# Energy Trust of Oregon Impact Evaluation of the New Homes Program 2012–2019

Submitted by Apex Analytics LLC

April 11, 2023

# Contents

EnergyTrust of Oregon

# MEMO

**Date:** 4/13/2023
**To:** Energy Trust Board of Directors
**From:** Dan Rubado, Sr. Project Manager – Evaluation
Fred Gordon, Director of Planning and Evaluation
Scott Leonard, Program Manager – Residential
**Subject:** Staff Response to the 2012-2019 New Homes Billing Analysis

Apex Analytics completed a billing analysis of homes that received support for above-code energy performance from Energy Trust's New Homes program. The analysis showed systematic errors in the simulated energy use of program homes and much lower than expected energy savings, when evaluated against a matched comparison group of similar, non-program homes. Not only did the program homes use more energy than expected from the simulations, but their non-program counterparts used less energy than expected. This resulted in a relatively narrow gap between program and non-program home energy usage, equating to low energy savings and realization rates. These results indicate the program's impact on individual new construction projects is relatively small. This is partly due to the unexpectedly high performance of homes not affiliated with the program, indicating they may have been built above the energy code standards at the time of construction. Another interpretation is the program's simulation models, and the embedded assumptions about how builders comply with code, are not accurately modelling the choices builders make in practice. Since non-program homes are performing better than expected, it is more difficult for program homes to exceed this elevated baseline. However, this conclusion does not recognize the nearly two-decade history of the program in influencing the market and working with code officials to advance residential energy codes over several code update cycles.

The program has a strong relationship with the Oregon Building Code Division and has worked closely with officials to provide information and recommendations about code updates. These activities, combined with the program's project level impacts, have influenced the code and the entire residential new construction market to create market conditions where program and non-program homes are being built to relatively high levels of performance. Part of the stated purpose and justification for the New Homes program is to transform the residential new construction market, which will be cost-effective over the long run, even if individual projects are not in the short run. With that perspective in mind, we have the following responses to Apex's recommendations for the New Homes program.

1. ***Recommendation to direct downstream savings impacts of the program.*** *Future efforts may consider examining the annual energy use of new homes built during the same timeframe but in other communities outside of program areas*.

   At the core of this recommendation is an assertion that Energy Trust should determine the energy savings claims for program homes using a market baseline by comparing energy use in program homes to those built outside the program. While this makes sense in many markets, and is consistent with Energy Trust guidelines, the new homes market is a special case due to the integral impact of Energy Trust's and the Northwest Energy Efficiency Alliance's (NEEA) efforts on codes and practice in Oregon.

Counter to Apex's recommended approach, we believe the New Homes program should continue using the current energy code as the baseline against which energy savings are measured and claimed for participating homes.

The program's activities over the past two decades have allowed the current energy code to become as stringent as it is today and have helped builders both meet and exceed energy codes. Energy Trust provides data to stakeholders involved in the code development process, to indicate whether the construction industry is ready to adopt above-code building practices into the next code, based on adoption rates in Energy Trust programs. The program has also introduced new measures and building techniques into the market, widely promoted efficient practices to make them more common, worked with code officials to adopt new requirements and supported builders to meet and exceed new requirements after new codes are adopted. Without this support, new homes would not only fall short of the current energy code, we believe the energy code itself would be a much lower bar. Therefore, all energy performance improvements in program homes beyond the energy code can be attributed to the program, either through its direct influence on individual projects, or its broader influence on shifting the codes and market over time. As such, Energy Trust should continue to use the energy code as the baseline when claiming savings for New Homes projects.

In practice, this means the program should continue to create an energy simulation model to estimate the energy use of each program home. Then a separate simulation should be specified as minimally code compliant and compared to the as-built simulation to estimate the difference in energy usage. This course of action is contingent on calibrating the energy simulation models used by the program and adjusting the energy modeling process to better align with current conditions and the observed energy performance, as described in more detail below. As an alternative path, the program is expanding its prescriptive measure portfolio to use in place of energy simulations, estimating savings for each efficiency measure above the code requirements for individual systems. This approach does not capture the nuances of individual homes, nor account for interactions between measures, although it avoids many of the pitfalls of simulation models described in this report, as well as the administrative burden of the energy simulation process.

2. ***Recommendation to support market effects.*** *Energy Trust may consider additional research to help identify market effects and how influential the program may be in advancing above-code construction.*

   We agree that market research is necessary to confirm the influence of the New Homes program and NEEA on market transformation, residential energy codes and the degree to which they have been transformed. If existing evidence and research on market transformation influence is insufficient, Energy Trust's Evaluation team will conduct follow-up market research in 2024 for this purpose. This would include interviews with a variety of market actors, including those who work outside of the program, to help establish how much the program's activities and the building practices it promotes have influenced market actors and code updates over the years. However, we do not see value in pursuing additional research related to building practices in states that have no residential new construction programs to create a point of comparison to building practices in Oregon. There are too many differences between states – from climates and building codes and regulatory environments – to obtain any reliable or actionable information from such an exercise.

We will consider conducting field research to verify code compliance and above-code efficiency measures and building practices in program and non-program homes. However, we foresee this type of field research being costly and it may not provide much additional value to Energy Trust in making a market transformation case, although it may be useful for improving the accuracy of energy simulations. A less costly alternative would be to consult data from NEEA's forthcoming Residential Buildings Stock Assessment (RBSA) to determine newer homes' relative energy performance and whether they are likely to meet or exceed the energy code.

If follow-up research confirms the program's role in helping to transform and shift the residential new construction market, this will provide further support for our assertion that we use the current energy code as the baseline for program homes when claiming savings. In addition, the program will develop a more formal market transformation strategy and logic model to ensure that it is positioned to continue pushing the new construction market and code towards higher efficiency.

3. ***Recommendation to address some of the program-side drivers behind savings realization rates.*** *Energy Trust should conduct an internal review and validation of the process associated with AXIS database data entry and program verifiers.*

   We agree the program needs to improve the accuracy of its energy savings estimates. However, part of the poor realization rates found in the evaluation may be due to non-program homes being built more efficiently than required by code. The energy simulation models used as the basis for these savings claims consistently underestimate energy use in program homes and slightly overestimate it for the code-built baseline. The New Homes program will calibrate the simulation models based on the energy use values listed for the most recent code cycle (2017) in this report. This may involve applying adjustment factors to simulation outputs or making adjustments to model assumptions.

   Energy Trust will analyze data for recently built homes in the forthcoming RBSA and align key model inputs and assumptions with RBSA results. This exercise should include inputs that are not known prior to occupancy and therefore not available to program verifiers during the simulation modeling process, such as number of occupants, occupancy schedule, presence of air conditioning, major plug loads (like hot tubs, freezers, etc.), thermostat temperature set points and schedule, and other drivers of home energy use. Inputting more accurate assumptions into the model should reduce the discrepancy between modeled and observed energy usage, on average. In addition, the program may need to make adjustments to the simulation models, or add correction factors to the outputs, to better account for interactive effects, especially with heat pump water heaters or similar equipment. Depending on where and how heat pump water heaters are installed in homes, they could have much larger space heating penalties than assumed in the simulation models, which could at least partly explain the low realization rates we observed in gas heated homes with electric water heating.

   Lastly, the program should review its processes for reviewing and validating data collection on-site by program verifiers and entry into the program's AXIS database. There may be points in this process where characteristics are incorrectly recorded on-site, data are incorrectly entered into the database, the program does not have sufficient visibility or oversight, the simulation software is using inappropriate default values, or there are errors in the simulation model itself. This review should include how data are captured, how quality control is conducted, and how the simulation models are specified and run. In addition to program processes, a review of technical processes with the database and modeling vendors may be necessary.

The program will consider conducting enhanced quality assurance for a time, to confirm certain key model inputs, especially in gas heated homes. This is in response to the findings in the report that program verifiers may be incorrectly recording the water heating fuel for some gas heated homes, and that other simulation model inputs may be incorrectly entered by verifiers. Enhanced quality assurance may include requiring verifiers to photograph the water heater and nameplate, along with other efficiency measures, or program staff could accompany program verifiers on home inspections to check that the water heater type and other parameters are recorded correctly. It may make sense to validate other key inputs while on-site.

4. ***Recommendation to adjust the assumed baseline "code" home.*** *If the program is unable to garner sufficient evidence to support substantial market transformation impacts, Energy Trust may also consider taking steps to calibrate the REM/Rate models with the energy use values reported here.*

   As noted above, if follow-up research finds that the New Homes program has not been pivotal in transforming the new homes market and the residential energy codes, then Energy Trust must consider transitioning the program to use a market baseline. In practice, this would involve calibrating the assumed energy usage of the baseline code homes to be in line with what was observed in this study for non-program homes. This could involve applying an adjustment factor to the code home simulation model outputs or adjusting the input parameters to achieve a similar outcome.

5. ***Recommendation to evolve and futureproof the program.*** *Consider alternate program design opportunities to advance building practices beyond current program requirements.*

   We agree with Apex that the program will need to continue to evolve its offerings and services to stay ahead of advancing codes. The program will identify, test, and support emerging advanced building practices and efficient technologies with enhanced incentives and services. This work has already started with the inclusion of new program offers such as net zero, battery storage/electric vehicle ready, and other initiatives, but the program will continue to look at alternative options. The program will help introduce new efficiency measures to the market and promote them to program builders and subcontractors. In addition to introducing more aggressive building techniques, the program may consider adopting more prescriptive measures focused on specific systems. This approach may help the program reduce its complexity and improve cost-effectiveness in the face of an increasing baseline efficiency, increasingly costly efficiency measures, and reduced energy savings. There is also some evidence from the interviews to suggest that some builders may be more responsive to more targeted offers for specific technologies and practices, at this point in the market's evolution.

   In addition, the program will consider how to better position itself as a market transformation program and what new activities it might undertake to continue pushing the entire market and ultimately codes. As stated above, depending on the outcome of new construction market research in 2024, Energy Trust may begin to quantify and claim above-code energy savings occurring in non-program homes, if it is established that the program is pushing the entire market beyond the current energy code. Having a clear market transformation framework will further increase the impacts of the program and add credibility to any market transformation savings claims that are made.

# Executive Summary

Energy Trust of Oregon (Energy Trust) has offered performance-based energy efficiency incentives to Oregon home builders through its New Homes program since 2009. Energy Trust expanded the program to builders in Southwest Washington in 2016. To participate in the program builders must become Energy Trust trade allies, going through training and signing participation agreements. The program provides builders with incentives, education, and training, among other support. Participating builders constructed almost 20,000 high-efficiency new homes in Oregon between 2012 and 2019 and 2,000 high-efficiency new homes in Washington between 2016 and 2019.

In early 2022, Energy Trust hired Apex Analytics (Apex) to validate electric and natural gas energy savings resulting from the New Homes program during the 2012–2019 timeframe. To estimate annual energy use, Apex followed a similar approach as previous studies, comparing energy usage from weather normalized billing data for program homes to energy use estimated by REM/Rate building simulation model. In addition, Apex purchased statewide assessor data to develop a matched comparison group of non-program homes, matching non-program homes to program homes based on closest geographic distances, square footage, and HVAC heating system types. The matched non-program homes served two purposes: to compare as-built conditions of non-program homes to reference homes used for REM/Rate simulation models, and to calculate energy savings by comparing weather normalized energy use of the program and matched comparison non-program homes.

To help draw supporting insights about the program and to identify potential drivers of differences between evaluated savings and program-claimed savings, Apex completed interviews with program and implementation staff, third-party program verifiers, and program trade ally builders. Benchmarking the results and methods from this evaluation relative to other evaluations uncovered additional insights.

The following information summarizes the key research objectives, questions asked, high-level descriptions of the approach, and key findings.

| Objective: Determine building simulation model accuracy in estimating annual energy usage. | |
|---|---|
| **Research Question** | **Approach** |
| Are program homes more efficient than building model estimates? | Compare the actual weather normalized energy use with building simulation modeled energy usage of program homes. |
| Do building model reference code estimates accurately reflect the energy use of non-program homes? | Compare the actual weather normalized energy use for the matched comparison non-program home with building simulation modeled energy usage for code-built specification of program homes. |

**Building simulation modeling does not accurately reflect actual energy use for program and non-program homes.** This evaluation found that program homes use more energy – and are therefore less efficient – and non-program homes use less energy – and are therefore more efficient – than predicted by the building simulation models.

| Objective: Determine building simulation model accuracy in estimating energy savings. | |
|---|---|
| Research Question | Approach |
| Do program homes use less energy than homes built outside of the program? | Compare program home actual weather normalized energy use relative to a matched comparison sample of similar homes. |
| What is the evaluated realization rate of program claimed savings? | Compare energy savings reported by the program relative to evaluated, in both absolute and relative (as a percent of annual load) terms. |

**Homes built through the New Homes program save energy, though not at levels reported.** The weather normalized billing data suggested that program homes use more energy than anticipated, while non-program homes use less energy than building simulation would predict. As a result, program homes save less energy than expected and the program has a relatively low savings realization rate.[1] Overall per home electric savings were 241 kWh versus 1,313 kWh claimed, resulting in a **18% electric realization rate.** For natural gas, overall per home savings were 35 therms versus 165 claimed, resulting in a **21% natural gas realization rate**.

| Objective: Determine energy savings variance based on household characteristics. | |
|---|---|
| Research Question | Approach |
| Do savings depend on factors like building vintage (year built) or applicable energy code cycle, square footage, space heating fuel, water heating fuel, builder type (large production vs. moderate or low-volume builders)? | Segment the analysis and energy savings results based on household characteristics. |

**While household attributes may drive some differences in achieved energy savings, they are not sufficient, alone, to drive the discrepancy between measured and reported energy savings.** Some groups tended to show higher realization rates than others, though no subgroups had realization rates aligned with program claims. The groups showing the strongest realization rates were moderately priced homes, built to earlier code cycles. Some groups showed higher electric realization rates while either opposite or indeterminate for natural gas, and vice-versa.

| Objective: Identify key drivers behind energy use and realization rate differences. | |
|---|---|
| Research Question | Approach |
| Are there factors within or external to the program that influence the energy simulation model, energy savings, or building practices across the new homes market? | Conduct series of interviews with program staff, program verifiers, and trade ally builders and benchmark other new homes evaluations. |

**The low savings realization rate across the New Homes program is a function of a multitude of factors.** Factors include building simulation modeling calibration, program tracking errors – especially with hot water fuel type, uncertainty around unidentified occupancy and behavioral characteristics, massaging of model inputs by verifiers, increased demand for energy-efficient homes among consumers in general, and spillover. Evidence from this

[1] The realization rate is the ratio of evaluated savings to claimed savings.

evaluation, from the quantitative impact, the qualitative interviews, and benchmarking, suggest the low realization rates are partly a function of all of these factors. Benchmarked studies have also found substantial evidence for spillover (market effects) from new homes programs.

In light of the findings presented in this study, there are some unresolved questions and recommendations for Energy Trust to consider.

1) **Recommendation to improve direct downstream savings impacts of the program**: **In future efforts, Energy Trust should examine the annual energy use of new homes built during the same timeframe but in other communities outside of program areas.**
    a. The analysis did not include homes built in other communities outside of the areas that included New Homes projects, by design. A benchmarked evaluation conducted for Wisconsin Focus on Energy added non-program groups outside of the program areas and found marginally higher baseline non-program energy use, improving the realization rates.
2) **Recommendation to measure market effects**: **Energy Trust may consider additional research to help identify market effects and how influential the program has been in advancing above-code construction.**
    a. Energy Trust should consider conducting outreach from voices not covered in this evaluation, namely from tradespeople (more broadly) and builders operating outside of the program.
    b. Energy Trust may consider benchmarking states with similar stringent building codes but lacking new homes programs.
    c. Energy Trust may consider collecting primary data through onsite research for program and non-program homes.
3) **Recommendation to address some of the program-side drivers behind savings realization rates: Energy Trust should conduct an internal review and validation of the process associated with AXIS database data entry and program verifiers.**
    a. Energy Trust should also work with PDC and PMC contractors to root out potential hot water fuel misclassifications. The negative savings realization rates for mixed fuel households revealed the potential for data entry errors.
    b. Energy Trust should work with verifiers to learn more about ways the current building simulation process is possibly being massaged to capture deeper, though maybe not realistic, energy savings.
4) **Recommendation to adjust the assumed baseline "code" home**: If the program is unable to garner sufficient evidence to support claiming substantial market transformation impacts, Energy Trust may also consider taking steps to calibrate the REM/Rate models with the energy use values reported here. This could include revising the assumed baseline code home accounting for the lower weather normalized energy use found in this study. The Wisconsin Focus on Energy program is currently adjusting baseline "code" homes in building simulation models after several years and multiple studies attempting to explain lower than anticipated evaluated realization rates.

