Out of Site! Lessons Learned from Alternative Approaches to Evaluating the Market's Response to Code Changes

Meghan Bean, Northwest Energy Efficiency Alliance
Marian Goebes, TRC
Lucy Albin, TRC
Daniel Kaufman, Industrial Economics, Incorporated
Christine Lee, Industrial Economics, Incorporated
Greg Englehart, Industrial Economics, Incorporated
Carrie Brown, Resource Refocus
Samuel Manning, NMR Group

ABSTRACT

Residential energy codes provide states with the opportunity to achieve substantial energy savings in newly constructed homes. Understanding the market's response to energy code changes can provide code proponents with information to increase compliance through tailored education for builders and officials, guide future code development, and ensure the code is clear and enforceable. The conventional approach to code compliance evaluation, which relies on large numbers of onsite audits, can, however, be prohibitively expensive and may not provide findings in time to support needed education efforts and inform the next round of code development. Further, because onsite audits are expensive, many studies focus on a few geographic areas, thereby missing urban versus rural differences.

This paper will synthesize findings from five studies that explore the feasibility of data collection approaches beyond onsite audits, conducted in four states that vary considerably in their approaches to code development and enforcement. Specifically, this paper details key methodological lessons learned, including barriers to collecting residential building permit data in both urban and rural areas; findings about what information can reliably be collected through permits and virtual home audits; and recommendations for collaborating with local market actors to inform study design and recruitment. Further, this paper summarizes results on the degree to which permit data represent as-built conditions and findings on compliance across urban and rural areas.

Introduction

Residential energy codes provide states with the opportunity to achieve substantial energy savings in newly constructed homes. The Northwest Energy Efficiency Alliance (NEEA) supports development and adoption of more stringent commercial and residential energy codes in its region (Idaho, Montana, Oregon, and Washington) to advance efficiency and "lock in" savings achieved through greater uptake of efficient products and practices driven by its market

transformation programs.[1] NEEA conducts research and evaluation projects to assess the market's response to a new code with the goal of collecting data that will:

- Inform NEEA's strategy to guide future code development and adoption
- Provide insight into elements of the code that may be confusing or complex and could be improved in the next code cycle
- Identify education and training needs for builders, code officials, and other market actors to help them comply with the new code
- Identify meaningful patterns in noncompliance across different jurisdictions (for example, urban and rural) to help NEEA tailor its training and education activities

To inform code development strategies and deploy needed training and education resources to support compliance with a new residential code, NEEA's codes research and evaluation projects need to occur fairly quickly after the code goes into effect but after enough time has elapsed that a sufficient number of new homes exist in the market. For this reason, conventional approaches to code compliance evaluation, which rely on large numbers of time-consuming and costly onsite audits, do not meet NEEA's needs. Thus, NEEA has been exploring the feasibility of alternative methods for assessing the market's response to code changes that better meet its timing and financial constraints. This paper details lessons learned from five studies conducted from 2021 to 2024 by NEEA and its research and evaluation contractors – TRC, Industrial Economics, Incorporated (IEc), Resource Refocus, and NMR Group (NMR) – that sought to use permits, virtual audits of inhabited homes, databases of above-code homes, and surveys/interviews with market actors to better understand builder behavior and code compliance under a state's most recent code. This paper focuses on NEEA's single-family residential codes work and does not address NEEA's commercial codes research and evaluation approach. Further, this paper does not address alternative code compliance methodologies, such as Delphi Panels (ERS and IEc 2016), or data sources, such as the REScheck database,[2] that have not been used by NEEA in recent years.

The paper begins with an overview of NEEA's codes work and the opportunities and constraints guiding NEEA's approach to residential code research and evaluation, followed by a summary of recent code research and evaluation projects in each of the four states in NEEA's region along with key findings from each study. The remainder of the paper shares methodological and analytical lessons learned from these projects, including the benefits and limitations of permit data collection, resident-based data collection approaches, and existing databases of above-code home data, as well as findings from NEEA's efforts to understand code compliance differences across rural and urban areas.

[1] Building energy codes can "lock in" a market transformation program's market progress by formalizing requirements for efficiency performance or related metrics that were not as stringent or did not exist before.
[2] REScheck is an online tool that enables builders and other market actors to enter information about a home's design to conduct trade-off calculations relative to a state's energy code requirements. https://www.energycodes.gov/rescheck

Code Evaluation at the Northwest Energy Efficiency Alliance

The Northwest Energy Efficiency Alliance (NEEA)

NEEA is an alliance of over 140 utilities and efficiency organizations that operates in four Northwest states – Idaho, Montana, Oregon, and Washington. Together, NEEA and its partners seek to transform markets for a broad range of energy efficient products and practices, including advanced heat pumps, commercial and industrial fans, luminaire level lighting control, and consumer products like refrigerators and televisions. Many NEEA market transformation program strategies include engagement with state and federal appliance standard processes and state building energy code processes to "lock in" savings achieved through greater market acceptance of a targeted product or practice.

