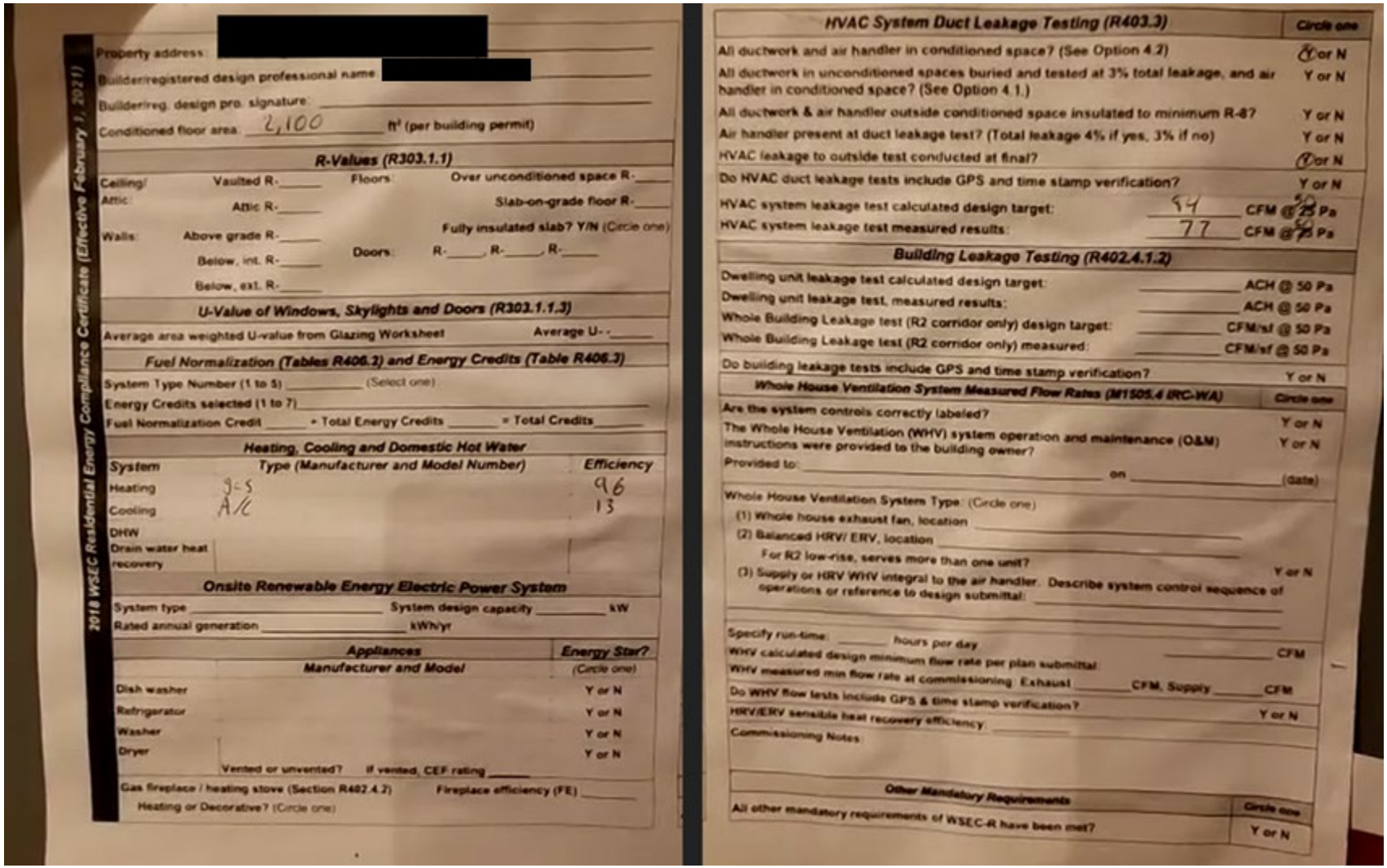
2015 Washington State Energy Code reference:

R402.4.1.2 Testing. The building or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding 5 air changes per hour. Testing shall be conducted with a blower door at a pressure of 0.2 inches w.g. (50 Pascals). Where required by the *code official*, testing shall be conducted by an *approved* third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the *code official*. Testing shall be performed at any time after creation of all penetrations of the *building thermal envelope*. Once visual inspection has confirmed sealing (see Table R402.4.1.1), openable windows and doors manufactured by *small business* shall be permitted to be sealed off at the frame prior to the test.

Compliance certificates were inconsistently formatted and displayed in homes where they were found. Some 2015 Compliance Certificate forms were used and posted in the home when the permit was issued using the 2018 requirements. At least one audit for a 2018 WSEC permitted home revealed a displayed builder's compliance form based on the 2012 WSEC Compliance Certificate.

Figure 33 shows an example of the 2018 WSEC Residential Energy Code Compliance Certificate, which were sometimes found taped to a wall, affixed to the electrical panel, or among home permit documents in a binder. Some compliance certificates were not complete, even though the home was compliant, as was the case for the certificate shown in Figure 33.

Figure 33. Example of 2018 WSEC Residential Energy Compliance Certificate, Incomplete



2018 WSEC Residential Energy Compliance Certificate (Effective February 1, 2021)

Property address: [redacted]

Builder/registered design professional name: [redacted]

Builder/reg. design pro. signature: _____

Conditioned floor area: 2,100 ft² (per building permit)

R-Values (R303.1.1)

Ceiling/ Attic:	Vaulted R-_____	Floors:	Over unconditioned space R-_____
	Attic R-_____		Slab-on-grade floor R-_____
Walls:	Above grade R-_____		Fully insulated slab? Y/N (Circle one)
	Below, int. R-_____	Doors:	R-_____, R-_____, R-_____
	Below, ext. R-_____		

U-Value of Windows, Skylights and Doors (R303.1.1.3)

Average area weighted U-value from Glazing Worksheet: Average U- -_____

Fuel Normalization (Tables R406.2) and Energy Credits (Table R406.3)

System Type Number (1 to 5) _____ (Select one)

Energy Credits selected (1 to 7) _____

Fuel Normalization Credit _____ + Total Energy Credits _____ = Total Credits _____

Heating, Cooling and Domestic Hot Water

System	Type (Manufacturer and Model Number)	Efficiency
Heating	GFS	96
Cooling	A/C	13
DHW		
Drain water heat recovery		

Onsite Renewable Energy Electric Power System

System type _____ System design capacity _____ kW

Rated annual generation _____ kWh/yr

Appliances	Manufacturer and Model	Energy Star? (Circle one)
Dish washer		Y or N
Refrigerator		Y or N
Washer		Y or N
Dryer		Y or N
	Vented or unvented? If vented, CEF rating _____	

Gas fireplace / heating stove (Section R402.4.2) Fireplace efficiency (FE) _____

Heating or Decorative? (Circle one)