5) **Recommendation to evolve and futureproof the program: Consider alternate program design opportunities to advance building practices beyond current program requirements.**

   a. Energy Trust could help builders stay ahead of the market by advancing higher-efficiency new construction, through pilot offerings, deeper incentives, training and other support, for efforts including net-zero homes, microgrid-enabled communities, passive-house design and developments, or even greater tiered options to exceed current stretch code requirements. These efforts should include establishing baseline building practices and logic models with key performance criteria to support future market transformation claims.

# 1. Introduction

This report details the approach and findings from an impact evaluation of the Energy Trust of Oregon (Energy Trust) New Homes program. Energy Trust has offered a residential New Homes program since 2009. The New Homes program provides trade ally builders training, support, and performance-based incentives to build homes that exceed statewide building code for energy efficiency. The performance-based incentives are based on a home's Energy Performance Score (EPS), a building energy scoring system based on building energy simulation to quantify savings for homes designed to exceed energy efficiency standards in the state building code. New Homes program savings have been evaluated twice and were last evaluated in 2018 for program years 2015-2016.[2,3] The primary goal of past analyses was to understand how building simulation (REM/Rate) energy models estimated program home energy use relative to actual weather normalized billing data use. This current evaluation, conducted by Apex Analytics (Apex), reviews an extended timeframe of program home participation data (2012–2019) and expands the analysis to compare actual weather normalized billing data use between program homes and a comparison group of similar, new construction homes built outside of the program. This report contains the following sections:

- Background
- Evaluation objectives
- Methodology
- Impact findings
- Exploratory interviews
- Benchmarking
- Conclusions and recommendations

# 2. Background

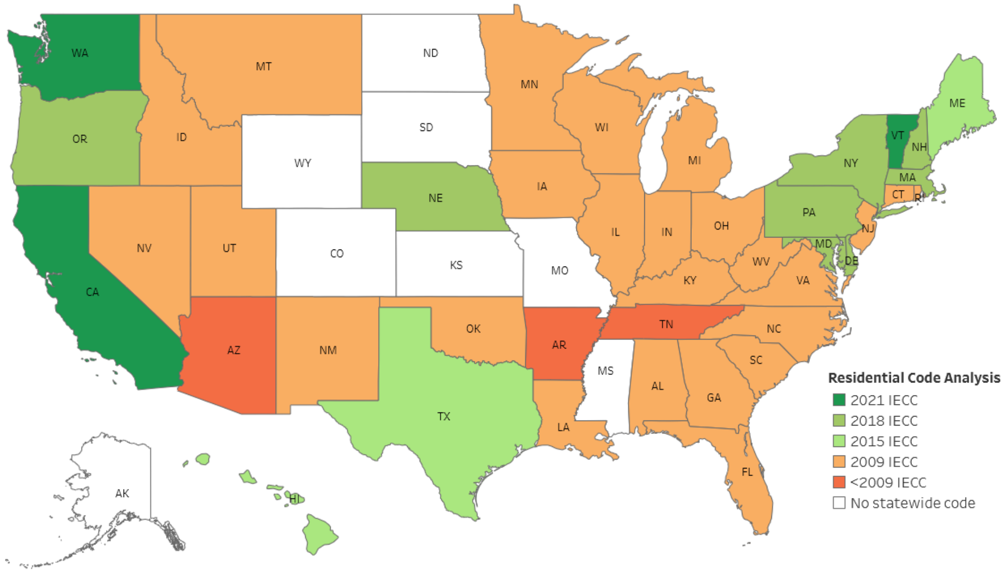
Over the past 20 years, Oregon and Washington have led the country in advancing higher efficiency-focused statewide building codes (see Figure 1 **Error! Reference source not found.** below).[4] A big push towards advancing building code began in 2006, when Oregon Governor Ted Kulongoski mandated a 15% increase in new residential construction energy performance by 2015. Resulting from this order and enacted during the evaluation 2012–2019 timeframe, Oregon passed two updates to their statewide residential building code (in 2014, and again in 2017) while Washington went through one revision (in 2015). A summary table of building code updates is shown in Table 1 below.

[2] Rubado, Dan, Energy Trust of Oregon, June 2015. 2009–2011 New Homes Billing Analysis. Accessed at https://www.energytrust.org/wp-content/uploads/2016/12/2009-2011_New_Homes_Billing_Analysis.pdf

[3] Cadeo Group, April 2018. EPS-HES Comparison Analysis. Accessed at https://www.energytrust.org/wp-content/uploads/2018/07/EPS-HES-final-report-wSR-final.pdf

[4] Information compiled from the https://bcapcodes.org/code-status/state/oregon/ website.

Figure 1. State Residential Energy Code (as of June 2022)




*Source: Department of Energy State Code Tableau-based reporting, available at: https://www.energycodes.gov/status/residential*

Table 1. Oregon and Washington Building Code Updates

| State | Code Version | Code Based on | Code Enforced Starting | Code Enforced Ending |
|---|---|---|---|---|
| OR | 2011 | 2009 IECC | 7/1/2011 | 12/31/2014 |
| OR | 2014 | State-developed, more stringent vs. 2009 IECC | 1/1/2015 | 12/31/2017 |
| OR | 2017 | Intl. Residential Code 2015 (IRC 2015) | 1/1/2018 | 9/31/2021 |
| WA | 2012 | 2012 IECC | 7/1/2013 | 6/30/2016 |
| WA | 2015 | Intl. Residential Code 2015 (IRC 2015) | 7/1/2016 | 1/31/2021 |

## 2.1 Program Description

Energy Trust's New Homes program offers builders incentives for new homes built with efficiency levels that exceed the building code minimum requirements. Energy Trust staff set the above-code building requirements based on discussions with builders, code officials, and program verifiers. Program verifiers began working with the program in 2012 and provide independent third-party inspection and verification of the new construction buildings. Some of the key upgrades builders use to qualify homes include efficient lighting, whole-home performance upgrades, higher levels of insulation, high-efficiency equipment and appliances, windows, air sealing, and solar systems. The program offers four unique tiered incentives, with higher-tiered incentives promoting more efficient construction. New

Homes incentives are based on a home's EPS, a measurement tool that assesses a home's energy use, estimated utility costs, and carbon impact. Energy Trust developed the performance-based EPS track in 2008 in response to the more stringent state building code mentioned above and the limitations of the prescriptive ENERGY STAR® framework. EPS was formally launched in mid-2009 along with an education and promotion campaign to recruit builders, verifiers, and real estate professionals. The EPS allows builders to clearly demonstrate how efficient the home is beyond code and helps homebuyers compare homes based on energy costs and efficiency.

To qualify for incentives, builders must become Energy Trust trade allies. Energy Trust program staff provide training to builders to encourage early-stage project inclusion during the design stage of new construction. Program-qualified new homes must be inspected by a third-party verifier before drywall is installed. If the building plans are set or construction has just begun, Energy Trust will provide free project modeling using the home plans. The verifier uses REM/Rate energy modeling software to estimate the energy savings of the home and determine the incentive amount. Energy savings are estimated based on the program home estimated energy use difference from a reference code home as defined in the REM/Rate modeling software. Energy Trust offers additional incentives for solar electric systems. The verifier inspects each home after insulation is installed and before drywall is completed, and also performs diagnostic tests to evaluate energy performance. Once construction is complete, the verifier returns for a final visit to ensure the home meets EPS requirements. The verifier updates the project model (stored in the AXIS database system[5]) with inspection details and performance results, confirms the energy savings and cash incentives, and issues the final EPS certificate.

The New Homes program savings has been evaluated twice since 2009: the first impact evaluation was conducted by Energy Trust staff in 2015[6] (for program years 2009–2011), and the second impact evaluation was conducted by Cadeo in 2018[7] (for program years 2015–2016). The primary goals of the prior evaluations were to determine the accuracy of modeled energy use reported by the New Homes program to claim savings, assess how modeled estimates perform in real-world conditions, and help better calibrate the models to improve energy use and savings estimates. The studies were also used to provide feedback to NEEA and Northwest utilities that were investigating similar performance-based incentive programs for new residential construction. The previous two evaluations found some areas of misalignment between actual and building model energy use and recommended calibrating the building simulation models to account for the differences.

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[5] AXIS is a Pivotal Energy Solutions cloud-based software product. AXIS software includes a centralized database and user interface to integrate energy ratings and energy efficiency program participation through data sharing by connecting raters/verifiers, certification organizations, QA organizations, utilities and others.

[6] Rubado, Dan, Energy Trust of Oregon, June 2015. 2009–2011 New Homes Billing Analysis. Accessed at https://www.energytrust.org/wp-content/uploads/2016/12/2009-2011_New_Homes_Billing_Analysis.pdf

[7] Cadeo Group, April 2018. EPS-HES Comparison Analysis. Accessed at https://www.energytrust.org/wp-content/uploads/2018/07/EPS-HES-final-report-wSR-final.pdf

Though these studies were useful in providing Energy Trust with comparisons of actual weather normalized billing usage relative to building simulation usage, they did not compare program home use against a baseline non-program energy usage comparison group to validate modeled versus actual energy savings. Furthermore, previous studies lacked the ability to discern the energy use of non-program homes or to understand how non-program homes usage compared against the baseline reference code homes from the REM/Rate building simulation models. This study is an attempt to close this gap, allowing Energy Trust to gain insight into validated energy savings from program-built homes against a reference non-program-home baseline.

## 2.2 Historical Program Activity

The New Homes program experienced slow but steady growth in participation by trade ally builders since inception in 2009. The annual program participation rates – provided by Energy Trust staff – across Oregon (since 2009) and Washington (since 2016) are shown in Table 2 below (current evaluation 2012–2019 timeframe is thick-bordered). According to calculations compiled by the program implementation contractor, TRC Companies (TRC), using the assessor database, participating program homes currently represent approximately 35% of newly built homes in Energy Trust's service territory in Oregon and Washington. The share of new homes participating in the program has increased over time in line with participation. According to program staff, the percentage of electric- versus gas-heated participating homes is consistent with the current housing stock heating fuel saturations.

Table 2. Annual Program Participation and Savings by State and Heating Fuel

| Year | Number of Program Homes | | % Electric-Heated Program Homes* | | % Gas-Heated Program Homes* | | Program as % of Total New Homes | Claimed Electric Savings (kWh) | Claimed Natural Gas Savings (therms) |
|---|---|---|---|---|---|---|---|---|---|
| State | OR | WA | OR | WA | OR | WA | All | All | All |
| 2009 | 292 | - | 29% | - | 69% | - | 13% | 821,500 | 105,110 |
| 2010 | 616 | - | 19% | - | 79% | - | 13% | 472,200 | 72,510 |
| 2011 | 813 | - | 17% | - | 82% | - | 20% | 686,400 | 116,370 |
| 2012 | 1,319 | - | 24% | - | 75% | - | | 1,291,711 | 197,791 |
| 2013 | 1,540 | - | 20% | - | 80% | - | | 1,512,435 | 227,483 |
| 2014 | 2,178 | - | 16% | - | 84% | - | | 2,098,437 | 223,646 |
| 2015 | 2,530 | - | 15% | - | 84% | - | | 2,779,255 | 351,859 |
| 2016 | 3,342 | 671 | 20% | 4% | 80% | 92% | | 5,490,995 | 555,173 |
| 2017 | 3,125 | 793 | 16% | 0% | 84% | 98% | 34% | 4,851,627 | 498,413 |
| 2018 | 2,755 | 711 | 17% | 0% | 82% | 100% | 31% | 5,091,630 | 524,899 |
| 2019 | 3,051 | 741 | 16% | 0% | 84% | 100% | 32% | 4,369,552 | 553,580 |

**The percentages may not add up to 100% because some sites are missing information about heating system fuel or have non-electric or non-gas heating system fuels listed in CRM.*
*** Source: Provided by Energy Trust staff*

To estimate annual energy savings, the New Homes program relies on program verifiers to enter program homes' characteristics into the REM/Rate model to determine anticipated annual energy use coupled with the baseline reference code-home energy use. This data is entered into the AXIS database system where the program tracks program-claimed energy savings. Apex summarized the average reported energy use by relevant state and building code cycle for each primary fuel type according to the AXIS system for program homes, the average reference baseline code-home use, and the difference between the two (average savings). As demonstrated in Table 3 below, the New Homes program assumed average per home 15% electric energy savings and average per home 30% natural gas savings for Oregon homes (Washington gas savings were lower, at 23%).

Table 3. Average New Home Program Claimed Usage and Savings (per Rem/Rate)

| State and Code Cycle | Electricity Use and Savings (kWh) | | | Natural Gas Use and Savings (therms) | | |
|---|---|---|---|---|---|---|
| | Program Home | Reference Home | Savings | Program Home | Reference Home | Savings |
| **Oregon** | **7,705** | **9,018** | **-15%** | **409** | **584** | **-30%** |
| OR2011 | 7,957 | 8,875 | -10% | 451 | 617 | -27% |
| OR2014 | 7,964 | 9,474 | -16% | 386 | 564 | -32% |
| OR2017 | 6,505 | 7,902 | -18% | 411 | 590 | -30% |
| **Washington** | | | | **387** | **504** | **-23%** |
| WA2012 | | | | 380 | 546 | -30% |
| WA2015 | | | | 389 | 493 | -21% |

**Source: Apex calculated averages from the AXIS tracking system*

## 2.3 Glossary

For this evaluation, it is important to set clear definitions around the evaluated components. Some definitions are provided below.

- **Program Home**: Any new construction home affiliated with an Energy Trust funding utility that met or exceeded program requirements and was built between 2012 and 2019 (for Oregon) or between 2016 and 2019 (for Washington), where the builder received an incentive and the home existed in Energy Trust's program tracking database.
- **Non-Program Home**: Any new construction home identified through a purchased assessor dataset that was built in Oregon or Washington between 2012 and 2019, where the builder did not receive an incentive and the home was not in the program tracking database.
    - **Comparison Matched Home**: A subset of non-program homes that were matched to program homes by location (would also be served by Energy Trust funding utility), HVAC type, and square footage (greater details on the matching logic is provided below in Impact Analysis Approach section).
- **Reference Home**: The series of baseline reference "homes" used for building simulation modeling to represent a code-built home. Used to estimate program-claimed savings from program model estimated usage.

- **Weather Normalized (WxN) Energy Use**: A home's annual energy use, according to actual billed usage, and normalized to account for weather (electric in kWh or natural gas in therms).
- **Building Simulation (Sim) Model Use**: A home's estimated annual energy use according to REM/Rate building simulation software used by the program (electric in kWh or natural gas in therms).
- **Evaluated Energy Savings**: The weather normalized energy use difference between a program home and matched comparison non-program home (electric in kWh or natural gas in therms).
- **Program Claimed Savings**: The building simulation modeled energy use difference between a program home and reference code home (electric in kWh or natural gas in therms).
- **Realization Rate (RR)**: The ratio of evaluated energy savings to program-claimed savings. A realization rate above 1.0 (or 100%) implies evaluated savings exceeded program claimed, anything below this implies evaluated savings fell short of program claims.