NEEA's Codes Work

In addition to "locking in" savings gained through market transformation, NEEA's codes work seeks to advance the efficiency of new construction buildings in the Northwest. NEEA engages in interconnected activities to maintain or advance energy code and support compliance with code in each of the Northwest states. Activities include:

- Support for energy code development and adoption, including conducting or funding research and submitting proposals through the public process
- Trainings on code for market actors, including compliance officials, builders, and engineers/architects
- Education resources for market actors working with code, such as hotlines, compliance tools, and circuit riders

The NEEA Codes team tailors its efforts to each state's code landscape and the specific code cycle it is participating in or supporting the adoption of. A recent evaluation of NEEA's Codes work found that NEEA successfully engages in each state's public process to increase or maintain stringency of energy codes and that NEEA's code proposals and the proposals it funds have notable influence on energy codes in the region (Albers, Bliss, and Johnson 2024). Further, NEEA-supported training and education resources provide valuable information and guidance to a broad range of market actors, including code officials, architects/engineers, and builders (Albers, Bliss, and Johnson 2024).

Opportunities and Constraints Guiding NEEA's Code Research and Evaluation

NEEA conducts code compliance evaluations and, occasionally, market research studies in each Northwest state after a new code takes effect. NEEA's code compliance evaluations must be conducted in time to inform strategy for the next code, guide needed training and compliance support, and provide inputs to energy savings analysis. To illustrate the often-narrow window between when a new code goes into effect and the proposal process for the next code begins, Washington State Energy Code (WSEC) 2018 went into effect in February 2021, and the first residential proposal for WSEC 2021 was received in April 2022.

NEEA's code compliance evaluations also inform program strategy for more localized or targeted efforts. Some NEEA code compliance evaluations compare results across regions because code development and support strategies will be more effective if the team has a clear understanding of whether all areas of a state are experiencing the same levels or compliance, or, instead, whether some areas are struggling to comply with portions of the code.

NEEA's code compliance evaluations also inform its work to estimate energy savings resulting from code changes in each state. Key inputs include estimates of state-wide, whole-home compliance and state-wide fuel mix for primary space and water heating. In some states, reports compare compliance across regions of the state (for example, climate zones or urban versus rural jurisdictions) to ensure that compliance estimates accurately capture the diversity of building environments, builder practices, and enforcement approaches across the state.

The U.S. Department of Energy's (DOE) Building Energy Codes Program has established guidelines for residential energy code field studies, which provide results that are comparable across states and between code cycles in each state, enabling states to identify trends and track progress (Bartlett et al. 2022). The DOE methodology relies on proportional random sampling of jurisdictions across the state, employs exclusively on onsite data collection, and focuses on "individual energy efficiency measures" (Bartlett et al. 2022, v). While this approach to code evaluation provides clarity on as-built conditions over time and across states, it presents challenges to meeting NEEA's needs because large numbers of onsite audits are time consuming and costly. Further, the DOE sampling methodology tends to favor urban areas where more building activity occurs, which does not enable an exploration of whether code compliance is occurring at similar levels across the state. For these reasons, NEEA has been exploring other data sources that are quicker and less expensive than conducting large numbers of onsite audits and enable a deeper dive into regional differences in market response to a code change.

Recent Code Research and Evaluation Projects

This section provides a summary of the five recent NEEA code research and evaluation studies that are the focus of this paper. NEEA's research and evaluation approach differs across studies for a variety of reasons. First, the states' code development, adoption, and compliance approaches differ, and there are different data sources available in each state. Second, the NEEA Codes team's code influence strategy and research questions are unique to each state. Third, when NEEA solicits bids for code evaluations through a competitive process, the organization receives a diverse range of proposed approaches, and each selected bidder may take a different approach to address the research objectives. Finally, NEEA and its contractors incorporate lessons learned from prior studies when scoping and conducting subsequent code evaluations.

Idaho Residential Code Compliance Evaluation. NEEA conducted an evaluation of homes built under the International Energy Conservation Code (IECC) 2018 with Idaho amendments. This evaluation provided a state-wide estimate of whole-home compliance from an energy use intensity (EUI) perspective as well as documentation of primary space and water heating fuel selection. Further, the report compared envelope tightness compliance in urban versus rural areas. The study followed DOE's sampling methodology (Bartlett et al. 2022), and the evaluation contractors, IEc and Resource Refocus, selected the sample option that best supported a comparison of urban and rural areas. Resource Refocus conducted Monte Carlo energy modeling

analysis of permit and onsite data to estimate the energy consumption of both an observed and code-compliant population of homes and the potential savings with improved energy code compliance (Kaufman et al. 2024; Bartlett, Halverson, and Xie 2019).[3] The modeling and savings analysis followed the DOE methodology; the key methodological difference is that this study used permits as an additional data source for some measures.

The results showed that 96% of the space heating systems are natural gas furnaces and 90% of the domestic hot water heating uses natural gas. As shown in Figure 1, the results estimate that the average home in Idaho uses 8% less energy than the average home that exactly meets current code requirements. From a whole-home EUI perspective, the weighted modeling results predict 97.8% compliance statewide. The sampled population includes homes with above-code measures, outweighing the impact of below-code measures. This is why the average home outperforms the code-compliant average by 8%, but there is still 2.2% non-compliance. An analysis of the previous code cycle estimated that the average home outperformed the code-compliant average by 15% with 2.7% non-compliance (Bartlett, Halverson, and Xie 2019).

The evaluators did not find a meaningful difference in envelope tightness compliance across urban and rural areas under IECC 2018 with Idaho amendments (Kaufman et al. 2024). External wall insulation had the lowest rate of compliance and the highest potential for energy savings if the non-compliant homes were brought to code-minimum levels. Qualitative interviews with code officials and builders also indicated that the market is generally able to comply with the code but that there are opportunities for training around wall insulation.