HVAC System Duct Leakage Testing (R403.3) — Circle one

All ductwork and air handler in conditioned space? (See Option 4.2)	Y or N
All ductwork in unconditioned spaces buried and tested at 3% total leakage, and air handler in conditioned space? (See Option 4.1.)	Y or N
All ductwork & air handler outside conditioned space insulated to minimum R-8?	Y or N
Air handler present at duct leakage test? (Total leakage 4% if yes, 3% if no)	Y or N
HVAC leakage to outside test conducted at final?	Y or N
Do HVAC duct leakage tests include GPS and time stamp verification?	Y or N
HVAC system leakage test calculated design target: 94	CFM @ 25 Pa
HVAC system leakage test measured results: 77	CFM @ 25 Pa

Building Leakage Testing (R402.4.1.2)

Dwelling unit leakage test calculated design target: _____	ACH @ 50 Pa
Dwelling unit leakage test, measured results: _____	ACH @ 50 Pa
Whole Building Leakage test (R2 corridor only) design target: _____	CFM/sf @ 50 Pa
Whole Building Leakage test (R2 corridor only) measured: _____	CFM/sf @ 50 Pa
Do building leakage tests include GPS and time stamp verification?	Y or N

Whole House Ventilation System Measured Flow Rates (M1505.4 IRC-WA) — Circle one

Are the system controls correctly labeled?	Y or N
The Whole House Ventilation (WHV) system operation and maintenance (O&M) instructions were provided to the building owner?	Y or N

Provided to: _____ on _____ (date)

Whole House Ventilation System Type: (Circle one)

(1) Whole house exhaust fan, location _____

(2) Balanced HRV/ ERV, location _____

For R2 low-rise, serves more than one unit? Y or N

(3) Supply or HRV WHV integral to the air handler. Describe system control sequence of operations or reference to design submittal: _____

Specify run-time: _____ hours per day

WHV calculated design minimum flow rate per plan submittal: _____ CFM

WHV measured min flow rate at commissioning: Exhaust _____ CFM, Supply _____ CFM

Do WHV flow tests include GPS & time stamp verification? Y or N

HRV/ERV sensible heat recovery efficiency: _____

Commissioning Notes:

Other Mandatory Requirements — Circle one

All other mandatory requirements of WSEC-R have been met?	Y or N

Although incomplete, the compliance documentation that TRC could find was helpful in determining compliance for some credit categories, and some indicated noncompliance. In particular, some of this compliance documentation indicated that the home did not meet the air leakage or duct leakage (HVAC distribution) credits that were claimed in the permit declarations, which was the most common reason some homes did not comply with the 2018 WSEC.

4.6 Permit Representativeness of As-built Conditions

In addition to evaluating the most common credit choices, TRC looked at each permit category individually to see how well permits represent built conditions. The level of detail available varied for each category, as discussed below.

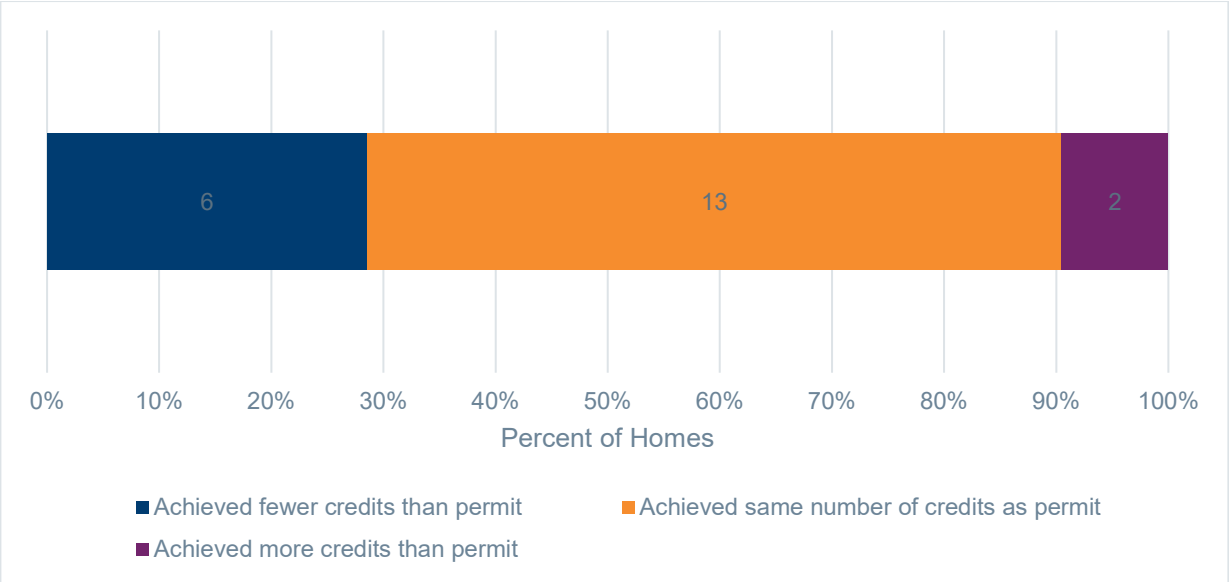
The envelope and DWHR categories were not evaluated, because as-built data was not available from the virtual audits for those credits. Information on the comparisons for fuel normalization are included in the space heating section.

In general, TRC found that the permits generally represented the installed condition found in virtual audits for appliances and other equipment. However, as described below, 29% of the post-construction whole house leakage results found in on-site compliance documentation showed leakier homes than pre-construction permit declarations. TRC finds that permits are a reasonable proxy for installed equipment but recommends that NEEA require verification of any field test results in future code evaluation studies.

4.6.1 Air Leakage Control

When analyzing the credits in the air leakage and ventilation category, TRC focused on the air leakage test results and did not consider the ventilation information, as this was self-reported by the residents and was not consistently known. TRC was able to obtain ACH50 test results and permit declarations for 21 homes and found that 71% of these homes met or exceeded the permit declarations, as shown in Figure 34.