# 3. Evaluation Objectives

The primary research objective of this impact evaluation was to verify the electric and natural gas savings attributable to the Energy Trust New Homes program for Oregon and Washington during the 2012–2019 timeframe. Apex first assessed the accuracy of the building simulation models by comparing weather normalized use to modeled use for both program and matched non-program new homes. Then we estimated energy-use savings by comparing weather normalized use of program homes to the matched non-program homes. This impact evaluation also sought to understand the drivers behind any observed differences in savings from the impact research. The specific research objectives for this study are discussed in Table 4.

Table 4. New Homes Impact Evaluation Objectives, Questions, and Approach

| Research Objective | Research Question | Approach |
|---|---|---|
| **Determine building simulation model accuracy in estimating annual energy usage.** | Are program homes more efficient than building model estimates? | Compare the actual weather normalized energy use with building simulation modeled energy usage of program homes. |
| | Are non-program homes more efficient than building model reference code estimates? | Compare the actual weather normalized energy use for the matched comparison non-program home with building simulation modeled energy usage for code-built specification of program homes. |
| **Determine building simulation model accuracy in estimating energy savings.** | Do program homes use less energy than homes built outside of the program? | Compare program home actual weather normalized energy use relative to a matched comparison sample of similar homes. |
| | What is the evaluated realization rate of program claimed savings? | Compare energy savings reported by the program relative to evaluated, in both absolute and relative (as a percent of annual load) terms. |
| **Determine energy savings variance based on household characteristics.** | Do savings depend on factors like building vintage (year built) or applicable energy code cycle, square footage, space heating fuel, water heating fuel, builder type (large production vs. moderate or low-volume builders)? | Segment the results based on household characteristics. |

# 4. Methodology

To address these research objectives and questions, Apex collected, processed, standardized, and analyzed numerous datasets, developed a process to match non-participating homes with participating homes based on a series of attributes, and estimated participating new homes' energy savings net of the matched non-participating home baseline. The following section details the approach used to determine electric and natural gas impacts from the 2012–2019 New Homes program.

## 4.1 Impact Analysis Approach

To estimate the energy impacts of the New Homes program, Apex compared weather normalized billing data for program homes against the matched non-program-home baseline. To run this analysis, we followed these key steps:

- Cleaned and processed tracking and assessor data sets.
- Merged program home addresses from tracking with assessor data set using software designed for this purpose called fuzzy join.

- Established a "test / validation" matching process using within program (program versus program) homes using known program tracking parameters
  - Matching process relied on home vintage, home square footage, location, neighborhood type (urban/suburban/rural), building type, home space heating fuel, and water heating fuel.
- Applied this same matching process to identify non-program homes using purchased statewide assessor data for all newly built OR and WA homes since 2009.[8]
- Requested electric (OR only) and natural gas (both OR and WA) billing data for program and matched non-program baseline homes.
  - Energy Trust staff performed the address merge to pull billing data for accounts on their system.
- Cleaned billing data sets.
- Merged dataset incorporating relevant home characteristic data from program tracking (program homes) and assessor data (non-program homes).
- Conducted Variable Base Degree Day (VBDD) modeling of billing data and weather normalization using the TMY3 data set.
- Reviewed data for outliers and flagged anomalous data.
- Compared the usage (savings is difference between program and non-program home annual weather normalized energy usage).
- Segmented the results.
- Developed confidence and precision estimates.

Developing the counterfactual (from matched non-program homes) to program home energy usage was a central component of this evaluation. To build this counterfactual, Apex required a comparison group of matched homes outside the program with sufficient data, both for the matching itself and for analysis of their energy usage. Because non-participating homes were not program participants, data normally ingested via the program were not available (i.e., building attributes, including mechanical, structural, and footprint). Apex identified data vendors that sell residential property data from publicly available assessor databases and compared the availability of particular property characteristics (percent of variables populated, at the county level). Ultimately, Apex purchased data from Estated, one such assessor data vendor.

Apex reviewed and standardized the Estated premise level data and then merged this dataset with tracking and Utility Customer Information (UCI) billing data using address matching logic. We then validated the Estated data, focusing on the following:

- **Year Built** (and applicable energy code, by extension)
- **HVAC System/Fuel Type**
- **Home Size**
- **Location** (Latitude and Longitude)

[8] Though this analysis focused on new homes built between 2012 and 2019, Apex included several additional years of new construction data from the assessor data purchase to account for potential misalignment in construction timeframes.

During initial data intake and processing, the Apex team verified that all required files and fields were provided by Energy Trust staff. Apex also checked the data to assess validity before moving on to the analysis. We also tested data source crosswalks for missing account/premise data and developed matching logic to merge Estated assessor data with program-tracking and utility-billing data.

Apex downloaded Census shapefiles representing the geometric boundaries of Urban, "Urban Cluster" (small town/suburban), and Rural areas. Then, we used the ArchGDAL GIS package to determine whether a point (new built residence) was inside a given boundary and assigned it the corresponding designation. This designation was then used in the matching process.

Apex generated five matches per program home to represent the assumed baseline "code" home according to REM/Rate, with the expectation of some attrition after matching. The matching algorithm had the following parameters:

- **Year Built:** Matches had to be built in the same or prior year as the program home.
- **Urban/Rural:** Matches had to fall into the same Urban/Urban Cluster/Rural designation as the program home.
- **Least Distance:** A least distance matching algorithm by home square footage and home location determined the best matches fitting the two prior criteria. The two parameters were normalized to weight them similarly, according to the following logic:
  - **Home Square Footage** was normalized to 2.5% increments from the program home square footage and capped at a maximum difference of 350 square feet.
  - **Locational Distance** was normalized to 750-meter (0.466-mile) increments from the program home location for Urban and Urban Cluster homes, and 7500-meter increments from the program home location for Rural homes. Homes 200 meters away or less were all considered to be 200 meters away to avoid overweighting nearness within a neighborhood.

To assess the effectiveness of the matching algorithm, we first matched program homes to other program homes and compared data not used in matching, including energy use.[9] This verification step indicated a high degree of alignment in energy use between the program homes and their matches, providing confidence that the algorithm successfully matched similar homes. After this verification step, we proceeded to match non-program homes to program homes in order to estimate energy use differences between otherwise similar properties.

As an additional step after Energy Trust exported a second UCI data set of matched non-program homes, we used a combination of program and billing data to align HVAC heating system types between program and non-program matches. For program homes, we used system information where available to determine whether the home had natural gas heat and natural gas water heating. For program homes where this information was unavailable and for non-program homes, we used natural gas consumption in winter as an indicator of a gas heating system, and natural gas consumption in summer as an indicator of a gas water

[9] Each home was matched to multiple other program homes, with replacement. In this step, poor matching could result in misalignment, so it serves as a valid verification procedure before true program to non-program matching.

heating system. We did not attempt to align cooling information because of Oregon and Washington's mild climates in summer, which would make it more difficult to conclusively detect a cooling-equipped home in the electric billing data.

As in the study of 2009–2011 homes, Apex utilized site-level VBDD models with a two-dimensional (heating and cooling) grid search to determine the best model fit for heating and cooling load, for electricity and natural gas usage. We then used these best-fit models to generate energy use, weather normalized to TMY3[10], for comparison with REM/Rate results. For program homes, we compared the site-level results for modeled energy use from billing data with the modeling software outputs and assessed whether there had been any change in comparability since the last analysis.

We compared the counterfactual modeled energy use estimates for associated program homes from REM/Rate with the actual energy use of matched baseline code homes, weather normalized to TMY3, to assess how well the modeling software captures code-home energy use. This analysis allowed the team to explore whether code-built homes have complied with or exceeded Oregon energy codes.

As part of the data processing task, Apex leveraged previously developed logic to flag or exclude homes with issues (missing data, erratic energy patterns, outliers, and net metering, among others). A summary of the attrition from this analysis is reviewed in the Appendix. Additionally, a summary of the final analysis dataset, including number of homes, square footage, average sales price, simulated energy usage, and REM/Rate predicted energy savings (in site BTU) are reviewed in the Analysis Dataset (5.2) section below.

Apex compared the weather normalized results obtained via billing analysis for program homes against those of code homes to determine top-line energy impacts and realization rates for the program. Apex tracked the evolution of code-home and program-home energy use, along with the difference between the two, across subsequent years after building. These results provided estimated program gas and electricity savings, percent savings, and realization rates. Apex aggregated these metrics to report on overall program savings, broken out by state, year built and state code cycle, and heating system type, among other explanatory parameters.

The outcome of this approach allowed the team to report on whether any actual or modeled energy use differences are due to misaligned assumptions in program-home energy use, code-home energy use, or both. We also paid particular attention to electrically heated homes to address discrepancies identified in previous modeling efforts. We segmented the results to assess whether these differences are more pronounced in certain groups.

## 4.2 Supplemental Interviews

Apex conducted interviews with program and implementation staff and trade ally builders to discuss the findings of the impact analysis and to gain greater understanding of any drivers that may have influenced the savings realization rates. Staff interviews included internal

[10] While new construction building simulations from 2011 to 2017 used TMY2, analysis and evaluation at Energy Trust use TMY3 for more up-to-date weather normalization. We use TMY3 for our weather normalization in this study, so differences in predicted use include that change of basis.

staff with Energy Trust; the Program Management Contractor (PMC), CLEAResult; and the Program Delivery Contractor (PDC), TRC. Apex also conducted interviews with program verifiers and trade ally builders. The interviewed trade ally builders represented 15% of the program homes built during the evaluation timeframe and were exclusively Oregon-based companies. Table 5 summarizes the completed interviews.

Table 5. Completed Interviews

| Interviewees | Completed |
|---|---|
| Internal Energy Trust staff | 2 |
| PMC CLEAResult staff | 4 |
| PDC TRC staff | 2 |
| Verifiers | 3 |
| Builders – Large production (+500 projects) | 2 |
| Builders – Moderate size (100–500 projects) | 4 |

Apex developed an interview guide, which was reviewed and approved by Energy Trust staff. We also worked with Energy Trust to identify and contact the appropriate interview targets. The primary goal of the interviews was to help interpret and explain the findings, especially those that did not align with expectations. This included reviewing the potential drivers of differences between actual and modeled energy usage and energy savings identified during the analysis. Ultimately, these interviews helped corroborate the drivers identified in the analysis and identified hypotheses explaining variances between expectations and results.

# 5. Impact Findings

The results of the impact research are reviewed in this report chapter, beginning with the results of the matching process and characterizing data contained in the final analysis dataset. This section then reviews each of the research objectives and specific research questions individually in distinct subsections.

## 5.1 Matching Results

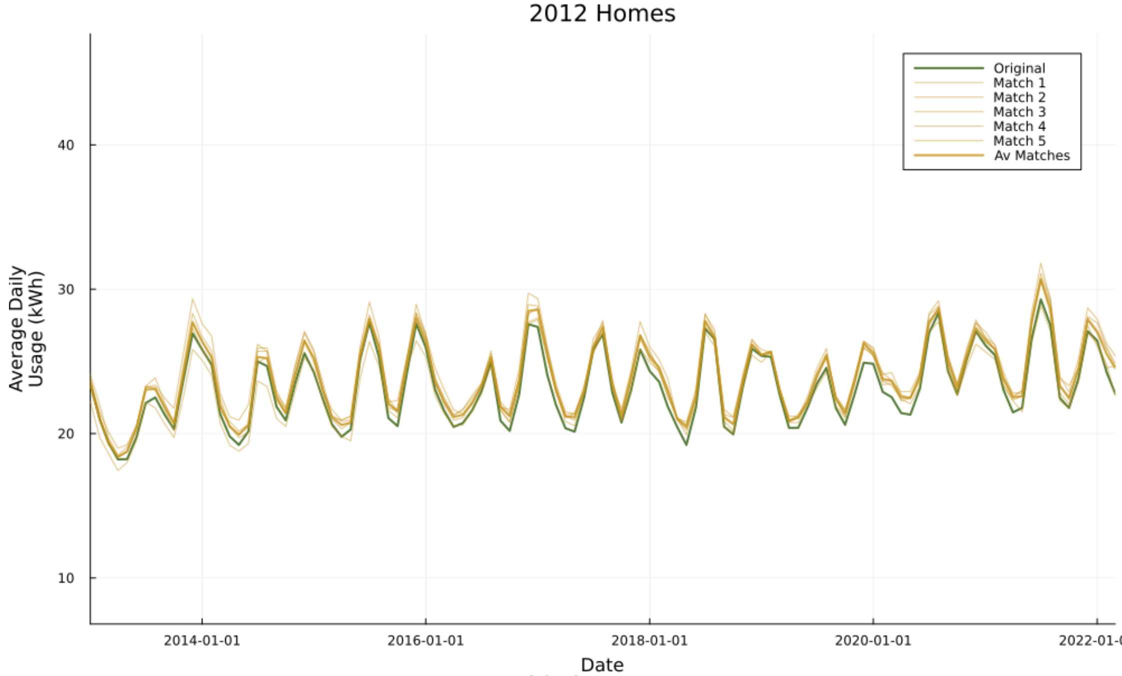
Apex conducted the matching analysis as described in the Methodology section. To test the efficacy of the method, we report the results of a comparison of post-construction energy use for program homes matched to other program homes. The energy use of these two groups should be equivalent, validating the matching algorithm. If that is the case, it would suggest that any differences between program and non-program home energy use are due to program effects and not to bias introduced in matching.[11]

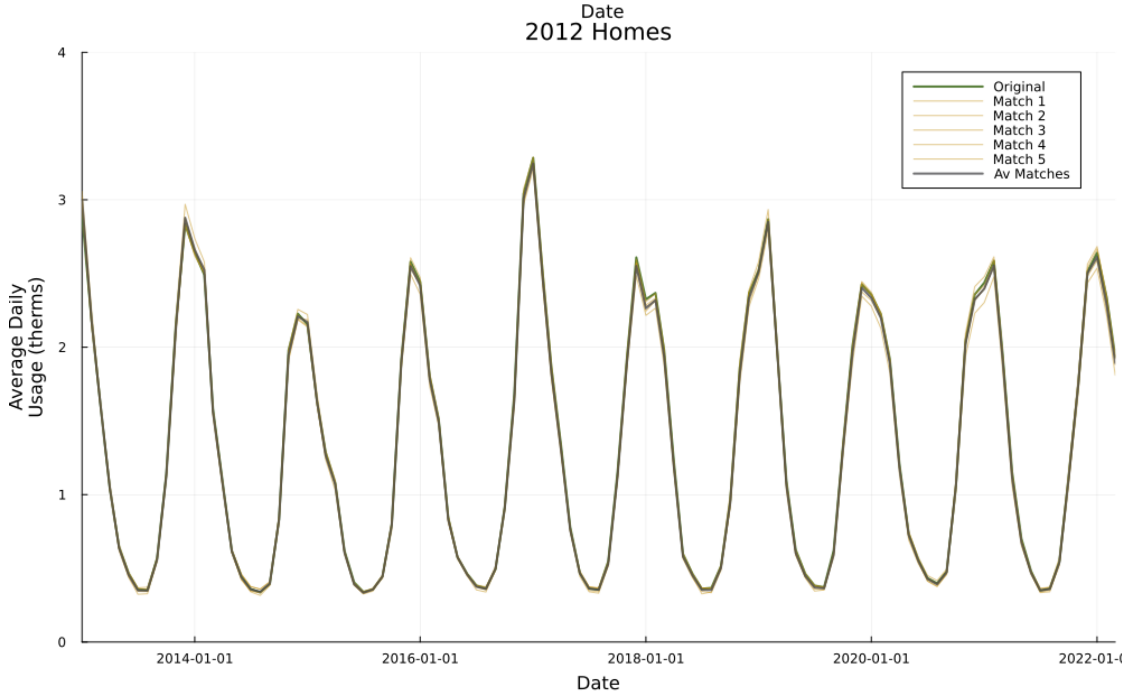
[11] Note that this cannot assure that all bias has been removed—if buyers of program homes have substantially different behavior due to differing family compositions or levels of wealth, their energy usage could be materially different. In other energy efficiency program evaluations, pre-period energy