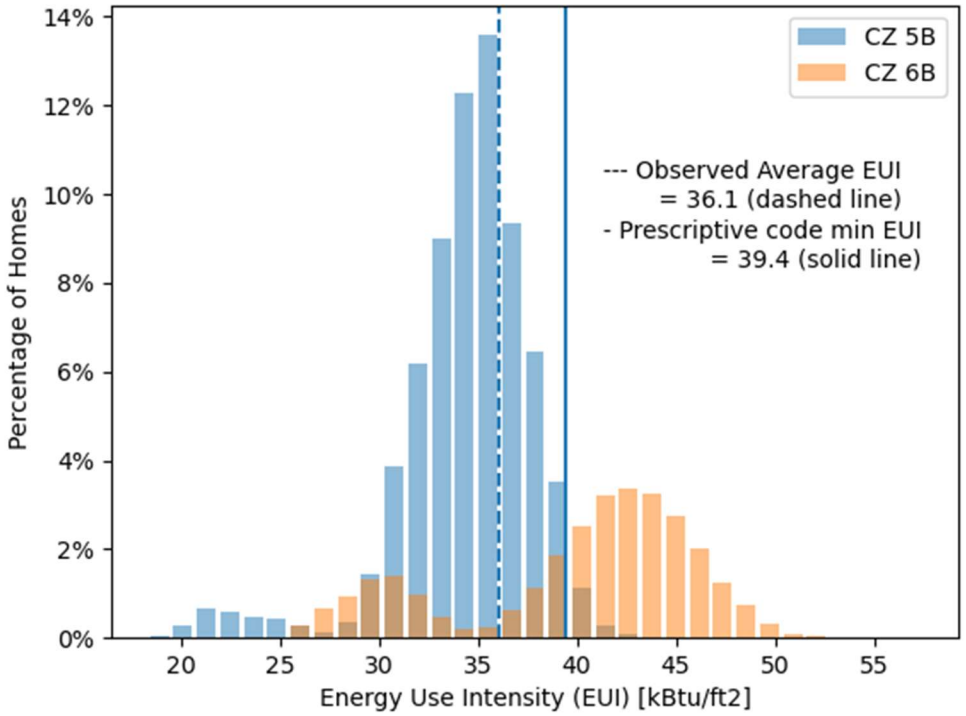

Figure 1. Statewide energy use intensity (EUI) analysis under IECC 2018 with Idaho amendments. *Source:* Kaufman et al. 2024.

[3] IEc and Resource Refocus also intended to use the AXIS database as a data source but determined that it was not viable for this study. These findings are detailed in the "Databases of Above-Code Homes" section.

Montana Residential Code Compliance Evaluation. NEEA's in-progress Montana Residential Code Compliance Evaluation will also provide a state-wide estimate of whole-home compliance from an energy use perspective, a comparison of envelope tightness compliance across rural and urban areas, and documentation of primary space and water heating fuel selection. This evaluation will study the market's response to both IECC 2018 with Montana amendments and IECC 2021 with Montana amendments. The evaluation contractors, IEc and Resource Refocus, originally sought to use permits as a primary data source for this study but found that sufficient permit data were not available (see "Permits" section for more information). The study will now use onsite audits as the primary data source, along with interviews with builders and code officials. Given the new focus on onsite audits, this study is being conducted in a manner that closely aligns with the DOE guidelines but uses a sampling approach that allows for a higher proportion of rural jurisdictions.

Oregon Residential Code Compliance Evaluation. NEEA's in-progress Oregon Residential Code Compliance Evaluation will assess state-wide compliance and fuel selection under the 2021 Oregon Residential Specialty code (ORSC). As in Montana, IEc and Resource Refocus intended to use permits from a representative sample of homes built under the 2021 ORSC as a primary data source to be analyzed along with data from a small sample of onsite audits of in-progress homes, AXIS[4] data for above-code homes, and resident self-directed audits from inhabited homes collected by NMR. Sufficient permit data are not available to support analysis, however, and IEc is exploring alternative data sources including plan sets, manufacturer invoices, and additional onsite audits focused on a subset of key measures, such as air leakage.

Washington Post-Code Adoption Market Research. WSEC 2018 included significant changes compared to the previous code, WSEC 2015. WSEC 2018 required that homes achieve a greater number of energy credits, the number and stringency of code credits available increased, and the code established the use of a fuel normalization table. The Washington Post-Code Market Research study was completed in late 2021, shortly after WSEC 2018 went into effect in February 2021. This study sought to gather information on builders' early responses to the code in an effort to inform NEEA's work on the WSEC 2021 code development process, which began in spring 2022. Because this study was conducted so soon after the code had gone into effect, NEEA did not seek a representative state-wide compliance estimate. The research team, TRC, reviewed permits for homes being built under WSEC 2018 and conducted an online survey with home builders (Lasher et al. 2022). Results showed that builders were changing their practices under WSEC 2018 compared with WSEC 2015, including a shift towards primary electric space heating (Figure 2) and water heating (Figure 3) and a greater diversity of pathways taken to comply with code (Lasher et al. 2022; Flynn and Caudill 2020).