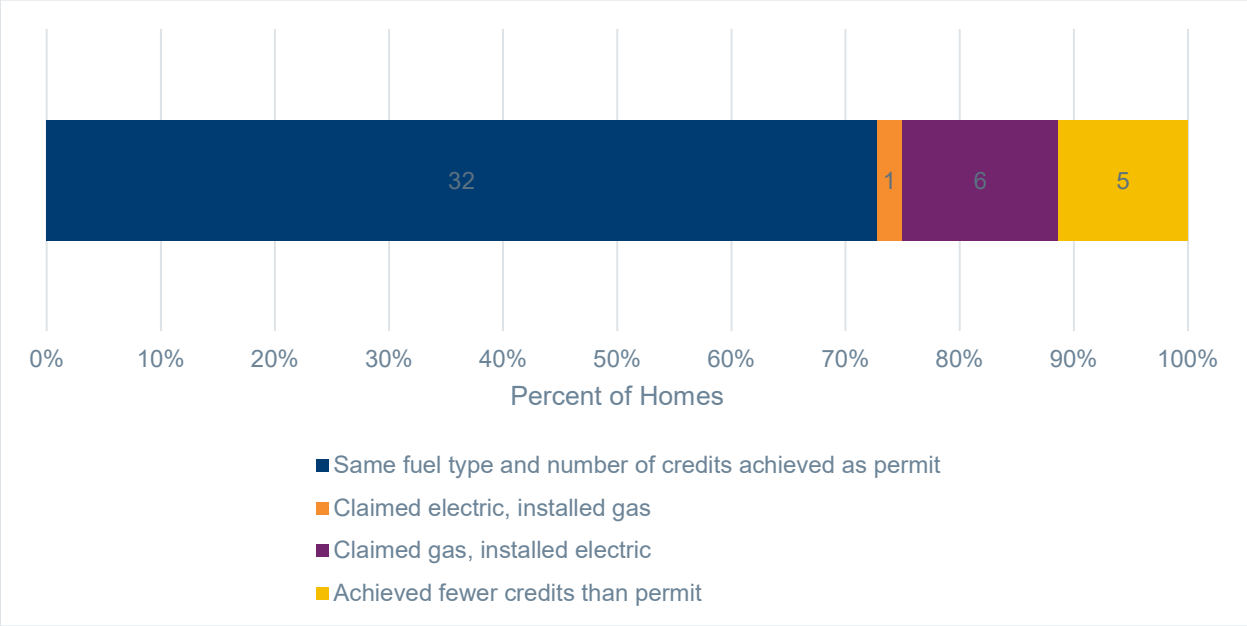
Figure 34. Air Leakage Audit Credits Achieved Compared to Permits (n=21)



4.6.2 HVAC System and Efficiency

Of the 44 audited homes with permits available, 86% met or exceeded the permit declarations. This includes 32 homes (or 73%) which achieved the same credit as claimed in the permit, and six (or 14%) that claimed gas but installed electric space heating equipment[29]. Only one home claimed electric but installed gas. The remaining five homes (11%) installed the same fuel type as claimed in the permit, but with a lower efficiency and credit option. This is summarized in Figure 35.

Figure 35. HVAC Audit Fuel Type and Credits Achieved Compared to Permits (n=44)

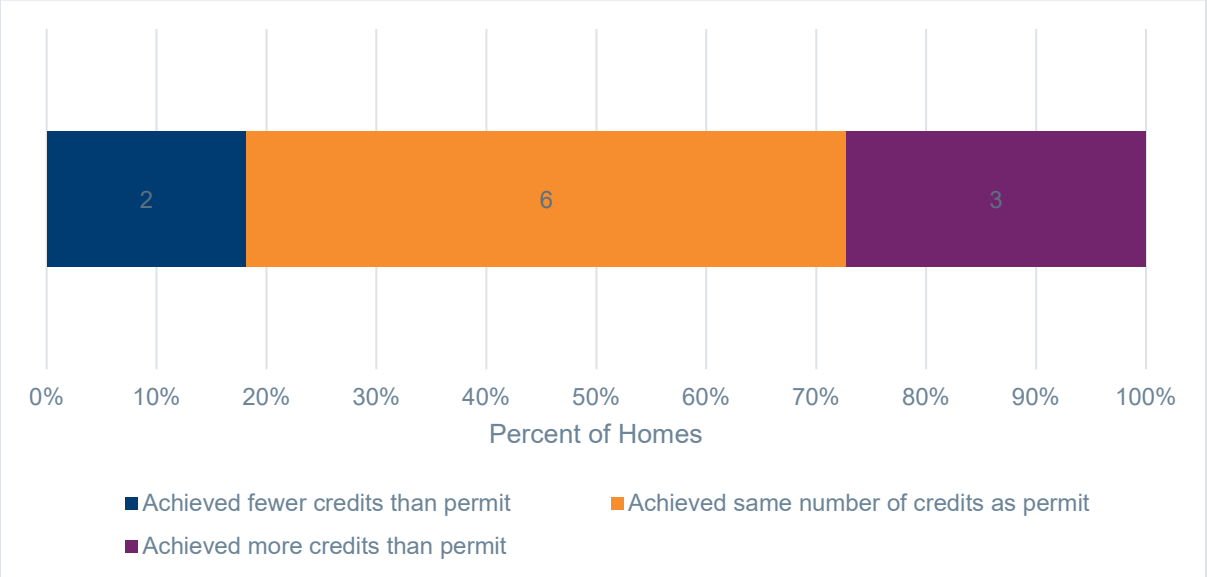


4.6.3 HVAC Distribution

For the HVAC distribution category, TRC was able to obtain both the duct leakage test results and permit declaration for 14 homes. Of those homes, three claimed the 4.2 credit, which cannot be verified with duct leakage results, so comparison is only possible for 11 homes. TRC could not evaluate requirements for this category other than the duct leakage test result, such as whether ducts were deeply buried ducts or in conditioned space. TRC found that 82% of these 11 homes met or exceeded the permit declarations, as shown in Figure 36.

[29] The percentage values in this paragraph are rounded, which is why 73% and 14% are described as summing to 86%.

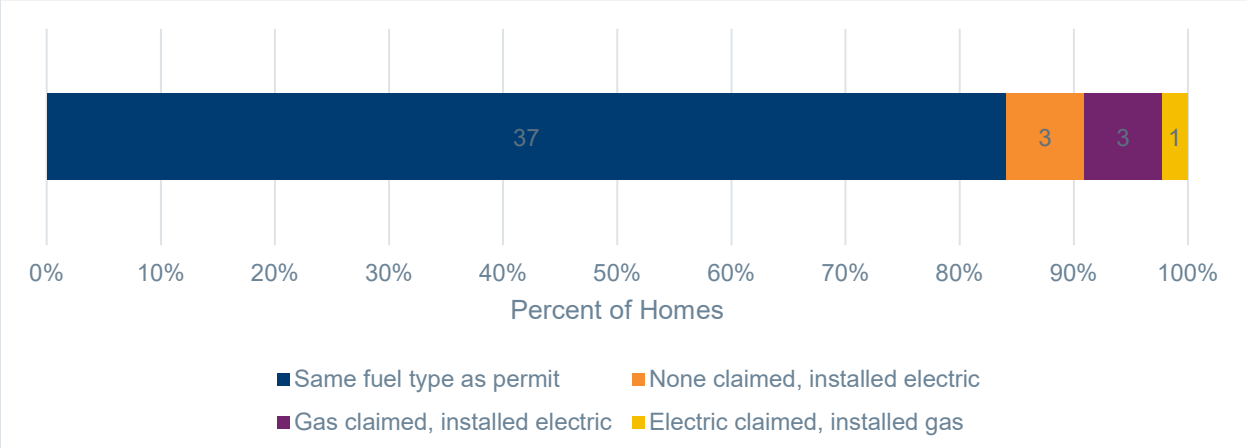
Figure 36. Duct Leakage Audit Credits Achieved Compared to Permits (n=11)