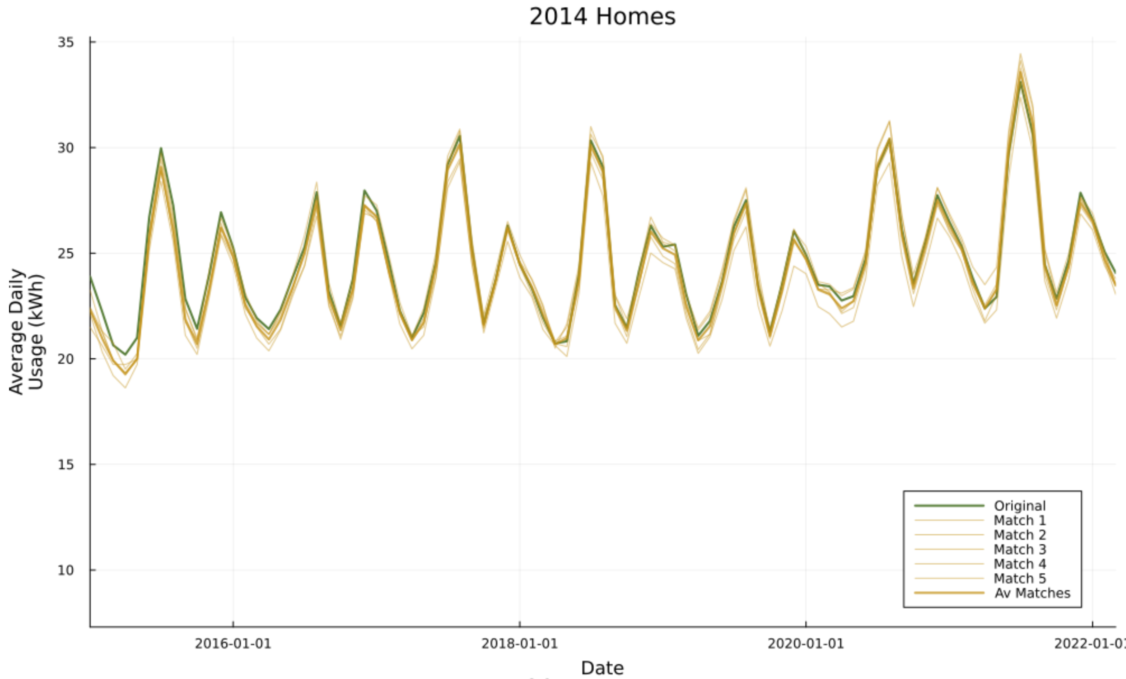
Monthly calendarized energy use aligns between program homes and their within-program matched comparison homes. A sample of average energy use for program homes and their within-program matches for program years 2012, 2014, and 2017 is provided in Figure 2. The figures show good alignment and similar energy usage patterns in aggregate.

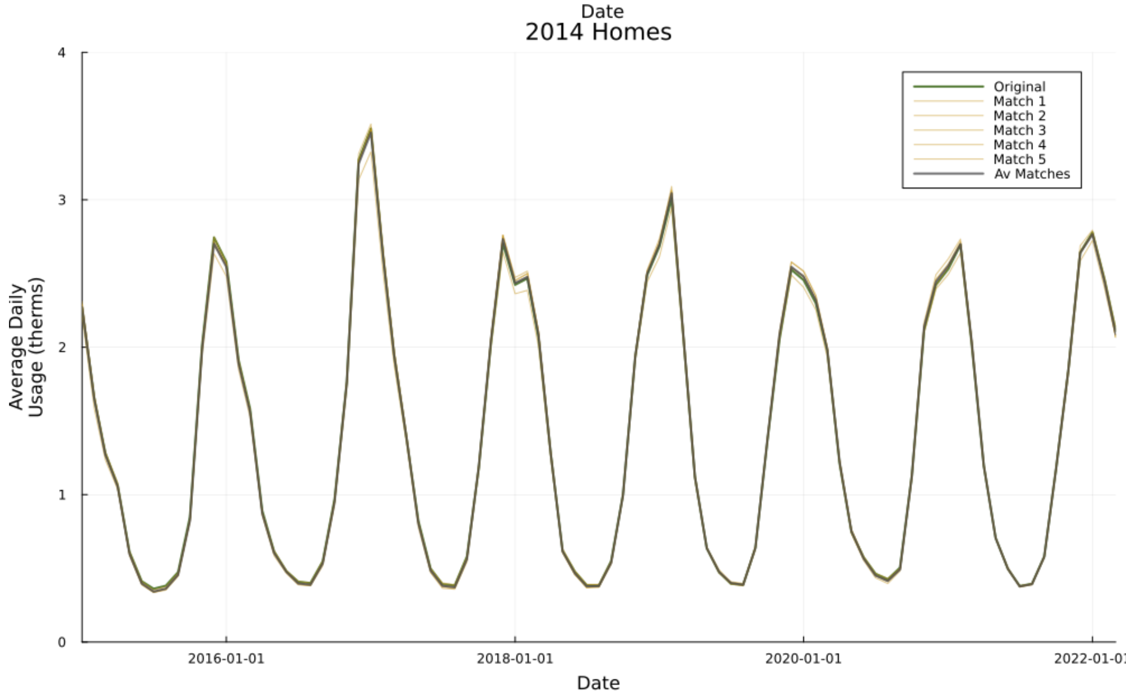
use data can be used to check the equivalency of matches. As these homes are new, this is not possible. Nonetheless, given that our matches should be similar in size and location to program homes, we do not anticipate major behavioral differences that would lead to bias.

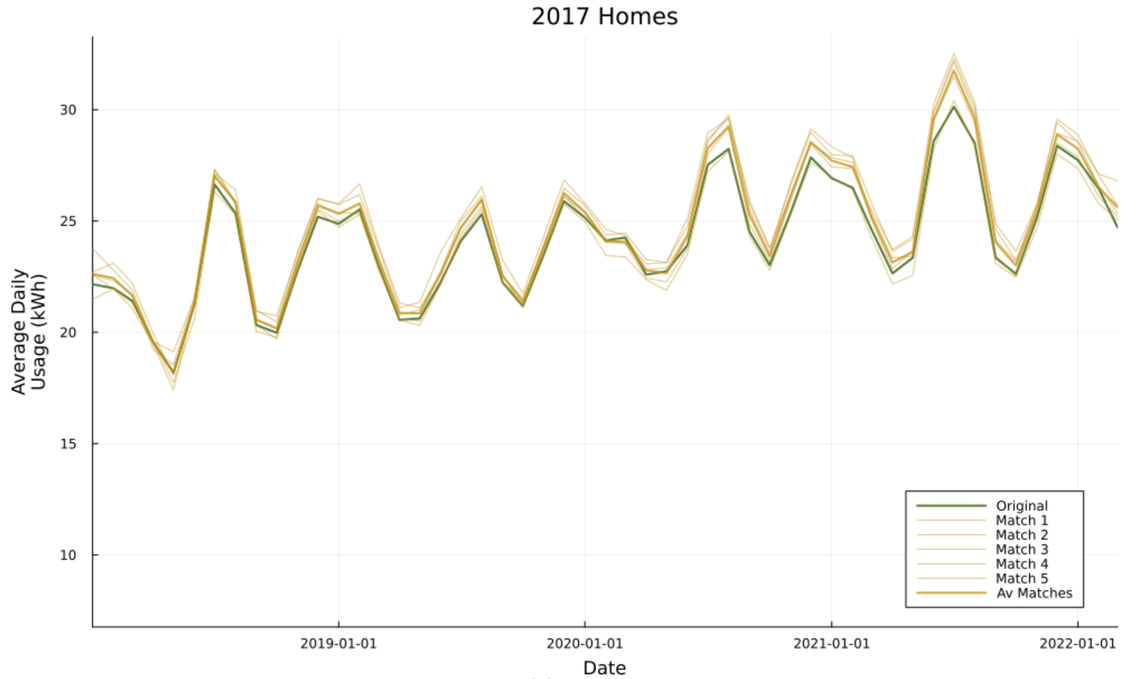
**Figure 2. Examples of Average Daily Usage Comparisons between Matched and Program Homes from Three Program Years**




2014 Homes
Average Daily Usage (kWh)
35
30
25
20
15
10
2016-01-01
2018-01-01
2020-01-01
2022-01-01
Date
Original
Match 1
Match 2
Match 3
Match 4
Match 5
Av Matches


2014 Homes
Average Daily Usage (therms)
4
3
2
1
0
2016-01-01
2018-01-01
2020-01-01
2022-01-01
Date
Original
Match 1
Match 2
Match 3
Match 4
Match 5
Av Matches



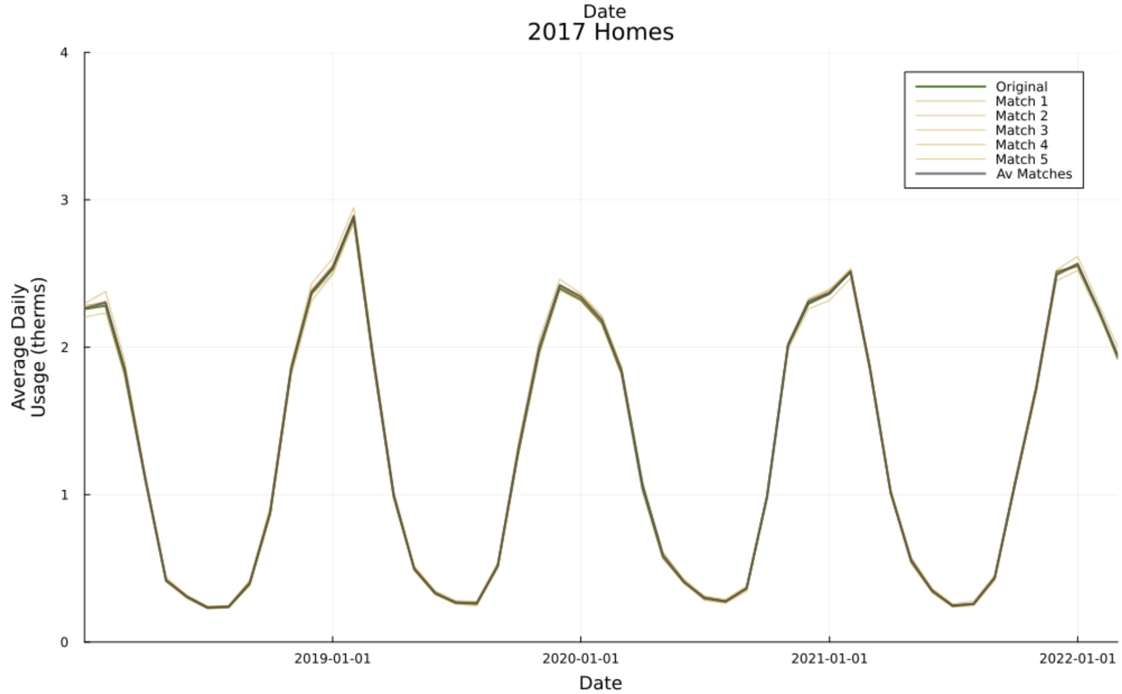
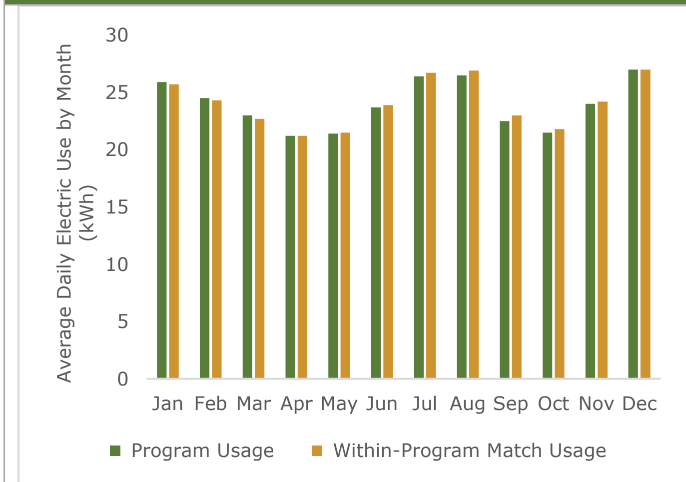
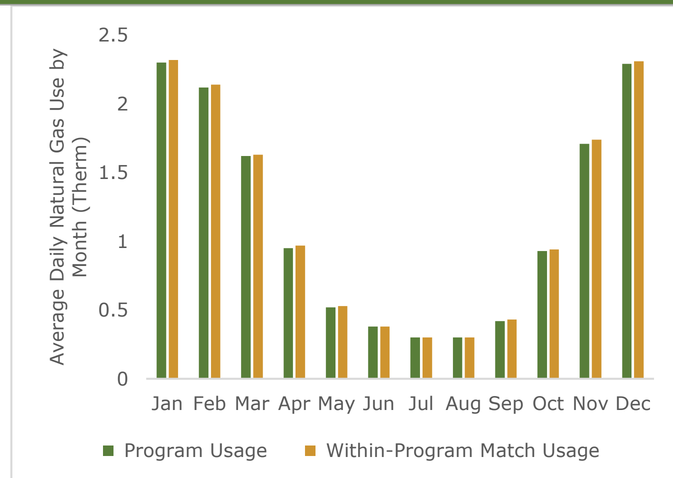




Table 6 summarizes average daily usage for these two groups. Aggregate average differences between groups for a given month do not exceed 2%, suggesting reasonable alignment after matching.

Table 6. Average Monthly Usage of Program and Matched Program Homes by Fuel

| Average Daily Electricity Use by Month | Average Daily Natural Gas Use by Month |
|---|---|
|  |  |





To confirm that these groups are not distinguishable, we ran significance tests (T-tests) of the within-program matches against the program homes for a given month, program year, and fuel. The T-tests result in a confidence estimate (p-value) for the probability of a given month being indistinguishable, with 100% indicating that they absolutely cannot be distinguished from each other and 0% indicating that month of data must have come from two different groups. Ideally this number is above 25%, with 5% being a lower bound on acceptability. Figure 3 shows the results by month, with each dot corresponding to a program year and fuel. The clustering of dots closer to 1 than to 0.05 indicates a higher degree of similarity than dissimilarity.

**Figure 3. Degree of Similarity between Program Homes and Matches, by Month and Year of Construction**

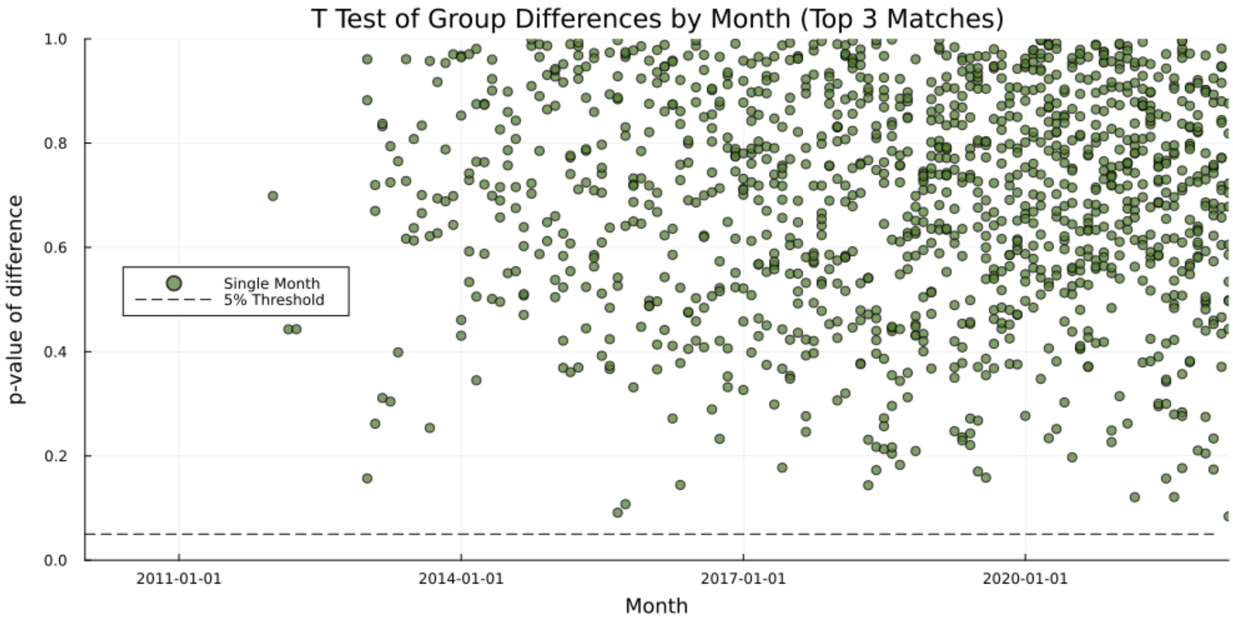



Table 7 shows average p-values by year for each fuel. As shown, the average values are all above 30%. In an individual month, no p-values were below 5% and few were below 25% (36 of 1196 months, or 3%). Therefore, Apex was confident the program and non-program home matching was sufficiently robust to compare energy use and estimate savings.