Washington Residential Code Compliance Evaluation. After completing the Washington Post-Code Market Research study (Lasher et al. 2022), NEEA conducted a formal compliance evaluation for WSEC 2018. Like NEEA's other residential code compliance evaluations, this

[4] AXIS is a centralized data collection, storage, and sharing hub that serves as a database for whole home data and inspection results for certified above-code homes and energy-rated code homes. The rater or verifier performing the inspection provides the data for AXIS. https://pivotalenergysolutions.com/#products

study sought to provide a state-wide estimate of whole-home compliance with WSEC 2018 and document space and water heating fuel selection. Further, NEEA sought to gain a deeper understanding of gas use in homes. TRC used permits and virtual home audits from a representative sample of homes across the state to calculate compliance with minimum energy requirements under WSEC 2018 (Albin et al. 2023). TRC found that 76% of homes complied with code – an estimate considerably lower than prior compliance evaluations in Washington (Cadmus Group 2013) and lower than typically found in other states (ACEEE 2022). While it is not possible to make apples-to-apples comparisons across studies due to differences in methodology, TRC posits that the lower compliance rate could be due to the significant increase in stringency compared with WSEC 2015 or the fact that the study recruited homeowners rather than builders to collect onsite data (see the "Resident Data Collection" section for more information). In addition, TRC gathered air and duct leakage results based on the reported blower door and duct blaster test results from builders,[5] whereas some studies have not captured compliance for these measures. TRC found that 29% of homes had a higher air leakage rate than targeted in their permit, and this was the measure that contributed most to noncompliance.

As shown in Figures 2 and 3, TRC again found evidence for a significant shift toward electric primary space and water heating under WSEC 2018 compared with WSEC 2015. TRC also found that, despite the shift toward electric spaces and water heating, 71% of homes had a gas hookup, which were most commonly used for natural gas cooking ranges and hearths.

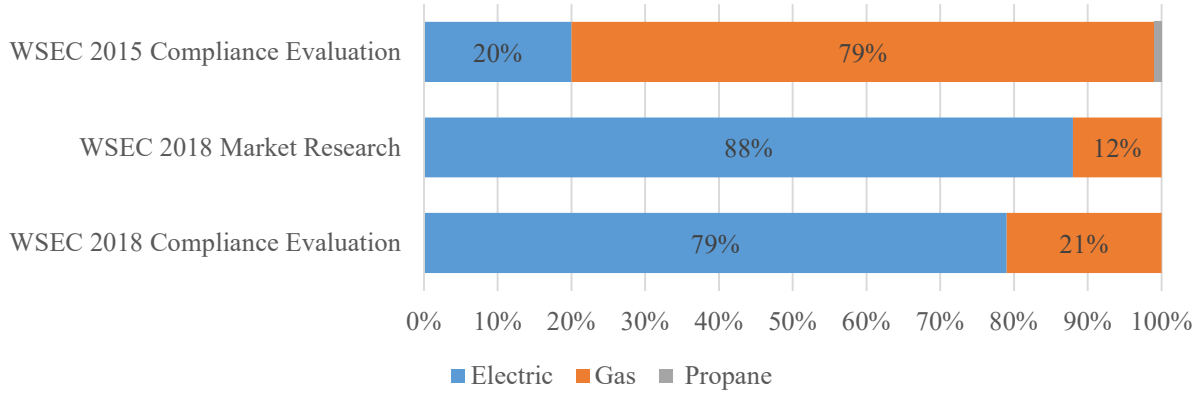

Figure 2. Primary single-family residential space heating fuel use under WSEC 2015 and WSEC 2018. *Sources:* Flynn and Caudill 2020, Lasher et al. 2022, and Albin et al. 2023.

[5] Washington State requires that builders post blower door and duct blaster test results in the completed home.

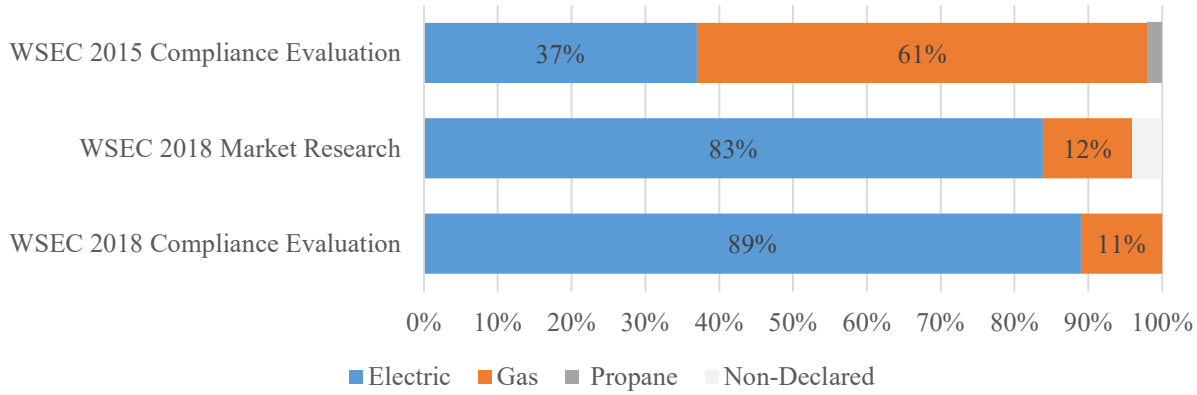

Figure 3. Primary single-family residential water heating fuel use under WSEC 2015 and WSEC 2018. *Sources:* Flynn and Caudill 2020, Lasher et al. 2022, and Albin et al. 2023.