4.6.4 Water Heating Fuel Type and Efficiency

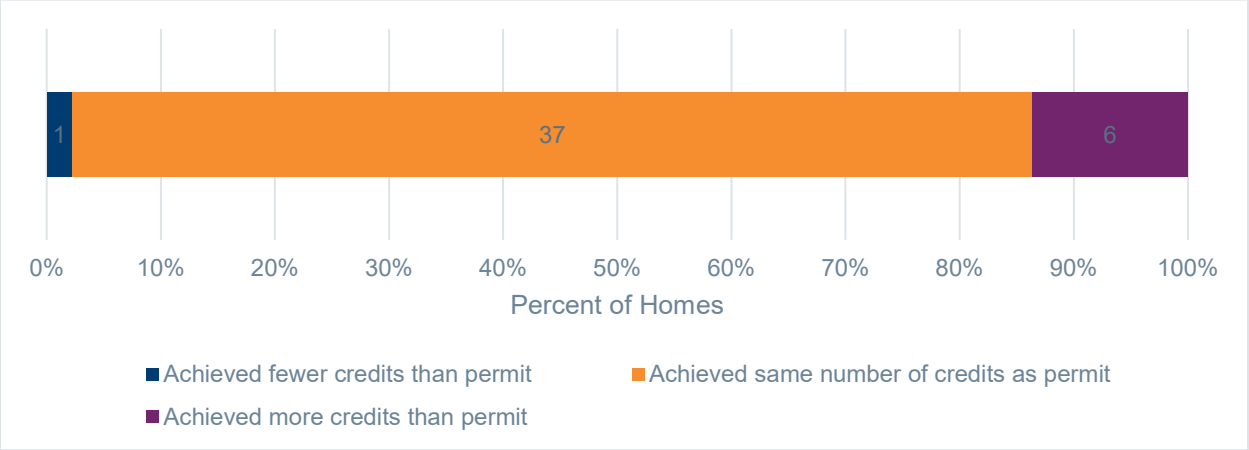
Of the 44 audited homes with permits available, 84% installed the same fuel type as declared in the permit. Three homes (7%) did not claim any credit in this category but installed an electric water heating system. The remaining four homes (9%) had conflicting results from the audit and permit – three homes claimed gas but installed electric, and one home claimed electric but installed gas, as shown in Figure 37.

Figure 37. Water Heating Fuel Type – Audit Results Compared to Permits (n=44)



TRC found that 98% of homes met or exceeded the credits claimed in the water heating category, with only one home meeting a lower credit than claimed, as shown in Figure 38.

Figure 38. Water Heating Credits Achieved Compared to Permits (n=44)



4.6.5 Renewables

Of the 44 audited homes with permits available, 42 (95%) installed what was claimed in the permit. Of these, the permit declarations showed seven homes claimed solar, while 35 did not. The other two homes installed solar but did not claim this credit in the permit. It is possible that these homes did not claim the renewables credit on the permit because it may have been installed after construction was complete.

4.6.6 Appliances

Of the 44 audited homes with permits available, 40 (91%) matched the permit, all of which did not declare the appliance credit. One home met the requirements but did not claim the credit in the permit. The other three homes claimed the appliance credit in the permit but did not achieve the necessary requirements. All three homes did not have qualifying clothes dryers, and two others had another appliance that did not meet requirements – one had a dishwasher that was not ENERGY STAR certified, and the other had a clothes washer that was not ENERGY STAR certified (this homeowner also reported that they had purchased the clothes washer and dryer themselves and that the builder was not involved in the appliance selection).

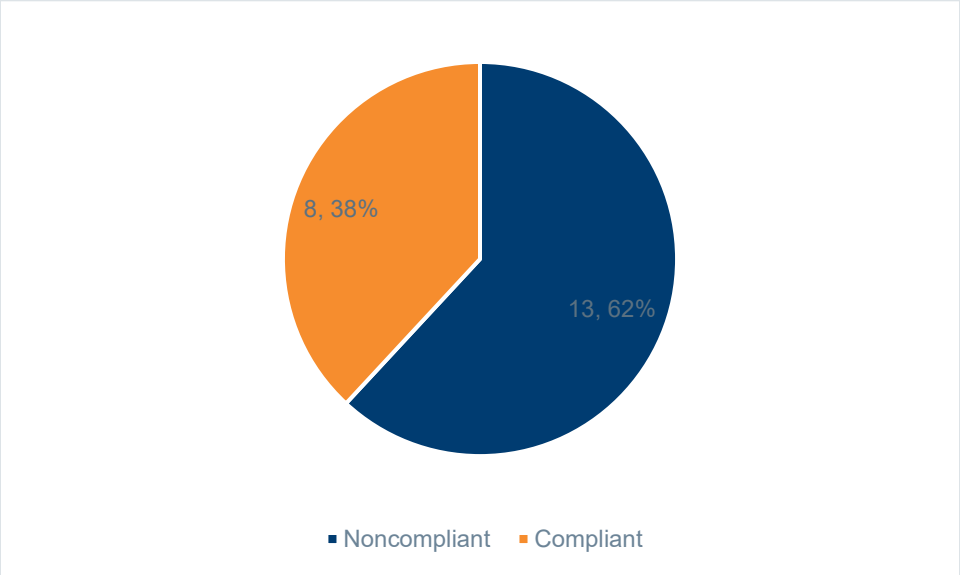
4.7 RESNET Analysis Findings

TRC identified 21 homes in the RESNET database that met the criteria outlined in Section 3.4 and determined compliance using the defined methodology. As described at the end of this section, the results presented here are based on 21 homes from four builders, so the findings may not apply to most homes in the RESNET database.

Overall, for the homes analyzed here, TRC found that the compliance rate for the RESNET dataset is much lower (38%) than TRC found in audited homes (76%). The compliance results from the RESNET analysis are shown in Figure 39. The low compliance rate for RESNET homes was surprising, given that most homes in the RESNET database participate in programs such as ENERGY STAR for Homes. Half of the RESNET homes (11 of 21) that were analyzed here were labeled in the RESNET database as meeting ENERGY STAR for homes (specifically, version WA 3.2). In addition, all of the RESNET homes analyzed here were modeled, with a