Table 7. T-Test for Distinguishability between Monthly Data for Program and Matched Program Homes

| Program Year | Fuel | Average p-value (all months) | p-value of 10th percentile | p-value of 90th percentile |
|---|---|---|---|---|
| **2012** | Electricity | 63% | 30% | 90% |
| **2013** | Electricity | 76% | 50% | 97% |
| **2014** | Electricity | 67% | 41% | 94% |
| **2015** | Electricity | 79% | 52% | 97% |
| **2016** | Electricity | 65% | 35% | 93% |
| **2017** | Electricity | 65% | 37% | 95% |
| **2018** | Electricity | 58% | 34% | 87% |
| **2019** | Electricity | 79% | 64% | 96% |
| **2012** | Gas | 81% | 56% | 97% |
| **2013** | Gas | 69% | 42% | 95% |
| **2014** | Gas | 82% | 63% | 97% |

| Program Year | Fuel | Average p-value (all months) | p-value of 10th percentile | p-value of 90th percentile |
|---|---|---|---|---|
| **2015** | Gas | 56% | 28% | 86% |
| **2016** | Gas | 65% | 40% | 86% |
| **2017** | Gas | 81% | 61% | 96% |
| **2018** | Gas | 64% | 28% | 96% |
| **2019** | Gas | 69% | 43% | 90% |

## 5.2 Analysis Dataset

After matching and filtering for outliers and other data anomalies in the dataset, 14,504 homes remained for analysis, with 12,142 in Oregon and 2,362 in Washington. Table 8 shows a summary (mean value) of these homes' characteristics by code version.

Table 8. Characteristics of Homes in the Analysis Dataset

| Sample Characteristic | OR2011 | OR2014 | OR2017 | WA2012 | WA2015 |
|---|---|---|---|---|---|
| Total Number of Homes | 3,490 | 6,393 | 2,259 | 501 | 1,861 |
| Mean Square Footage | 2,327 | 2,404 | 2,262 | 2,513 | 2,404 |
| Mean Price | $335,445 | $454,066 | $463,970 | $632,748 | $568,432 |
| Mean Simulated Natural Gas Use (ex ante therms) | 445 | 386 | 411 | 380 | 389 |
| Mean Simulated Electricity Use (ex ante kWh) | 7,969 | 7,975 | 6,505 | | |
| Mean Predicted energy savings (in site BTU) using simulation | 21% | 25% | 26% | 20% | 14% |

## 5.3 Energy Usage Comparisons

The following sections describe our analysis of comparing the building simulation model predictions of both program and non-program homes to actual weather normalized energy use from billing data. Unless otherwise specified, results are reported by default for "All groups," which reflects fuel usage across the entire available sample of homes for a given fuel for homes that had service of that fuel, i.e., electricity results include electricity used in both gas heat and electric heat homes.

### 5.3.1 Building Simulation Model Accuracy: Program Homes

**Building simulation models underestimated program homes annual energy use.** Apex compared weather normalized energy use from actual energy bills with building simulation model predicted energy usage of program homes. As shown in Table 9, the simulation model underestimated both gas and electric use for program homes in all code years. The underestimation is smallest for the Oregon 2011 code with 2011 electric and gas use underestimated by 4% and 16%, while electric underestimation was worst for the Oregon 2017 code at 24% and gas underestimation was worst for the Washington 2012 code at 45%. The last column in that table shows the percentage difference of program-home weather normalized usage from simulated, with positive numbers indicating the program home used more energy than the simulation predicted.

Overall, the simulations underestimated weather normalized use by an average of 8% of electric use and 26% of natural gas use. As illustrated in Figure 4 (density plots showing the distribution of simulated versus weather normalized use of program homes across all groups[12]), the gas chart on the left shows a systematic skewing of the actual usage being above simulated usage, while the electric chart on the right shows the distribution occurring more randomly around the prediction. These plots suggest that the natural gas discrepancy may be an issue with the simulations or with the pipeline to reported savings, while the electricity use discrepancy is likely due to differences in occupancy or behavioral assumptions.

**Figure 4. Density Plot of Program Home Annual Weather Normalized versus Simulated Natural Gas (left) and Electric (right) Usage**

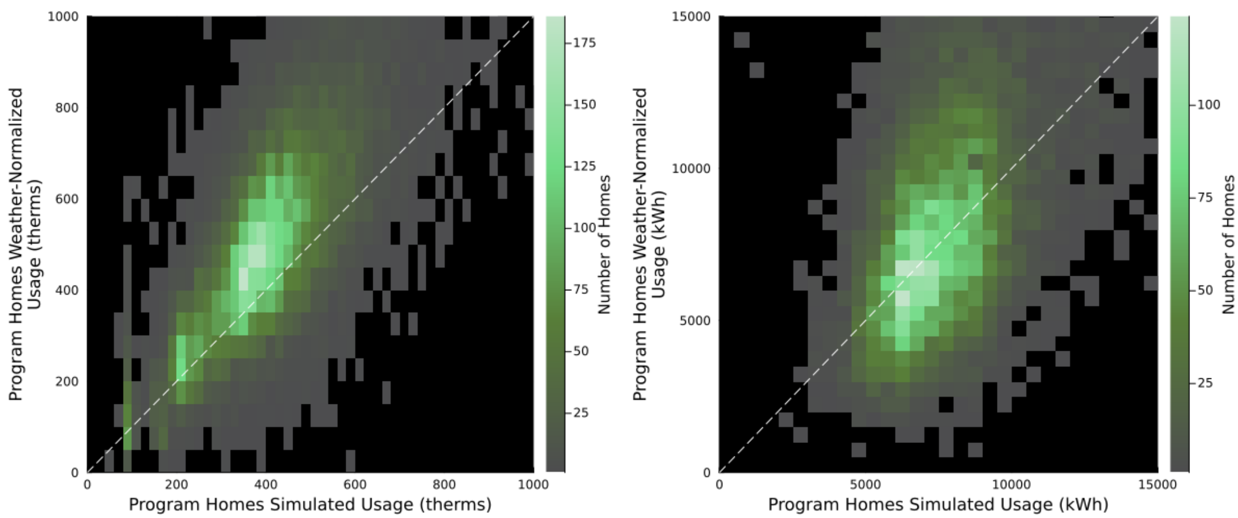



Table 9. Program Home Annual Weather Normalized versus Simulated Natural Gas and Electric Usage, by Code Version

| State | Fuel | Code Version | Number of Homes | WxN Usage | Simulated Usage | WxN Usage vs. Simulated |
|---|---|---|---|---|---|---|
| OR | Electricity | OR2011 | 3,195 | 8,309 | 7,969 | 4% |
| OR | Electricity | OR2014 | 5,563 | 8,406 | 7,975 | 5% |
| OR | Electricity | OR2017 | 1,869 | 8,054 | 6,505 | 24% |
| OR | Gas | OR2011 | 3,148 | 518 | 445 | 16% |

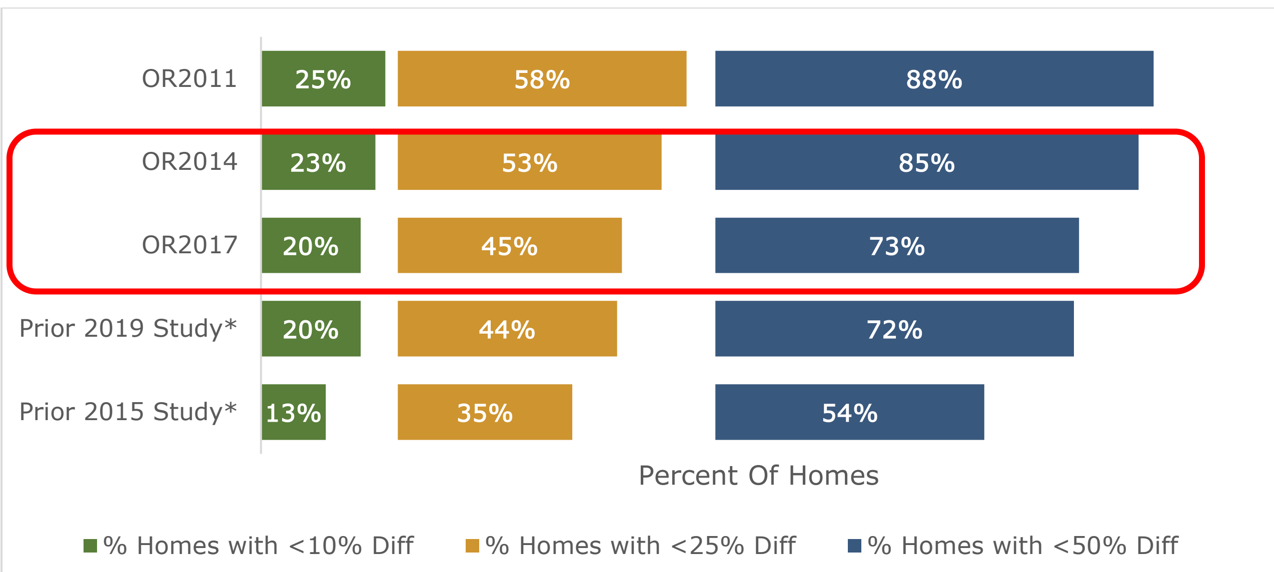
[12] "All groups" implies fuel usage across the entire available sample of homes for a given fuel for homes that had service of that fuel, i.e., the electricity figure includes electricity use in both gas heat and electric heat homes.

| State | Fuel | Code Version | Number of Homes | WxN Usage | Simulated Usage | WxN Usage vs. Simulated |
|---|---|---|---|---|---|---|
| OR | Gas | OR2014 | 5,920 | 502 | 386 | 30% |
| OR | Gas | OR2017 | 2,076 | 494 | 411 | 20% |
| WA | Gas | WA2012 | 504 | 550 | 380 | 45% |
| WA | Gas | WA2015 | 1,861 | 513 | 389 | 32% |

For breakouts by system type, see Table 24 in Appendix 4.

In , we compare the simulated versus weather normalized usage differences by three percentage difference bins consistent with those seen in the prior New Homes evaluation studies.[13] The simulated therm usage for homes in the current evaluation (386–445 therms) was substantially lower than in the prior New Homes analysis (488–517 therms), resulting in a much larger difference from the weather normalized usage. The Apex team checked the simulated usage carefully in both the program-tracking and AXIS datasets to ensure that we did not miss any reported data. The building simulation model used in the current study is different than previous studies, and we determined that the models predicted gas use for the same homes differently, which explains these results.

Figure 5. Absolute Differences Between Weather Normalized and Simulated Usage by Code Version




**Note: Prior 2015 study electric differences weighted based on number of homes between gas and electric heat.*

## 5.3.2 Building Simulation Model Accuracy: Non-Program Homes

**Building simulation models overestimated the annual energy use associated with non-program reference homes in some groups.** Apex compared the weather normalized energy use with building simulation modeled energy usage of non-program reference homes. The

[13] Rubado, Dan, Energy Trust of Oregon. June 2015. 2009-2011 New Homes Billing Analysis

results by state and code version are shown in Table 10. The simulation model overestimated gas and electric use for reference homes in Oregon in all but one code year, and underestimated gas use for non-program reference homes in Washington. Figure 6 shows the distribution of simulated reference homes versus weather normalized use of non-program homes as density plots, with Washington and Oregon homes combined. In both cases, simulated usage is slightly lower than average usage, indicated by falling below the dotted white line.

**Figure 6. Density Plot of Non-Program Home Annual Weather Normalized versus Simulated Natural Gas and Electric Usage**

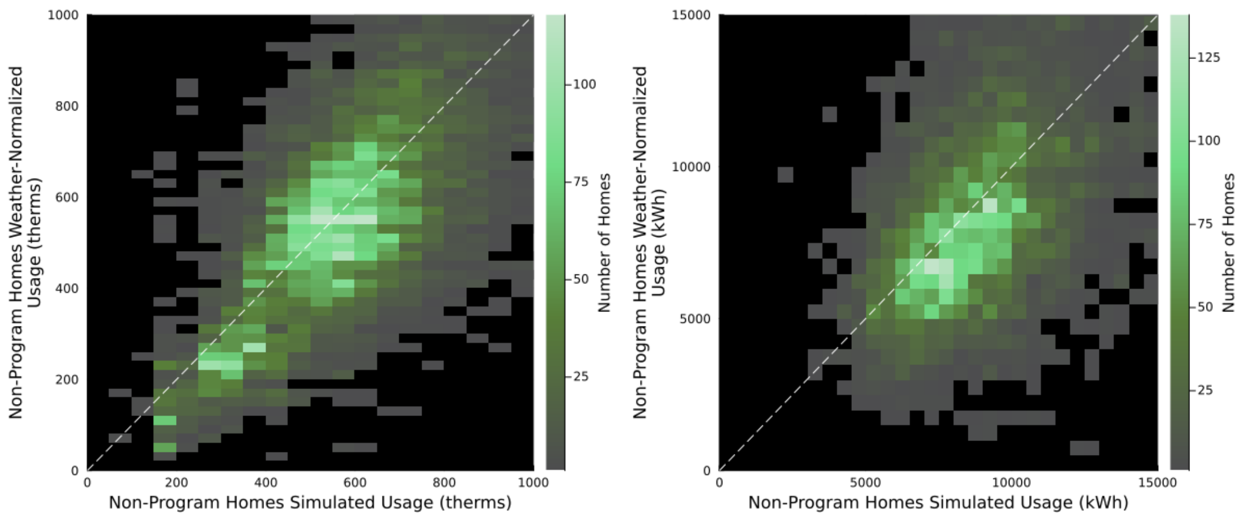



Table 10. Non-Program Home Annual Weather Normalized versus Simulated Natural Gas and Electric Usage, by Code Version

| State | Fuel | Code Version | Number of Homes | WxN Usage | Simulated Usage | WxN Usage vs. Simulated |
|---|---|---|---|---|---|---|
| OR | Electricity | OR2011 | 8,337 | 8,371 | 8,888 | -6% |
| OR | Electricity | OR2014 | 12,573 | 8,754 | 9,485 | -8% |
| OR | Electricity | OR2017 | 4,249 | 8,291 | 7,901 | 5% |
| OR | Gas | OR2011 | 8,424 | 568 | 611 | -7% |
| OR | Gas | OR2014 | 14,045 | 535 | 564 | -5% |
| OR | Gas | OR2017 | 4,930 | 509 | 589 | -14% |
| WA | Gas | WA2012 | 1,399 | 566 | 546 | 4% |
| WA | Gas | WA2015 | 4,592 | 555 | 493 | 13% |

For breakouts by system type, see Table 25 in Appendix 4.