Alternatives to Onsite Data Collection

This section provides lessons learned about approaches to assessing the market's response to a code change beyond onsite audits. Specifically, this section provides findings on limitations to the availability of permit data and the degree to which permits represent as-built conditions, details lessons learned from two data collection approaches that target residents of occupied homes, and explores the conditions under which these data collection efforts can be supplemented by existing databases of above-code homes and interviews with market across.

Permits

All five studies addressed in this paper explored the feasibility and limitations of permit data collection to support analyses of market response to code change and code compliance. Each study provides insight into the benefits and challenges of permit data collection as well as an assessment of the degree to which permits represent as-built conditions (among studies where adequate permit data were available).

Permit availability may not be comprehensive enough to support compliance analyses. For the in-progress Montana and Oregon Residential Code Compliance Evaluations (Kaufman et al. In progress a, Kaufman et al. In progress b), the evaluation team intended to use building energy permits (building permits that provide data about a home's energy performance relative to energy code requirements) as a primary data source. Once data collection began, however, IEc determined that they would be unable to collect sufficient data to support analyses. Under Montana's Building Energy Codes Program, some jurisdictions conduct local enforcement of building codes, whereas other jurisdictions are enforced by the state. Among jurisdictions enforced by the State of Montana, many of which are smaller and more rural jurisdictions, no energy permits are required. Further, permits available in locally enforced jurisdictions often did not contain the specific values needed to support analysis (for example, documenting only whether a home passed or failed inspection without listing the results). In Oregon, IEc found that, when available, permits did not contain energy code information needed to support analysis.

Code enforcement agencies' willingness to share permits varies considerably. Even in states where the code enforcement and permitting process should yield an adequate sample of permits, accessing those permits may be challenging if code officials are not willing or not able to share them. NEEA's code research and evaluation projects in all four states have found considerable variability in how willing code enforcement agencies are to share permit data. Specifically, in Washington, TRC found that some jurisdictions destroy permit documents after 90 days or require that documents be viewed in person. In Idaho and Montana, IEc found that non-response and refusals were a substantial challenge to obtaining permit data. Further, rural jurisdictions had a higher rate of refusals, non-response, and lack of permit data compared to urban jurisdictions. In some cases, building officials indicated they were the sole employee of the jurisdiction's building department and did not have time to provide the data. In other cases, they refused to provide data or did not respond to multiple phone and email requests; this could reflect lack of data, time constraints, and/or attitudes toward code compliance studies.

When permit data are available, they likely provide reliable information for some, but not all, measures. In the Washington Residential Code Compliance Evaluation, TRC was able to compare permit data to virtual audit data collected for the same home. They found that "permits generally represented installed equipment but were less reliable for leakage test results" (Albin et al. 2023, 4). Specifically, permits typically included accurate information about appliances and equipment, but they often included air leakage estimates that were better (that is, tighter) than the homes actually performed, as assessed by compliance certificates available in the home. Further reinforcing the accuracy of permit data for installed equipment, the Washington Post-Code Market Research Study (Lasher et al. 2022), which relied exclusively on permit data, and the Washington Residential Code Compliance Evaluation (Albin et al. 2023), which used both permit and virtual home audit data, yielded very similar results regarding the proportion of homes using primary electric space and water heating. Table 1 provides the data sources TRC used for each measure of interest when calculating compliance with WSEC 2018.

Table 1. Data Sources for Determining Compliance with WSEC 2018 (Albin et al. 2023)

WSEC 2018 Credit Category	Source for Determining Compliance
Fuel normalization	Virtual home audit data
Efficient building envelope options	Permit data
Air leakage control and efficient ventilation options	Virtual home audit data if available, otherwise permit data
High efficiency HVAC	Virtual home audit data
HVAC distribution system	Permit data
Drain water heat recovery	Permit data
Efficient water heating	Virtual home audit data
Renewable electric energy options	Combination of virtual home audit data and permit data
Appliance package options	Virtual home audit data

For the Idaho Residential Code Compliance Evaluation (Kaufman et al. 2024), IEc and Resource Refocus examined data collected from permits and onsite audits of in-progress homes and concluded that permits only included adequate data on three measures: window U-factor, window solar heat gain coefficient (SHGC), and ceiling insulation. Although other insulation data was available in the permits, in consultation with NEEA, the evaluators opted to gather wall and foundation insulation information through onsite audits to account for the insulation installation quality (IIQ). Minimum R-values are specified in code, but IIQ is not. Importantly, improper installation can affect overall assembly performance. Table 2 includes the data sources Resources Refocus used when calculating compliance. Given that permits only provided reliable data for three measures and the AXIS database was not a viable data source for this analysis (see "Databases of Above-Code Homes" section for more information), NEEA's Idaho Residential Code Compliance Evaluation used an approach that was very similar to the DOE approach.