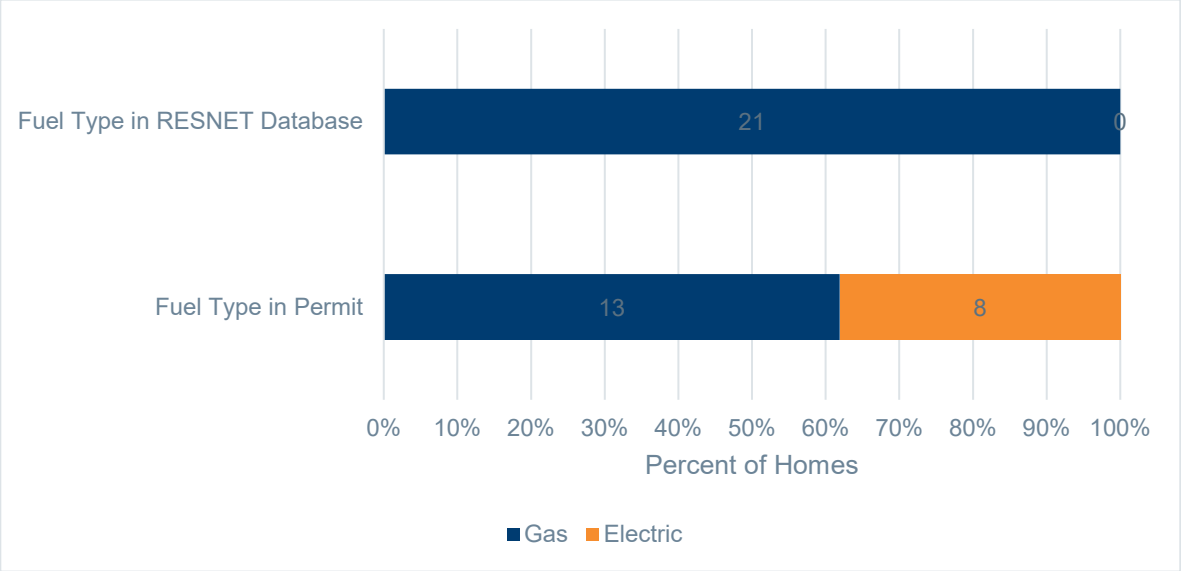
Home Energy Rating System (HERS) index between 45 and 60. TRC checked the date submitted on the permit documentation and/or the jurisdiction's online database and confirmed that all homes were submitted under the 2018 WSEC.

Figure 39. Proportion of Compliant and Noncompliant Homes in RESNET Analysis (n=21)



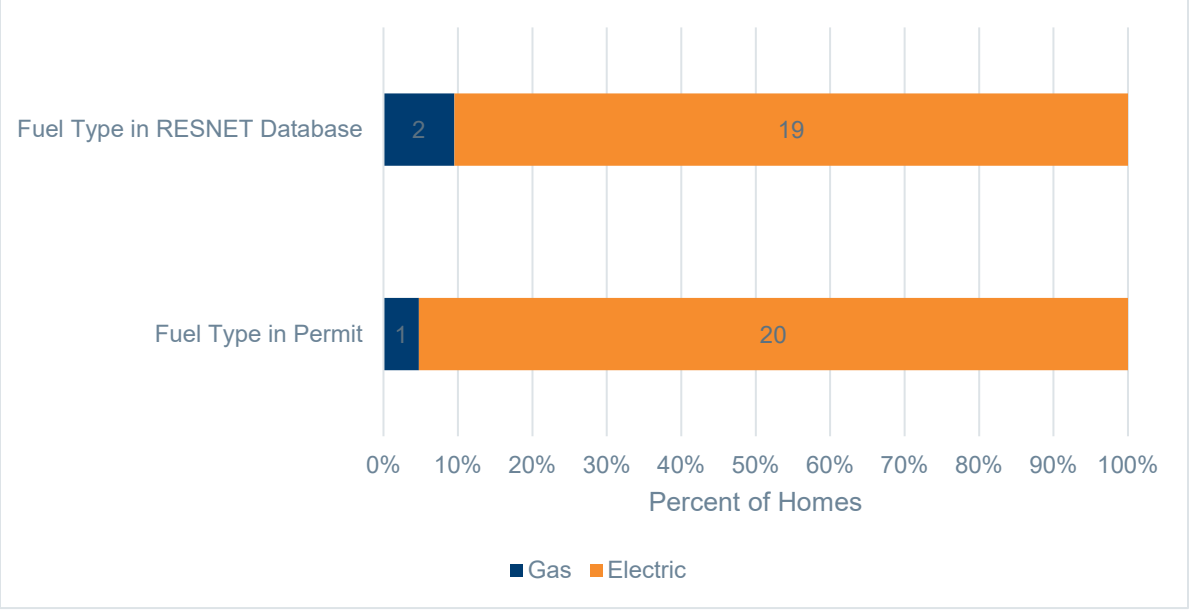
TRC also investigated the space heating fuel type and found that there was more variation, both within the RESNET analysis and as compared to the audit results. All homes in this dataset had permit documents in addition to the RESNET data, which enabled a direct comparison. TRC found that of the 21 homes, permit declarations indicated that only 13 homes (62%) used gas space heating. However, all 21 homes (100%) employ gas space heating according to the RESNET database. This implies that permits are not a reliable indicator of built conditions for homes in the RESNET database. Both estimates also show a much higher prevalence of gas space heating equipment compared to the audit findings (18%). Results are displayed in Figure 40.

Figure 40. Space Heating Fuel Type Comparison Between Permit Declarations and RESNET Database



The water heating fuel type results are more closely aligned. The permit documents showed 20 homes using electric water heating (95%), compared to the RESNET database's 19 homes (90%). The audit analysis showed electric water heating was used in 89% of homes. Results are shown in Figure 41.

Figure 41. Water Heating Fuel Type Comparison Between Permit Declarations and RESNET Database



The RESNET findings appear to reach different conclusions than the audit results presented in Section 4.1. However, there are more limitations and assumptions used in the RESNET analysis than the code compliance determination of audited homes. First, the dataset represents a much more limited view of the state, which TRC does not believe to be representative. Only a subset of the builders in Washington state typically rate and register

homes with RESNET. Further, the results provided for RESNET data represent fewer homes (21 total), which represent only five jurisdictions[30], six subdivisions, and four builders. For this reason, TRC did not incorporate the RESNET analysis into the statewide findings. TRC also did not analyze the findings by climate zone or jurisdiction volume due to the minimal representation. Second, the data reported in RESNET is much more limited and generic than the information TRC were able to obtain from the audits. This means that more assumptions needed to be made to determine code compliance. For example, the only information reported for water heating is system type and fuel type, with no efficiency ratings available. This meant that TRC could not verify credits for this category beyond confirming the system and fuel types matched, but the efficiency could be lower than claimed in the permit. On the other hand, if the system or fuel type did not match the permit, a different credit could still have been achieved, but TRC did not have the information to make that determination.

4.8 Implications for Multifamily Units

TRC assessed the reasonableness of applying the compliance rate found here, which was based on single-family homes, to multifamily units.

Virtual audits were conducted on single-family homes only, and the dataset does not include any multifamily units. However, TRC anticipates that the multifamily compliance rates will be at least as high as the single-family rate. This is because dwelling units serving R-2 occupancies (multifamily units) require 4.5 credits, which is lower than the average number of required credits (5.4) in the single-family dataset used to determine compliance. In addition, multifamily units are more likely to have electric heat pumps than single-family, based on census data. According to the American Community Survey, in 2021 for the Western states of the U.S. (which includes the state of Washington):

- For new, single-family homes, 29,000 had electric heat pumps and 6 times as many (180,000) had central gas furnaces.
- For new, multifamily units, 17,000 had electric heat pumps compared to about the same number (16,000) with forced-air gas furnaces.

However, it can be more challenging to install a heat pump water heating in a multifamily dwelling unit because it can be difficult to identify a suitable installation location.