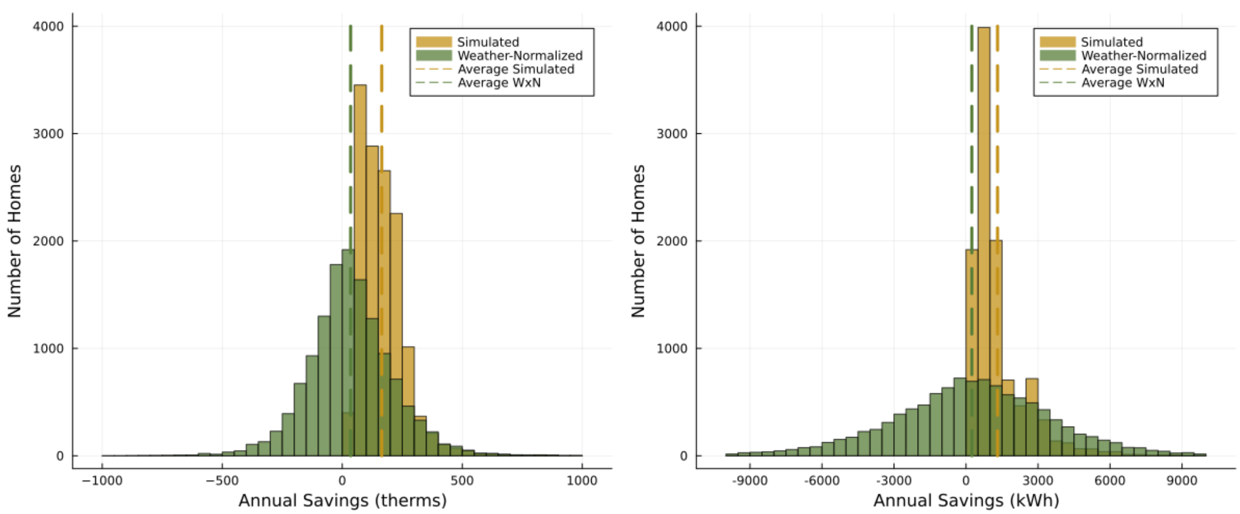
Averaged across both states, building simulations overestimated use by 5% for both electric and gas. Unlike the estimates for program homes, these simulations assume that the reference home has appliances and shell characteristics that match code, as the team did not have this data. It is likely that the matched non-program homes are slightly more energy efficient than simulated by the model,[14] either through customer behavior, construction above code, or subsequent retrofits and upgrades to energy-efficient appliances.

### 5.3.3 Program Savings Accuracy

**Weather normalized billing data suggest program homes use less energy than non-program homes.** Apex compared program home actual weather normalized energy use to the matched non-program homes. For each fuel type and code version in both Oregon and Washington, the program homes used less energy than the matched non-program homes and the differences were statistically significant. As discussed earlier, we also found statistically significant differences from simulated savings across all groups.

Figure 7 is a histogram of simulated savings for program homes overlaid with a histogram of weather normalized differences from the matched comparison group. While the building simulation model will always find that similarly sized homes with a more efficient shell and appliances will use less energy than homes without these features, occupant behaviors can have large impacts on energy use, and it is possible to have non-program homes that use less energy than their program counterparts, even when the sites are matched well. The histogram shows this distribution of savings, along with averages which are lower for weather normalized usage compared to simulated usage.

**Figure 7. Histograms of Program Home versus Counterfactual (Non-Program) Energy Savings**




[14] Note, there is no comparison with the prior study since non-program homes were not included in that study.

Table 11 shows these savings by group, along with the half-width of the 90% confidence interval, and the resulting realization rate (weather normalized savings/simulated savings). The Oregon program achieved an RR of 18% for electricity and 20% for natural gas across all years, while Washington achieved an RR of 30% for its natural gas program across all years.

Given that the building simulation underestimated program-home usage and overestimated non-program-home usage, relatively low realization rates are expected. Program home savings is the difference between usage and its counterfactual, typically with values between 10% and 35% of the counterfactual. Deviations from program estimates of household energy usage result in three to ten times the impact on the resulting realization rate. In other words, a 5% deviation from one estimate could result in a realization rate of 50% to 85%, and deviations observed in these data exceeded 5%. In the case of this program, deviations from both program and reference home simulations contributed to this reduction.

Table 11. Program Home Annual Weather Normalized versus Simulated Natural Gas and Electric Savings, by Code Version

| State | Fuel | Code Version | # of Homes | # of Matches | Simulated Savings | WxN Savings | WxN Savings CI (90%) | Realization Rate |
|---|---|---|---|---|---|---|---|---|
| OR | Electricity | OR2011 | 3,195 | 8,337 | 918 | 62 | 10.6 | 7% |
| OR | Electricity | OR2014 | 5,563 | 12,573 | 1,510 | 348 | 9.3 | 23% |
| OR | Electricity | OR2017 | 1,869 | 4,249 | 1,396 | 237 | 16.2 | 17% |
| OR | Gas | OR2011 | 3,148 | 8,424 | 165 | 50 | 0.5 | 30% |
| OR | Gas | OR2014 | 5,920 | 14,045 | 178 | 33 | 0.4 | 19% |
| OR | Gas | OR2017 | 2,076 | 4,930 | 179 | 15 | 0.8 | 8% |
| WA | Gas | WA2012 | 504 | 1,399 | 166 | 16 | 1.3 | 10% |
| WA | Gas | WA2015 | 1,861 | 4,592 | 104 | 42 | 0.7 | 41% |
| OR | Electricity | All | 10,663 | 25,249 | 1,313 | 241 | 6.5 | 18% |
| OR | Gas | All | 11,165 | 27,458 | 175 | 35 | 0.3 | 20% |
| WA | Gas | All | 2,367 | 5,996 | 117 | 37 | 0.6 | 31% |

For breakouts by system type, see Table 26 in Appendix 4.

Note that the issue with underestimation of therm usage in program homes (called out in Section 5.3.1) reduces our reported realization rates, but not the estimates of therm savings themselves. If this issue is addressed and the reported therms are altered retroactively, they can be compared to weather normalized therm savings to arrive at new realization rates. In other words, if the model simulation inaccuracy is addressed, realization rates of the program will be higher.

## 5.4 Segmentation of Impact Results

Apex segmented the analysis to identify drivers behind realization rate differences between groups. The following section includes charts and findings based on the segmentation of impact results.

### 5.4.1 Results by Code Version and Heating and Water heating Fuel Type

We segmented the realization rate results by code version and system type. In Oregon, electricity use data was available for homes with natural gas heat and water heat, homes with electric heat and non-gas (electric, propane, wood) water heat, and a mix of the two. The portion of homes with natural gas water heat and another fuel source for home heating was small (346 sites), so we did not break them out separately. Some sites had natural gas data despite having electric heat and water heat, which may be due to gas fireplaces or stoves, but we excluded their gas data from this analysis.

Figure 8 and Figure 9 show the realization rates by code version for both Oregon and Washington program homes. Realization rates for all-gas homes (homes using natural gas fuel for both space and water heating), the largest group in the study (10,433 sites), were positive and similar to the overall values, with a slight decline by code year in Oregon and the reverse trend in Washington. Realization rates for the smaller group of all-electric homes were less consistent, rising in the 2014 code version and then dropping to roughly zero for OR2017. Notably, the electric realization rates for all-gas homes were quite high. We expect that this is because the electric-appliance measures contributed strongly to the estimated electric savings in these cases, and they are both routinely evaluated in other programs and not coupled to the other measures.

**Figure 8. Natural Gas Savings Realization Rates by Code Version and System Type**

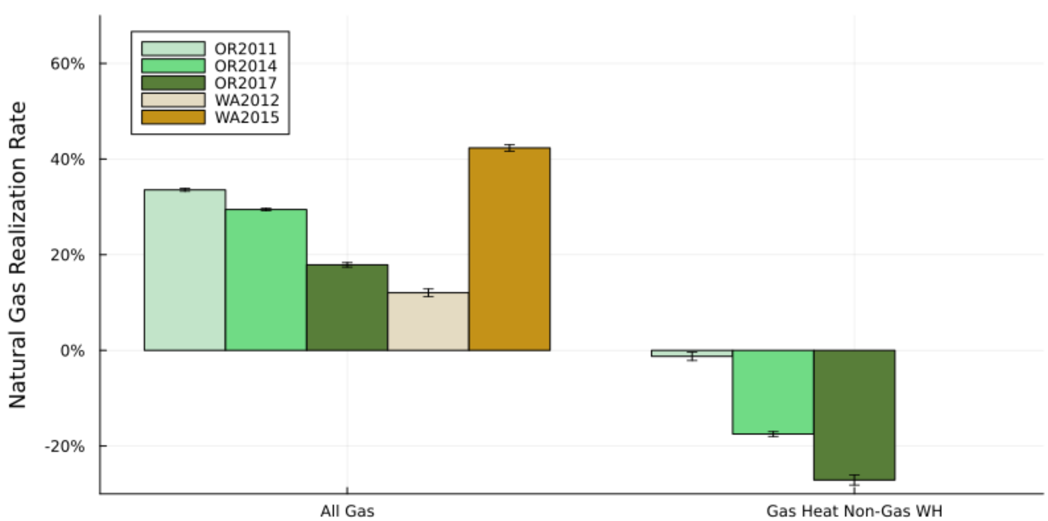
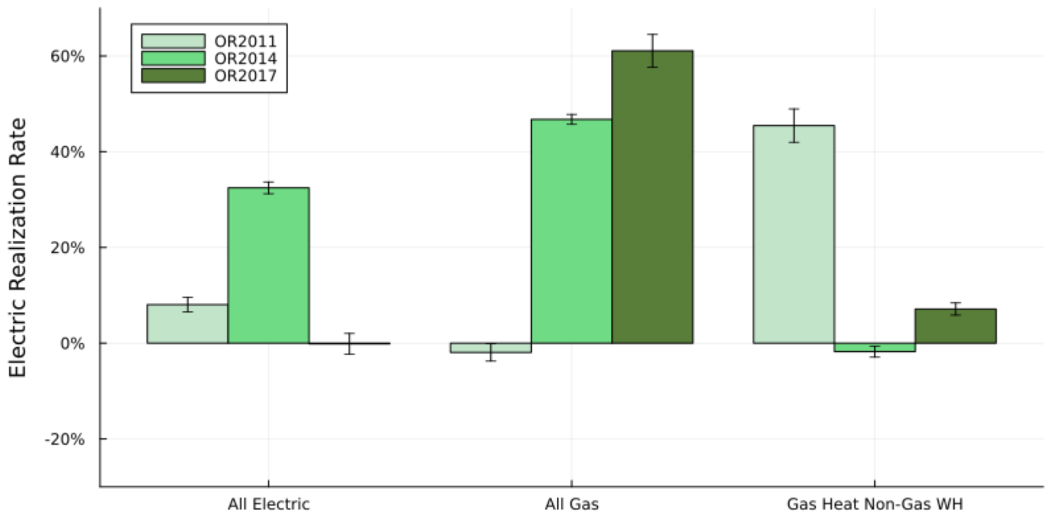


Figure 9. Electricity Savings Realization Rates by Code Version and System Type




Surprisingly, gas realization rates for homes with gas heat and non-gas water heaters were negative. That suggests that comparison homes used less natural gas than program homes. One potential cause could be erroneous assignment of water heater type in the program data. Our matching logic gave program data primacy for determining water heater type and assigned it secondarily (when program data was "NA") based on summer consumption. For the matches, only billing data could be used. If these homes have gas water heaters when program data indicated they do not, they would consume more natural gas. If they are compared to homes that do not have gas water heaters (determined by billing data), they would likely use more natural gas, resulting in negative realization rates. While this is a possibility, the evaluation team did not have sufficient information to assess it beyond speculation.

For completeness in reporting, Table 12 shows the realization rates by fuel and code version, excluding homes that used a different fuel for home heating than water heating (i.e., thereby removing the homes leading to the issues noted above). The realization rates are higher, at roughly 30% for both electric and gas fuel savings, indicating that either the simulations are better for single-fuel homes or that excluding the aforementioned potential error improves achievement. The changes to estimated savings are small compared to estimated whole-home use, but because they are a comparison between a program home and a counterfactual non-program home, they are proportionally up to 1.6 times the estimates with all homes included.

Table 12. Annual Weather Normalized versus Simulated Natural Gas and Electric Usage, excluding Dual-Fuel Homes, by Code Version

| State | Fuel | Code Version | # of Homes | Weather Normalized Usage | Weather Normalized Usage (Matches) | WxN Savings | Realization Rate |
|---|---|---|---|---|---|---|---|
| OR | Electricity | OR2011 | 2,734 | 8,219 | 8,235 | 16 | 2% |
| OR | Electricity | OR2014 | 3,730 | 8,038 | 8,622 | 584 | 43% |
| OR | Electricity | OR2017 | 1,209 | 7,663 | 7,985 | 322 | 35% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **OR** | Gas | OR2011 | 2,690 | 563 | 622 | 59 | 34% |
| **OR** | Gas | OR2014 | 4,036 | 591 | 651 | 60 | 29% |
| **OR** | Gas | OR2017 | 1,347 | 582 | 621 | 39 | 18% |
| **WA** | Gas | WA2012 | 445 | 583 | 604 | 21 | 12% |
| **WA** | Gas | WA2015 | 1,800 | 518 | 562 | 44 | 42% |
| **OR** | Electricity | All | 7,673 | 8,044 | 8,384 | 340 | 30% |
| **OR** | Gas | All | 8,073 | 580 | 637 | 56 | 29% |
| **WA** | Gas | All | 2,245 | 530 | 570 | 40 | 34% |

For breakouts by system type, see Table 27 in Appendix 4

## 5.4.2 Results by Property Size

We segmented overall realization rates by home square footage. Figure 10 and Figure 11 show the natural gas and electric realization rates by square footage bin. Realization rates don't scale linearly with home size but are generally higher for the square footage bins above 2,000 square feet. This could be because larger homes have a more stable weather dependency independent of resident behavior, so the simulations are more accurate.