Table 2. Data Sources for Determining Compliance with IECC 2018 with Idaho Amendments (Kaufman et al. 2024)

IECC 2018 with Idaho Amendments Component	Source for Determining Compliance
Envelop tightness	Onsite audit data
Window U-factor	Permit data
Window SHGC	Permit data
Wood-framed wall R-value	Onsite audit data
Mass wall R-value	Onsite audit data
Ceiling R-value	Permit data
Lighting equipment	Onsite audit data
Floor R-value	Onsite audit data
Basement wall R-value	Onsite audit data
Crawlspace wall R-value	Onsite audit data
Slab R-value and depth	Onsite audit data
Duct insulation	Onsite audit data
Duct leakage	Onsite audit data
Duct insulation in condition space	Onsite audit data

Organizations considering building energy permits as a data source for research or evaluation on the market's response to code changes should consider the following questions:

- To what degree are permits available across the state? Does the quality of the permit data differ across the state? How is code enforced, and are permits required in all areas of the state? What factors may influence how willing code officials are to share permit data?
- What information is available in permits, and to what degree does that information meet the research or evaluation needs? For example, does it include energy values for all key measures of interest? To what extent does permit data reflect as-built conditions? For data that is not included in permits, what other data sources are available?
- How will the study measure compliance for measures that rely on field measurements, such as air leakage and duct leakage?

Virtual Data Collection with Residents of Inhabited Homes

A conventional data collection approach using onsite audits of in-progress homes requires builders to allow access to building sites. This may create bias in the homes included in the study. Builders that do not support energy code, are not building to energy code, or are skeptical of the researchers' motives may choose not to participate or only allow access to a subset of homes. Data collection that obtains access to homes by working with residents avoids this bias and, further, enables collection of information about appliances or other energy-using devices that are added after the home is completed. It is important to note that, given the low response rate to recruitment found in previous studies (Albin et al. 2023), a large population is needed for this method.

Virtual audits of inhabited homes provide reliable, but not comprehensive, information on homes. Resident-based data collection approaches likely cannot collect reliable information on some measures, such as insulation, due to safety concerns or difficulty accessing some parts of the home. Further, residents may not be able to correctly identify measures of interest to the study. The Washington Residential Code Compliance Evaluation found that virtual home audits provided reliable information on installed HVAC and water heating equipment, installed appliances, and renewable energy sources (Albin et al. 2023; Table 1). TRC conducted virtual audits of inhabited homes built under WSEC 2018. Residents were recruited via mail to participate in a virtual audit where a trained TRC staff member would connect with them via video call and instruct the resident which areas of the home to visit and capture on camera. The auditor would then take a picture of the equipment or measure and later verify the information.

The Oregon Residential Code Compliance Evaluation is using a resident self-directed audit, conducted with an online survey platform, to collect information about inhabited homes built under the 2021 ORSC (Kaufman et al. In progress b). Primary residents are being recruited via mail to participate in a guided self-audit survey to provide data about and take pictures of key measures in their home. After data are submitted, trained NMR staff review the images for accuracy and completeness. Based on prior research using self-directed audits, audits are expected to provide reliable information on HVAC and water heating equipment, appliances, ventilation, and ducts, along with information on fuel use and some above-code elements.

Compliance certificates, when available, can provide a valuable source of information on air leakage performance and expand the information available for resident-based data collection approaches. In the Washington Residential Code Compliance Evaluation, TRC found that participants were able to locate a compliance certificate in 61% of homes. Compliance certificates in Washington are required, and they must include, among other elements, envelope post-construction air leakage test-out results as well as results from any required duct testing. This means that, for homes where a compliance certificate was located, TRC was able to collect home performance information that could otherwise only have been collected during a traditional onsite audit. This information then enabled TRC to compare (modeled) air leakage results included in permits to actual air leakage test results, which led to the finding that permits did not always provide reliable estimate of leakage.

Organizations considering resident-based data collection methods for research or evaluation on the market's response to code changes should consider the following questions:

- To what degree does the information available through audits of inhabited homes meet the research or evaluation needs? For "hidden" measures that are not accessible to homeowners, what other data sources are available?
- Are compliance certificates a code requirement in the state? If so, what proportion of residents have access to the certificate in their home?

Databases of Above-Code Homes

Using a verified database of above-code homes may provide a cost-effective way to gather data on some homes of interest, which frees up resources to conduct more cost- and time-intensive data collection in other homes. Further, databases of above-code homes likely include more information than permits or audits of inhabited homes individually. NEEA has explored or is in the process of exploring using such databases – the AXIS database and the RESNET[6] database – to understand code compliance and the market's response to a new code.

In Oregon, IEc has found that the AXIS database can serve as a reliable data source for above-code homes in the parts of the state within the Energy Trust of Oregon's territory, which accounts for about 85% of the state. Above-code homes make up about one-third of new construction homes in Oregon, so relying on AXIS data significantly reduces the amount of onsite data collection required. Because the Energy Trust of Oregon requires that energy code information is verified and entered into the AXIS database for a home to be certified, the AXIS database contains robust energy code information that can support evaluation.

The other two studies that have explored the viability of above-code databases for compliance evaluation have found them to be insufficient, and data from these databases were not included in the final analyses. TRC intended to use RESNET data in the Washington Residential Code Compliance Evaluation but found that, among homes of interest for the evaluation, entries represented only a small sample of builders and subdivisions and therefore were not representative of the whole state (Albin et al. 2023). Further, TRC found that the compliance rate among homes in the RESNET sample was considerably lower than compliance among homes included in the permit/virtual home audit sample. IEc and Resource Refocus intended to use the AXIS database in the Idaho Residential Code Compliance Evaluation but found that only one home in the database was in the permit or onsite audit samples, suggesting that there may be a lag between when homes are built and when their data are added to the AXIS database. Further investigation is needed to assess when homes are added to the database.