It is likely that the compliance rate would be at least as high for multifamily as found for single-family, so TRC recommends assuming the same 76% compliance rate. Additional rationale for using this compliance rate is available in APPENDIX D: Multifamily Compliance Rationale.

[30] The jurisdictions represented are Pasco, Kittitas County, Pierce County, Kitsap County, and Liberty Lake. Three jurisdictions are in Climate Zone 5B, and two are in Climate Zone 4C. This includes one low, one medium, and three high construction volume jurisdictions.

4.9 Challenges of Methodology and Applicability to other States Served by NEEA

Another research objective of this study was to assess the efficacy and replicability of using this methodology over time and in other states served by NEEA. This section describes some of the challenges TRC encountered, and how this might impact the method's applicability to other states.

TRC's challenges included the following:

- The permit date reported in Construction Monitor was sometimes inaccurate. Early in the study, TRC conducted a handful of audits of homes that were listed in Construction Monitor as pulling a permit after February 1, 2021, but that TRC later determined (from the building permit) the permit was pulled prior to February 1, 2021. These homes were subject to the 2015 WSEC and not eligible for the present study. TRC developed the following workaround: after a resident submitted the initial questionnaire, TRC would go to the jurisdiction's website and identify the date that the permit request was received. If the date was on or after February 1, 2021, TRC would move forward with the audit. If the date was before February 1, 2021, TRC would notify the resident that they were not eligible for the study and send them a $25 gift card. TRC removed jurisdictions from the sample that did not have this information available online to avoid conducting audits of homes that were out of the project scope.
- TRC could only determine compliance for homes where we had both audit data and a permit; the permit provided data on "hidden measures" that could not be collected in a virtual audit such as envelope measures and test-out results for air leakage (blower door) and duct leakage (duct blaster) tests. While most jurisdictions provided permit data (online or through a request to the building department), TRC found that a few jurisdictions in Washington destroyed permit documents after 90 days.
- TRC used Construction Monitor data for sampling jurisdictions and identifying homes for recruitment, and some jurisdictions are not included in Construction Monitor data.

In general, TRC believes this method is replicable in Washington and could be repeated in that state to track compliance over time or with a different market segment (for example, multifamily). In addition, the virtual audit method could be used to determine information about appliances, including fuel choice. However, for this method to be used in other states to determine code compliance:

- Most of their jurisdictions should be included in Construction Monitor or another data source should be used for sampling.
- Compliance documentation including leakage test results should be posted in most homes if possible. If not available, the method would likely overestimate compliance.

- For new construction studies where it is possible that some recently built homes were constructed under a previous code, most of their jurisdictions should have a website where researchers could check when the initial permit was pulled.
- Most of their jurisdictions should retain permits.

One advantage of using virtual (instead of in-field) audits was it enabled data collection from various jurisdictions across the state at relatively low cost. Data quality was high, and TRC was able to view equipment and equipment plates and collect information from residents in a contactless mode, eliminating the potential for Covid-19 transmission. Compared with in-field data collection that requires traveling to the homes, TRC was able to capture data from homes spread out across the state, including in some rural areas where TRC completed only one or two audits per jurisdiction. One disadvantage is it requires participants to have smart phones and high-speed internet. This could be challenging in very rural areas or other areas with low access to highspeed internet, such as some tribal areas.

5 Key Takeaways

This study found the following:

Approximately three-quarters (76%) of homes complied with 2018 WSEC Section R406 (Additional Energy Efficiency Requirements). This is likely an overestimate because about half the audited homes did not have compliance certificates with test results available, which was the source of noncompliance for the majority of homes. The proportion of noncompliant homes was higher for those homes in Climate Zone 5B, where one-third of homes did not comply, although the difference in compliancy by climate zone was not statistically significant. The reasons for noncompliance were that:

- Homes did not meet the leakage test results that they targeted for air leakage or duct leakage (six of the 12 noncompliant homes).
- Homes used the 2015 WSEC even though the permit date indicated they should follow the 2018 WSEC (three of the 12 noncompliant homes).
- The home did not meet the efficiency requirements (HSPF) for claimed in its permit for the heat pump (one of the 12 noncompliant homes).[31]
- The home installed gas appliances instead of the electric appliances declared in their permit (one of the 12 noncompliant homes).
- The home was short in multiple credit categories (one of the 12 noncompliant homes).

Audit results support previous study findings[32] that a major shift to electric space and water heating use has taken hold since the 2018 WSEC, with 79% of audited homes using electric primary space heating and 89% using electric water heating. Homes in Climate Zone 5B were more likely to have gas water heating (17%) than homes in Climate Zone 4C (6%), while the proportion of homes using gas space heating was similar in Climate Zone 4C (22%) and Climate Zone 5B (21%).

While most homes used electric space heating or water heating, almost all had gas cooking appliances and almost half had a gas fireplace. Roughly one-quarter of homes audited, or 15 of 56 homes, had no natural gas hookup. Of those, two used propane. Of the 41 homes with a gas hookup, 95% had a gas range for cooking and almost half (46%) used their gas hookup for a range and one or more fireplaces.

Most homes (85%) were medium-sized, defined by the 2018 WSEC as 1,500 to 5,000 sf, which requires six credits. A minority of homes (18%) were small (<1,500), which requires three credits; all small homes complied with the 2018 WSEC.

[31] Due to supply chain issues with high efficiency equipment, the SBCC adopted an emergency ruling in June 2022 that allowed homes to claim a higher credit value with lower efficiency equipment, but this home was built prior to this ruling (sold in 2021).

[32] The Washington Residential Post-Code Adoption Market Research Study found using permit reviews that 88% of homes had electric space heating and 83% had electric water heating. https://neea.org/resources/washington-residential-post-code-market-research-report

The RESNET database does not appear to be a representative method for determining statewide compliance. The database contains a sample of homes from relatively few builders and is likely not representative of compliance and buildings practices across the state. This study analyzed 21 homes from the RESNET database from four different builders; these homes had a lower code compliance rate and a greater prevalence of gas space heating than homes that analyzed using virtual audits, which were identified through Construction Monitor. This is surprising since homes in the RESNET database often pursue programs such as ENERGY STAR for Homes, while homes in Construction Monitor represent all new construction homes that are permitted.

Homes used a variety of pathways to comply with the 2018 WSEC. The most popular credit categories were for efficient water heating and high efficiency HVAC. Many homes targeted air leakage control and ventilation, although this was a credit where TRC found a high level of noncompliance based on compliance documentation available in the home. About half of homes targeted efficient envelope and HVAC distribution credits. Few homes earned the renewable energy, DWHR, and appliance package credits. The following table shows how homes met credits under the 2018 WSEC.