**Figure 10. Natural Gas Savings Realization Rates by Home Square Footage**

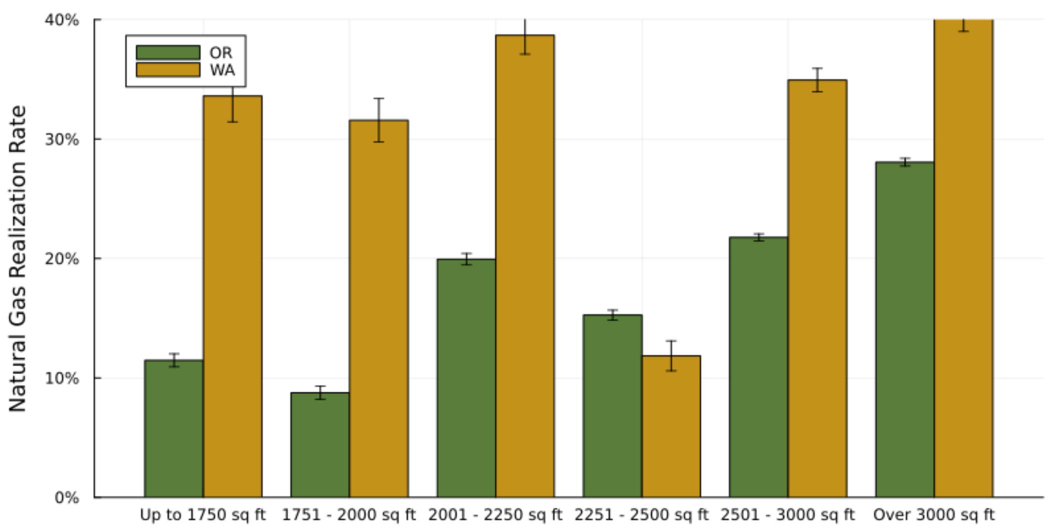
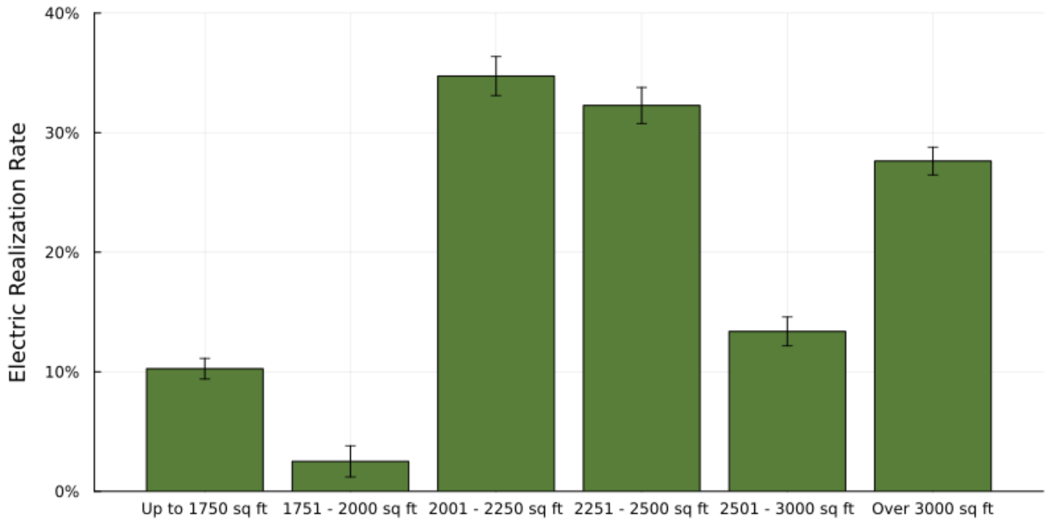


Figure 11. Electricity Savings Realization Rates by Home Square Footage




## 5.4.3 Results by System and Savings Tier

We analyzed site-level, all-fuel predicted energy usage and savings to segment the realization rates by system and savings tier. We combined the reported savings from program tracking on the basis of MMBtu at the site level. The natural quintiles of the data set were very close to the 5% breaks shown in Figure 12 and Figure 13, so the bins shown have similar numbers of homes for each fuel type (although not necessarily fuel and system type). Figure 14 shows these values for Washington, which are not broken out by system type as only natural gas data is available and very few systems are not single-fuel natural gas.

Figure 12. Oregon Natural Gas Savings Realization Rates by Savings Tier and System Type

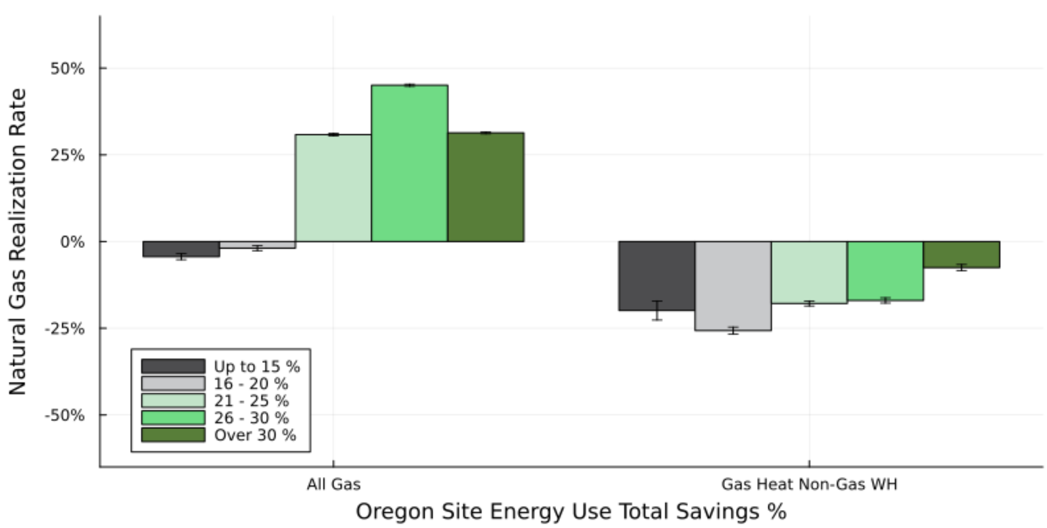


**Figure 13. Oregon Electric Savings Realization Rates by Savings Tier and System Type**

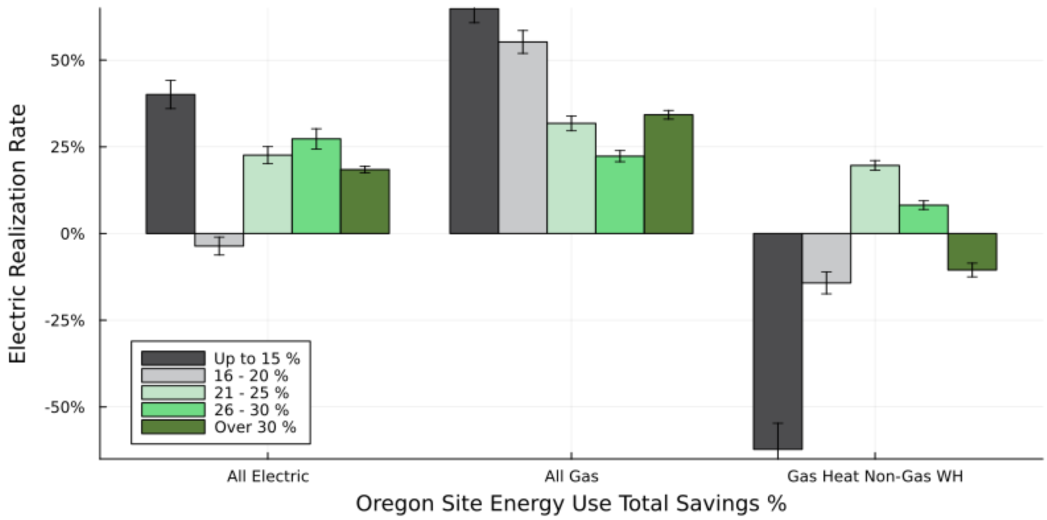
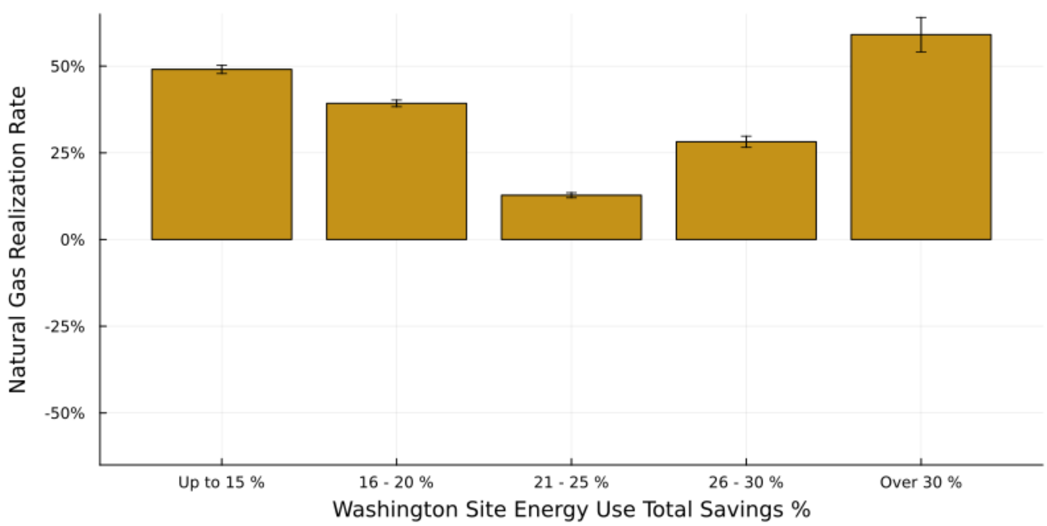



**Figure 14. Washington Gas Savings Realization Rates by Savings Tier**




As with the segmentation by code version and system type, gas-heated homes with non-gas water heaters have overall negative realization rates. However, as shown in Table 13, the number of sites with single-fuel-system combinations outweighs the number of sites with mixed fuels, with only ≈25% of sites in either the natural gas or electric fuel analyses having gas heat and non-gas water heat. Nonetheless, it is important to note that natural gas realization rates for single-fuel homes are modestly higher than the overall averages when these mixed-fuel homes are excluded. In all cases except for natural gas realization rates for mixed fuel systems, the realization rate for the middle tier is similar to the overall realization rate for the whole fuel.

Table 13. Natural Gas and Electric Savings Realization Rates by Savings Tier and System Type

| System Combination | Fuel | Quintile | # of Homes | Avg. sq ft | Sim Savings | WxN Savings | RR |
|---|---|---|---|---|---|---|---|
| All Gas | Gas | Up to 15% | 1,654 | 2,202 | 87 | -4 | -4% |
| All Gas | Gas | 16 - 20% | 1,059 | 2,501 | 149 | -3 | -2% |
| All Gas | Gas | 21 - 25% | 1,883 | 2,509 | 192 | 59 | 31% |
| All Gas | Gas | 26 - 30% | 1,934 | 2,576 | 226 | 102 | 45% |
| All Gas | Gas | Over 30% | 1,562 | 2,649 | 316 | 99 | 31% |
| Gas Heat Non-Gas WH | Gas | Up to 15% | 173 | 1,676 | 62 | -12 | -20% |
| Gas Heat Non-Gas WH | Gas | 16 - 20% | 622 | 1,763 | 85 | -22 | -26% |
| Gas Heat Non-Gas WH | Gas | 21 - 25% | 1,012 | 2,090 | 111 | -20 | -18% |
| Gas Heat Non-Gas WH | Gas | 26 - 30% | 692 | 2,551 | 144 | -24 | -17% |
| Gas Heat Non-Gas WH | Gas | Over 30% | 238 | 2,400 | 214 | -16 | -8% |
| All Electric | Electricity | Up to 15% | 164 | 1,839 | 1,686 | 676 | 40% |
| All Electric | Electricity | 16 - 20% | 151 | 1,814 | 2,430 | -88 | -4% |
| All Electric | Electricity | 21 - 25% | 123 | 1,987 | 3,213 | 726 | 23% |
| All Electric | Electricity | 26 - 30% | 71 | 1,816 | 3,571 | 975 | 27% |
| All Electric | Electricity | Over 30% | 288 | 1,816 | 5,511 | 1,017 | 18% |
| All Gas | Electricity | Up to 15% | 1,392 | 2,177 | 375 | 243 | 65% |
| All Gas | Electricity | 16 - 20% | 915 | 2,492 | 644 | 356 | 55% |
| All Gas | Electricity | 21 - 25% | 1,446 | 2,530 | 789 | 251 | 32% |
| All Gas | Electricity | 26 - 30% | 1,717 | 2,588 | 942 | 210 | 22% |
| All Gas | Electricity | Over 30% | 1,439 | 2,673 | 1,370 | 469 | 34% |
| Gas Heat Non-Gas WH | Electricity | Up to 15% | 155 | 1,622 | 732 | -456 | -62% |
| Gas Heat Non-Gas WH | Electricity | 16 - 20% | 626 | 1,730 | 894 | -127 | -14% |
| Gas Heat Non-Gas WH | Electricity | 21 - 25% | 1,003 | 2,092 | 1,562 | 307 | 20% |
| Gas Heat Non-Gas WH | Electricity | 26 - 30% | 673 | 2,559 | 2,336 | 191 | 8% |
| Gas Heat Non-Gas WH | Electricity | Over 30% | 194 | 2,478 | 2,864 | -301 | -11% |

### 5.4.4 Results by Builder Size

We broke out realization rates by the volume of homes built by a given builder within the program period to check for a correlation. Builders were classified as large if they had completed over 500 homes, and small if they had completed less than 50. We found higher electric savings realization rates for medium builders (Figure 15), and lower realization rates in the medium builder size for gas use (Figure 16).

**Figure 15. Electric Savings Realization Rates by Builder Size**

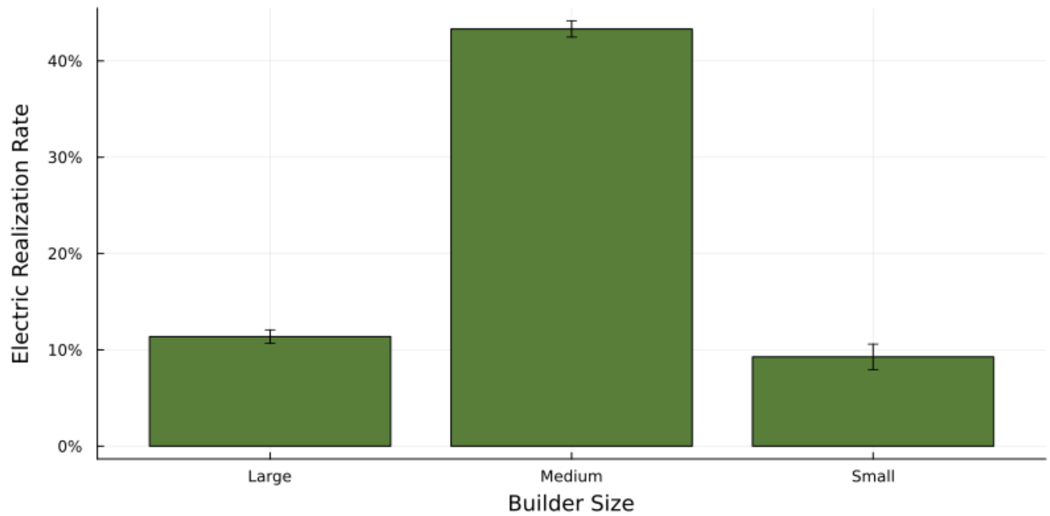
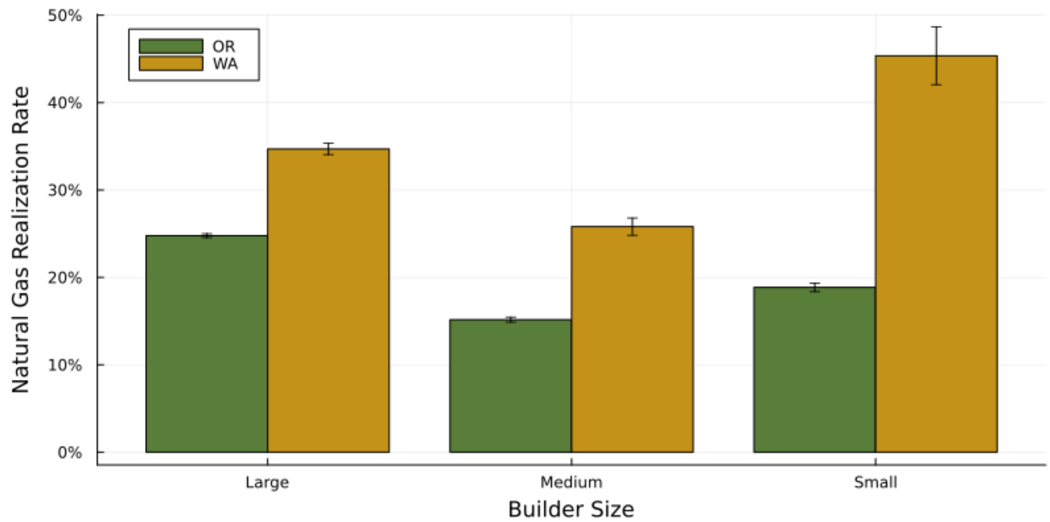



**Figure 16. Natural Gas Realization Rates by Builder Size**




The number of homes within each bin and the average square footage per home are summarized in Table 14. Large installers tend to build larger homes, by 100 to 300 square feet on average, compared to medium and small installers. This tendency doesn't correlate consistently with realization rate differences among groups.