Organizations considering databases of above-code homes for research or evaluation on the market's response to residential code changes should consider the following questions:

[6] The RESNET database is a national registry of home energy ratings conducted by Home Energy Rating System (HERS®) raters. Raters gather information about the home using field verification and diagnostic testing (for example, blower door and duct blaster testing), often for the purposes of certifying the home for a utility program or above-code program, and record the information into the RESNET database. https://www.resnet.us/

- What data are included in the database, who enters the data, and what objectives are they trying to meet?
- How and when are data entered into the system? Does the timing meet the study's needs?
- Compared with other data sources, how representative are the data? Do they appear to provide a representative spread across key strata, such as jurisdictions' building permit volume or rural versus urban areas?

Surveys and Interviews with Market Actors

While surveys and interviews with market actors, such as builders and code officials, cannot provide reliable quantitative data to inform compliance analysis or a representative look at installed equipment, they can help identify areas where training, education, or compliance support are needed and provide "ground truthing" – that is, ensuring that results are representative of what market actors are actually experiencing.

The Washington Residential Post-Code Market Research study conducted a survey of builders to collect early feedback on WSEC 2018, which enabled TRC to collect builder narrative around why they were choosing certain compliance pathways. TRC identified builders using home builder associations' publicly available contact or member lists. Both the Montana and Idaho Residential Code Compliance Evaluations include interviews with code officials and builders to assess what elements of the code are most challenging to comply with, validate and explain observations from other data collection activities, and identify areas where additional training and/or compliance assistance could improve compliance on key measures. Recruitment has been challenging, however, particularly for homebuilders, which could reflect the busyness of the homebuilders and/or skepticism about participating in a code compliance evaluation.

Organizations considering surveys/interviews with market actors for research or evaluation on the market's response to code changes should consider the following questions:

- Would qualitative insight from market actors help address the research questions beyond what can be gleaned from quantitative data sources?
- What existing relationships can be leveraged to reach and build trust with market actors?

The Importance of Local Collaboration

Across the five studies addressed in this paper, collaboration with local market actors was essential. Local market actors are familiar with the nuances of their state's code and enforcement approach and can provide valuable insight into sampling and data collection methodologies. For example, for jurisdiction-based sampling approaches, local market actors may be able to provide useful guidance on the nuances and trade-offs of various sample options that non-local stakeholders may not be aware of. Further, local market actors can support data collection by making introductions to builders, code officials, or other actors of interest or by informing recruitment language that will resonate with other local actors. In Idaho and Montana, IEc convened technical advisory groups (TAGs) of local experts to inform the sample design. These groups helped select between candidate sampling plans and also provided useful guidance on the team's data collection approach. Some TAG members also made connections with builders. In Washington, TRC worked with local builders and programs to increase response rates to the

builder survey. In Oregon, NEEA is actively collaborating with the Energy Trust of Oregon to inform the team's understanding of the code and guide efforts to capture above-code homes.

Conclusions

The studies summarized in this paper explored the feasibility of alternative approaches to assessing the market's response to code changes: permit data collection, resident-driven data collection of inhabited homes, databases of above-code homes, and surveys or interviews with market actors. NEEA has determined that alternatives meet its needs in terms of project timing, budget, flexibility to increase the number of sites in rural areas, but each alternative approach also has limitations. NEEA and its contractors have identified the following three takeaways that will guide NEEA's residential code research and evaluation approaches in the future.

Studies that seek to use data collections methods other than onsite audits should draw from multiple data sources. All data sources that can inform code compliance estimation and broader assessments of the market's response to code have limitations. Table 3 summarizes the benefits and constraints of each data source assessed. Code research and evaluation projects that seek to use data sources other than onsite audits will benefit from a triangulation approach where multiple data sources are collected and then assessed for which provides the highest quality data for each individual measure. It is important to note that if multiple data sources are used for Monte Carlo modeling or similar approaches, it is essential to coordinate between the data sources to maintain the appropriate sample sizes in each jurisdiction, either by selecting a subset of observations or applying weights to each observation. As an example, care must be taken to not oversample above-code homes if using an above-code database as a data source.

Table 3. Benefits/Constraints of Data Sources for Assessing Market Response to Code Changes

Data Source	Benefits	Constraints
Onsite audits of in-progress homes	Provide comprehensive information on hidden measures and installed equipment	Time-consuming and costly Require recruitment through builders
Permits	Less expensive and time-consuming than audits Provide reliable information on installed equipment	Availability may be limited Leakage performance (and other key measures) may not be accurately captured
Virtual audits of inhabited homes	Less expensive and time-consuming than onsite audits Provide reliable information on installed equipment	Require recruitment through homeowners Hidden measures are likely not accessible
Databases of above-code homes	Less expensive and time-consuming than audits	Data may not be comprehensive, representative, or timely enough to support evaluation
Surveys/interviews with market actors	Provide qualitative information on the market's response to code	Do not provide generalizable quantitative data for evaluation