Table 11. Summary of Credits Earned by 2018 WSEC Category

Credit Category	Frequency with which Credits were Earned	Common Approach(es) to Earning Credit(s)	Method Used to Verify Credit(s)	Comment on Data Quality
Efficient Water Heating	**Very Common**: All but two homes (96%) earned credits.	Most had a Tier 3 heat pump water heater (84% of homes), which provides 2 credits.	Audit data.	High
High Efficiency HVAC	**Very Common:** All but one home (98%) earned credits.	Most had an air source heat pump (73%) for one credit, but 25% had an efficient gas furnace.	Audit data.	High
Air Leakage Control and Ventilation	**Common:** Most homes (71%) earned or pursued a credit.	Almost half of homes (43%) pursued the lowest credit option which requires 3.0 ACH50 or tighter and no HRV. Another 28% chose a tighter envelope and HRV.	Compliance documentation of air leakage test results found by the resident (with guidance from the auditor) in about half of homes. Permit declarations for the remaining homes.	Medium. TRC may have overestimated compliance for homes where TRC used permit declarations, since (for homes where compliance documentation was available) test-out results were often leakier than permit declarations.

Credit Category	Frequency with which Credits were Earned	Common Approach(es) to Earning Credit(s)	Method Used to Verify Credit(s)	Comment on Data Quality
Efficient Building Envelope	**Common:** Most homes (63%) pursued a credit.	Most homes (63%) have a slight improvement worth 0.5 energy credits and are avoiding exterior continuous insulation.	Permit declarations.	Lower, since this could not be field verified.
HVAC Distribution	**Fairly Common**: More than half of homes claimed or achieved credit.	Homes used a mix of reduced duct leakage and deeply buried ducts.	Compliance documentation of duct leakage test results found by the resident (with guidance from the auditor) in about a third of homes. Permit declarations for the remaining homes.	Medium. TRC may have overestimated compliance for homes where TRC used permit declarations, since (for homes where compliance documentation was available) test-out results were often leakier than permit declarations.
Renewable Energy	**Less Common**: A minority of homes (16%) had a solar PV system.	This was a more commonly achieved credit option (33%) among the homes with a gas furnace.	Auditor verified the presence of a solar PV system by asking the resident and assumed the solar PV capacity using permit declarations	Medium
DWHR	**Rare:** 9% of homes claimed this credit.		Permit declarations	Lower, since this could not be field verified.
Appliance Package	**Rare:** One home (2%) earned this credit. Two claimed it in permits but did not meet the dryer requirements.	Many audited homes met the credit requirements for their refrigerator, dishwasher, and clothes washer, but did not meet the efficiency requirements for the clothes dryer.	Audit data	High

TRC was able to find some type of compliance certificates in 61% of audited homes. Those that were found were inconsistent in format, typically had incomplete information, and varied in their location in the home. In about half of homes, TRC was able to locate (with the assistance of residents) compliance certificates with leakage test results (blower door and duct leakage test results), which was used for verifying the air leakage and HVAC distribution credits.

This study found lower code compliance rates than what previous studies have found in Washington and in other states. A 2013 study[33] of residential code compliance in Washington found a 96-97% compliance rate. The difference in results could be that this study used a different methodology for recruitment or for determining compliance, because builders have more challenges meeting the 2018 WSEC – perhaps because the code is more stringent, or other reasons.

TRC finds that permits are a reasonable proxy for installed equipment but recommends that NEEA require verification of any field test results in future code evaluation studies. The methods used in this study, which included virtual audits and permit review, provided valuable insights including the fuel type of installed appliances, the use of natural gas in the home, and (in about half of homes) the test results for leakage tests (air tightness and duct leakage). To determine code compliance, TRC typically needed the home's permit in addition to audit data. TRC was able to obtain the permit in most cases (for 79% of audited homes), but some jurisdictions did not keep these beyond 90 days. Permit data and audit data typically aligned, although some test results showed worse (leakier) homes or ducts than permit declarations, and a few builders declared electric appliances in permits but installed gas appliances.

[33] Northwest Energy Efficiency Alliance (NEEA), "Washington Residential Energy Code Compliance." https://neea.org/resources/washington-residential-energy-code-compliance

6 APPENDIX A: 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

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, *Ceilings below a vented attic* **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 *International Residential Code* or Section 403.8 of the *International Mechanical Code* 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	Compliance based on Section R402.4.1.2: Reduce the tested air leakage to 2.0 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 0.25 cfm/ft^2 maximum at 50 Pascals **and** All whole house ventilation requirements as determined by Section M1507.3 of the *International Residential Code* or Section 403.8 of the *International Mechanical Code* shall be met with a heat recovery ventilation system with minimum sensible heat recovery efficiency of 0.65. 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.	1.0	1.5
2.3	Compliance based on Section R402.4.1.2: Reduce the tested air leakage to 1.5 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 0.25 cfm/ft^2 maximum at 50 Pascals **and** All whole house ventilation requirements as determined by Section M1507.3 of the *International Residential Code* or Section 403.8 of the *International Mechanical Code* shall be met with a heat recovery ventilation system with minimum sensible heat recovery efficiency of 0.75. 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.	1.5	2.0
2.4	Compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.6 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 0.15 cfm/ft^2 maximum at 50 Pascals **and** All whole house ventilation requirements as determined by Section M1507.3 of the *International Residential Code* or Section 403.8 of the *International Mechanical Code* 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. 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.	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	All supply and return ducts located in an unconditioned attic shall be deeply buried in ceiling insulation in accordance with Section R403.3.7. 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. Duct leakage shall be limited to 3 cfm per 100 square feet of conditioned floor area. Air handler(s) shall be located within the conditioned space.	0.5	0.5
4.2	HVAC equipment and associated duct system(s) installation shall comply with the requirements of Section R403.3.7. Locating system components in conditioned crawl spaces is not permitted under this option. Electric resistance heat and ductless heat pumps are not permitted under this option. Direct combustion heating equipment with AFUE less than 80% is not permitted under this option. 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.	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	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. 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.	0.5	0.5
5.2	Water heating system shall include one of the following: ENERGY STAR rated gas or propane water heater with a minimum UEF of 0.80. 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.	0.5	0.5

TABLE 406.3 (continued)
ENERGY CREDITS

OPTION	DESCRIPTION	CREDIT(S)	
		All Other	Group R-2
5.3	Water heating system shall include one of the following: ENERGY STAR rated gas or propane water heater with a minimum UEF of 0.91 **or** 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 **or** Water heater heated by ground source heat pump meeting the requirements of Option 3.3. 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.	1.0	1.0
5.4	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 **or** 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. 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.	1.5	2.0
5.5	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 **or** 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. 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.	2.0	2.5

TABLE 406.3 (continued)
ENERGY CREDITS

OPTION	DESCRIPTION	CREDIT(S)	
		All Other	Group R-2
5.6	Water heating system shall include one of the following: 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 *Advanced Water Heating Specification* with the UEF noted above **or** 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. 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.	2.5	3.0
6. RENEWABLE ELECTRIC ENERGY OPTION			
6.1	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: 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. Documentation noting solar access shall be included on the plans. For wind generation projects designs shall document annual power generation based on the following factors: 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. 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.	1.0	1.0
7. APPLIANCE PACKAGE OPTION			
7.1	All of the following appliances shall be new and installed in the dwelling unit and shall meet the following standards: Dishwasher – ENERGY STAR rated Refrigerator (if provided) – ENERGY STAR rated Washing machine – ENERGY STAR rated Dryer – ENERGY STAR rated, ventless dryer with a minimum CEF rating of 5.2. 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.	0.5	1.5

a. An alternative heating source sized at a maximum of 0.5 Watts/ft^2 (equivalent) of heated floor area or 500 Watts, whichever is bigger, may be installed in the dwelling unit.

7 APPENDIX B: Virtual Audit Recruitment Letter

807 E Roy Street, Suite 301
Seattle, WA 98102

[redacted] PHONE

Dear resident,

The Northwest Energy Efficiency Alliance (NEEA) is working with TRC, an energy research firm, to conduct a research study investigating the most recent Washington State Energy Code (WSEC) and the design elements and appliances builders choose to comply with the new building code. Permit records indicate you live in a recently constructed single-family home under the new building code. Please participate in a 25-minute video call. As a thank you, you will receive a **$100 e-gift card**.

Participate in a brief call regarding your new home!

1. Scan the QR code to confirm your eligibility and identify a video call time convenient for you.

2. Participate in a video call with a TRC technician, who will take screenshots of your appliances, heating, and cooling equipment.

3. Receive $100 e-gift card as a thank you for your participation.

Any information you provide will remain strictly confidential and reported only in aggregate to inform our research. If you have questions about this study, please reach out to our team at [redacted] or feel free to contact the project manager, [redacted] at [redacted]. If you would like to contact NEEA regarding this study, please contact the NEEA project manager [redacted]. To learn more about NEEA, please visit www.neea.org.

Thank you in advance for your participation in this important study to understand new homes in WA.

Sincerely,

The WA Code Study Team at TRC and NEEA
[redacted]

8 APPENDIX C: RESNET Data Fields

Home Characteristics	Hidden Measures	Fuel Selection and Equipment
• RegistryID • StreetAddress • City • State • Zip • ClimateZoneNo • DateRated • DateRegistered • HomeType • ConstructionYear • ConditionedArea • StoriesAboveGrade • NumberBedrooms • HERSIndex • FoundationType • EnergyStarVersion	• FoundationRigidInsulation • FoundationBattInsulation • FoundationInsulationGrade • FloorCavityInsulation • FloorContinuousInsulation • AGWWallConstructionType • AGWallFramingFactor • AGWallContinuousInsulation • AGWallCavityInsulation • AGWallInsulationGrade • AGWallInsulationType • CeilingInsulationDepth • CeilingCavityInsulation • CeilingContinuousInsulation • CeilingInsulationType • RadiantBarrier • WindowUFactor • WindowSHGC • ACH50 • VentilationType • VentilationRate • VentilationRunTime • VentilationFanWattage • DuctLeakage • DuctLeakageTotal • DuctLeakageTightnessTest • DuctLeakageUnits • DuctsConditioned • AGWallUo • FoundationWallUo • CeilingUo • OverallEnclosureUA	• AnnualGas • NumCoolingSystems • NumHeatingSystems • NumHotWaterSystems • ACEfficiency • ACOutputCapacity • HeatingSystemType • HeatingEfficiency • HeatingEfficiencyUnits • HeatingOutputCapacity • HeatingFuel • WaterHeaterType • WaterHeaterFuel • WaterHeaterCapacity • On-site Generation

9 APPENDIX D: Multifamily Compliance Rationale

This appendix provides TRC's assumptions of how difficult it would be for multifamily (MF) units to earn each credit category compared to single-family (SF) homes. Multifamily units must earn at least 4.5 credits to comply with Section R406. TRC used these results to inform Section 4.8.

Table 12. Consideration of Likely Energy Credit Categories Earned for Multifamily Units

Credit category	Most likely credit earned	Number of credits	Estimated % of MF units earning credit	Rationale for Assumptions
Fuel Normalization	FN2: Fuel normalization: Heat pump	1	100%	Assumed slightly higher compliance for MF than SF. Most MF units are probably earning this. For SF homes, the average credit earned as 0.8, because 79% had a space conditioning heat pump (SCHP). It is not significantly harder or easier to install SCHPs in MF units than SF residences. SCHPs are now the prescriptive requirement in California multifamily buildings under 2022 Title 24 Part 6.
Envelope	1.1: u-value=0.24	0.5	100%	**Applied SF results to MF.** Our assumption aligns with findings for SF homes, where average credits earned was 0.4 in this category. Most (76%) SF homes earned credits 1.1-1.3, which specifies u-values between 0.20 and 0.28. It should be a similar level of difficulty for MF compared to SF. A few buildings probably are not earning any credits in this category, but a few buildings are probably earning higher credits worth more points. For simplicity, we assume 100% earn the lowest credit category (0.5 pts), since that was most popular credit in single-family.
Air leakage Control and Efficient Ventilation, and Efficient Ventilation	2.1 Air leakage Control <=cfm50/sf, and fan efficacy 0.35 W/cfm or better	1	50%	**Applied SF results to MF.** Our assumption of an average of 0.5 credits aligns with the SF result: average of 0.5 credits in this category. The MF credit requires blower door testing to show air leakage <=0.30 cfm50/sf. This is a relatively leaky tightness level so is fairly easy to meet, but many MF projects may not want to target this credit since it is risky. It is not a "widget" they can install, but rather a good labor practice (good sealing). Probably a small percent of MF buildings are earning a higher credit (2.2 or 2.3) that requires a tighter dwelling unit: <=0.25 cfm50/sf and an HRV.

High Efficiency HVAC	3.1 High efficiency HVAC	1	100%	**Applied SF results to MF.** Same rationale as for Fuel Normalization. Our assumption of an average of 1 credit aligns with the single-family results: average of 1.1 credits in this category.
Efficient Water Heating	5.5 HPWH Tier 3	2	50%	**Assumed lower compliance for MF than SF**. Almost all (96%) of SF homes earned a credit in this category, and most earned credit 5.5 for a HPWH Tier 3, for average of 2.0 credits in this category. However, it can be challenging to identify a suitable installation location for multifamily units. HPWHs should be vented directly to the outside to not cool the air around them, or requires ~1,000 cubic feet of air space, which limits installations in interior mechanical closet. If located outdoors (for example, balcony), HPWHs have lower efficiency. Because of the space constraint issue, we estimate ~50% of MF units earn credit 5.5
Renewable Electric Energy	6.1	1	30%	**Applied SF results to MF.** Our assumption aligns with the SF result: average of 0.3 credits. For MF, this credit awards 1.0 credit per 1,200 kWh of PV or wind generation.
Appliance Package	7.1	1	0%	**Applied SF results to MF**. Our assumption aligns with the SF result: 1 home out of 44 earned this credit. The MF requirements are the same, including a requirement for a ventless dryer with an efficiency level that requires a heat pump dryer (which is rare)
Likely credits earned			**Around 4.3**	Because total credits earned is slightly lower than total needed (4.5 credits), this illustrates that MF compliance may be challenging. **We recommend that NEEA apply the SF compliance rate to MF**.