Recruitment is challenging for all data sources, particularly in rural areas. These studies have demonstrated that all data sources, including onsite audits, involve recruitment and data collection challenges. For example, code officials may be unwilling or unable to share permit data, both builders and residents may be reticent to allow access to homes, and market actors may be too busy or unwilling to participate in surveys or interviews. In the Washington Residential Code Compliance Evaluation, the overall recruitment rate for participants in the virtual audit was 0.8%, meaning that just under one person per one hundred recruitment mailers responded and completed an audit (Albin et al. 2023). While the recruitment mailers were relatively cheap, this method requires a large population to reach a sizeable sample. Research across Idaho and Montana has shown that these challenges are particularly prevalent in rural areas. Specifically, rural areas had more refusals and non-responses to requests for permit data. In Montana, among jurisdictions enforced by the state, many of which are smaller and more rural jurisdictions, no energy permits are required. In both states, rural jurisdictions are more time-consuming for inspectors to travel to and often have lower levels of building activity, making it difficult to find homes at the right stage of construction to inspect.

Flexibility and collaboration are key. NEEA's exploration of alternative methods to assess the market's response to code changes has required considerable flexibility and collaboration from NEEA, its third-party contractors, and its partners. Because many alternative data sources had not yet been evaluated in NEEA's four-state region, some studies invested resources into sources that, in the end, did not inform analysis (for example, permit data in Montana and data from databases of above-code homes, such as RESNET in Washington and AXIS in Idaho). While these efforts were worthwhile because they informed ongoing work to continuously improve the methodology NEEA uses to assess the market's response to code, they required that both NEEA and its evaluators continuously re-visit the best way to meet each study's research objectives. Moving forward, NEEA intends to implement the lessons learned in each state and lean more heavily on local partners in each state when beginning future research and evaluation projects that assess the market's response to a code change.

References

Albers, N., R. Bliss, and K. Johnson. 2024. "Codes Market Progress Evaluation Report #5." Portland, OR: Northwest Energy Efficiency Alliance. https://neea.org/resources/codes-mper-5

Albin, L., M. Goebes, G. Marr, B. Close, G. Lasher, B. Faris, S. Jones, B. Farnsworth, L. Medal, S. Srinivasan, and Y. Beesemyer. 2023. "Washington Residential Code Evaluation." Portland, OR: Northwest Energy Efficiency Alliance. https://neea.org/resources/washington-residential-code-evaluation

American Council for an Energy-Efficient Economy. 2022. "Compliance." https://database.aceee.org/state/compliance

Bartlett, R., M. Halverson, V. Mendon, J. Hathaway, and Y. Xie. 2022. "Residential Building Energy Code Field Study: Data Collection & Analysis Methodology." Washington, DC: U.S.

Department of Energy. https://www.energycodes.gov/sites/default/files/2022-09/bto-Res-Field-Study-Methodology--updated.pdf

Bartlett, R., M. Halverson, and Y. Xie. 2019. "Idaho Residential Energy Code Field Study." Washington, DC: U.S. Department of Energy. https://www.energycodes.gov/sites/default/files/2019-09/Idaho_Field%20Study_State_Report.pdf

Cadmus Group. 2013. "Washington Residential Energy Code Compliance." Portland, OR: Northwest Energy Efficiency Alliance. https://neea.org/resources/washington-residential-energy-code-compliance

ERS and IEc. 2016. "Advanced Energy Codes Impact Evaluation Interim Report: First Delphi Process Results." Albany, NY: NYSERDA. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/PPSER/Program-Evaluation/2016ContractorReports/2016-advanced-energy-codes.pdf

Flynn, P. and E. Caudill. 2020. "2019-2020 Washington Residential New Construction Code Study." Portland, OR: Northwest Energy Efficiency Alliance. https://neea.org/resources/2019-2020-washington-residential-new-construction-code-study

Kaufman, D., C. Lee, G. Englehart, C. Brown, A. LaRue, and R. Davis. 2024. "Idaho Residential Code Compliance Evaluation." Portland, OR: Northwest Energy Efficiency Alliance. https://neea.org/resources/idaho-residential-code-compliance-evaluation

Kaufman, D., C. Lee, G. Englehart, C. Brown, A. LaRue, and R. Davis. In progress a. "Montana Residential Code Compliance Evaluation." Portland, OR: Northwest Energy Efficiency Alliance.

Kaufman, D., C. Lee, G. Englehart, C. Brown, A. LaRue, R. Davis, S. Manning, J. Powell, and M. Woundy. In progress b. "Oregon Residential Code Compliance Evaluation." Portland, OR: Northwest Energy Efficiency Alliance.

Lasher, G., M. Goebes, D. Wildenhaus, B. Farnsworth, S. Jones, D. Halim, A. Gemme, N. Sreejayan, and J. Sinex. 2022. "Washington Residential Post-Code Market Research." Portland, OR: Northwest Energy Efficiency Alliance. https://neea.org/resources/washington-residential-post-code-market-research-report

Pivotal Energy Solutions. 2024. "AXIS." https://pivotalenergysolutions.com/#products

Residential Energy Services Network (RESNET). 2021. https://www.resnet.us/

U.S. Department of Energy. 2024. "Residential Energy Code Field Studies." https://www.energycodes.gov/residential-energy-code-field-studies

U.S. Department of Energy. 2024. "REScheck." https://www.energycodes.gov/rescheck