Table 14. Number of Homes and Average Square Footage by Builder Size Bin

| State | Fuel | Builder Size | Total Homes | Avg. Sq Ft |
|---|---|---|---|---|
| OR | Electricity | Large | 4,907 | 2,390 |
| OR | Electricity | Medium | 3,443 | 2,310 |
| OR | Electricity | Small | 1,419 | 2,256 |
| OR | Gas | Large | 5,353 | 2,426 |

| | | | | |
|---|---|---|---|---|
| OR | Gas | Medium | 3,438 | 2,347 |
| OR | Gas | Small | 1,421 | 2,353 |
| WA | Gas | Large | 1,226 | 2,588 |
| WA | Gas | Medium | 1,025 | 2,250 |
| WA | Gas | Small | 95 | 2,312 |

### 5.4.5 Results by Property Value

We summarized realization rate results by home price (in nominal dollars) in Figure 17 and Figure 18. These figures show higher realization rates for both natural gas and electricity in the middle of the price band, between $350,000 and $1,000,000 sale price. These home prices were from 2011 to 2019 in unadjusted dollars, so they have undoubtedly risen in the current Oregon and Washington housing markets.

**Figure 17. Electric Savings Realization Rates by Initial Home Sale Price**

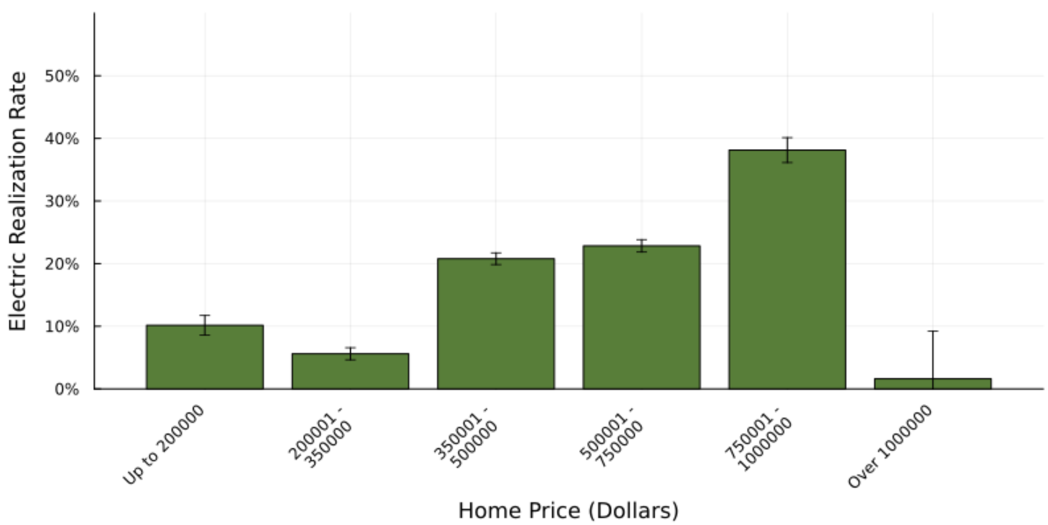
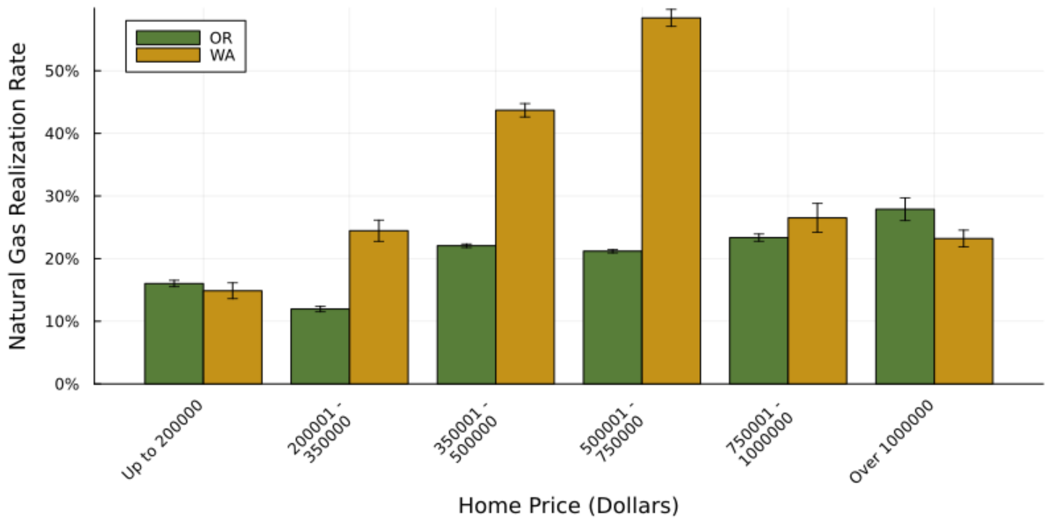


Figure 18. Natural Gas Savings Realization Rates by Initial Home Sale Price

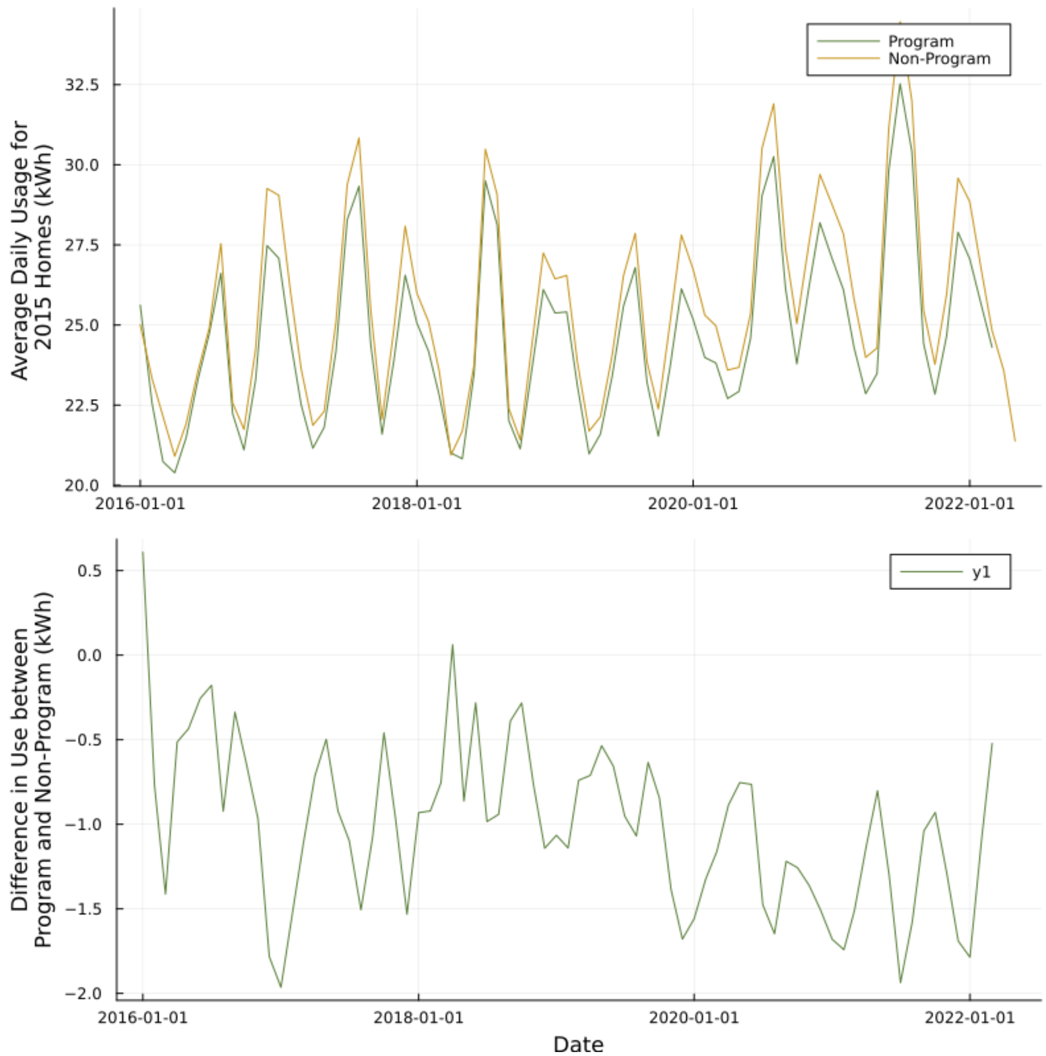



### 5.4.6 Savings Persistence

The Apex Team investigated whether program homes and non-program homes had different time trends to their energy usage. Depending on the relationship between these groups, realization rates might improve or degrade with time. An example of these trends for 2015 program and non-program home electric use is shown in Figure 19. The average daily electric use for program and non-program homes grew over time, though at a higher rate for non-program homes[15].

[15] Note that these graphs were generated from the pre-filtered data in order to provide directional guidance. In other words, absolute differences will likely not line up with final estimated values in TMY3 because only the fully cleaned data is included in that analysis.

**Figure 19. Energy Use Trends from 2015 Program and Non-Program Homes**




For this investigation, we looked at the average daily usage of program homes built before 2016, for 1 to 5 years after their construction. We compared this to the matched group of non-program homes built before 2016. We selected homes built before 2016 to provide a sufficiently-long time trend while grouping multiple years of data. We found steady increases in use for both groups across the 5 years, as shown in Table 15. However, the program homes' energy use, for both natural gas and electricity, increased by less than their matched comparison homes. This difference resulted in an increase in annual savings over time for program homes, which would result in a slightly increasing realization rate.

Table 15. Program and Matched Non-Program Home Energy Use, by Year after Build Date

| Years post Cx | Annual Use (kWh) | Baseline Annual Use (kWh) | Annual Savings (kWh) | Annual Use (therms) | Baseline Annual Use (therms) | Annual Savings (therms) |
|---|---|---|---|---|---|---|
| 1 | 8,646 | 8,903 | 257 | 461 | 506 | 45.9 |

| Years post Cx | Annual Use (kWh) | Baseline Annual Use (kWh) | Annual Savings (kWh) | Annual Use (therms) | Baseline Annual Use (therms) | Annual Savings (therms) |
|---|---|---|---|---|---|---|
| 2 | 8,714 | 8,967 | 252 | 481 | 528 | 46.9 |
| 3 | 8,715 | 8,986 | 271 | 498 | 548 | 50.7 |
| 4 | 8,860 | 9,183 | 323 | 502 | 553 | 50.9 |
| 5 | 9,069 | 9,374 | 305 | 503 | 554 | 50.8 |
| Δ(1 to 5) | **423** | **471** | **49** | **43** | **48** | **4.9** |

In Figure 20 and Figure 21, we show these trends for homes built between 2013 and 2018. We see consistent deepening of savings across program years. This persistence, and increase in savings, may suggest program homes are higher-quality built homes, with greater resilience to decay and offsetting increases in energy use over time.

**Figure 20. Difference between Program and Matched Non-Program Home Annual Natural Gas Use, by Year**

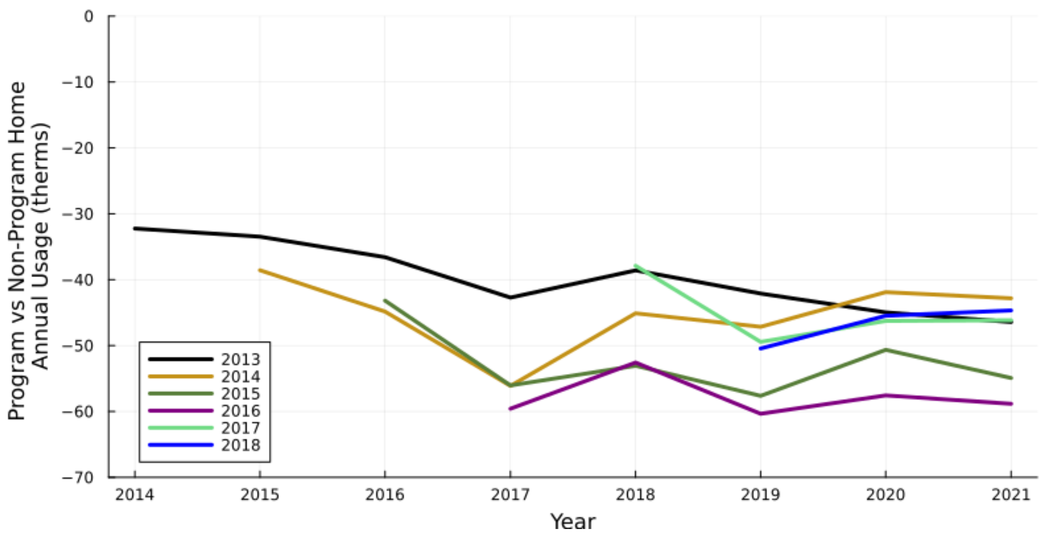
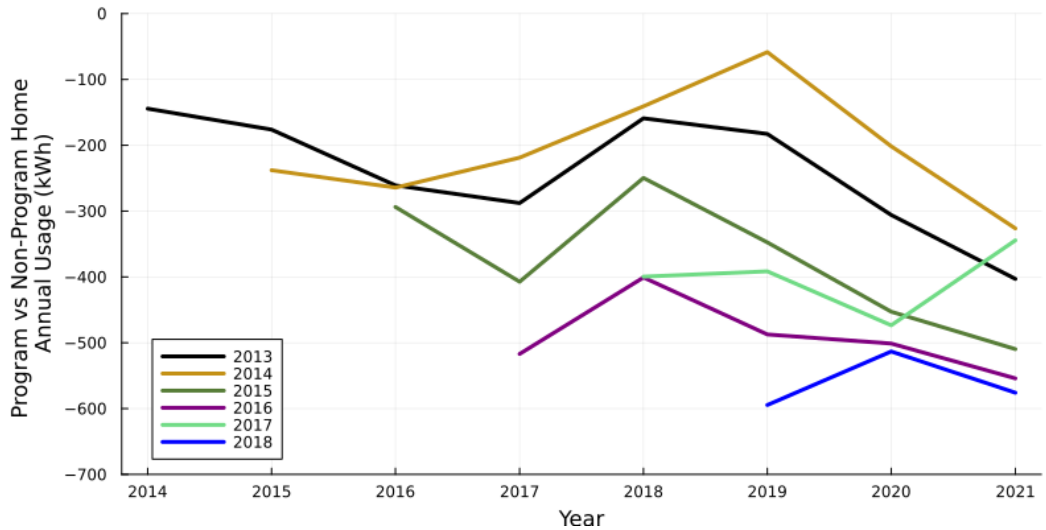


**Figure 21. Difference between Program and Matched Non-Program Home Annual Electric Use, by Year**




## 5.4.7 Treating for COVID Impacts

The usage data used as inputs to weather normalization spanned the period from 2012 through March 2022. Beginning in March 2020, residents' energy usage patterns shifted as their behaviors changed in response to COVID19. These changes could have been due to state and local lockdown orders, greater reliance on food delivery, online purchasing, remote schooling, remote work, and other related factors. Those changes in turn may have reduced the efficacy of energy-saving features such as automatic thermostat setbacks or occupancy-sensing lighting. To determine whether these changes had a strong impact on realization rates, we segmented the data into pre-COVID (up to February 2020) and post-COVID (March 2020 onward) sets and re-ran the weather normalization for each. This analysis produced new estimates for weather normalized use for program and matched non-program homes, allowing us to calculate pre-COVID and post-COVID realization rates.

The new energy use estimates for both scenarios are shown in Table 16. Weather normalized electric use increased by 7.5% to 9.5% for both program and matched homes, which is likely due to more time spent at home (comparing data during COVID to data before COVID in Table 16). Natural gas use changed by less than 2.5% for each group. Note that the number of included homes for code version OR2017 and WA2015 drops substantially using only pre-COVID data due to an insufficient post-period data[16]. We report them here as-is despite the difference in groups because the values shown would have been used to calculate the realization rate if our analysis had been limited to pre-COVID data only.

[16] The program homes built in the later code periods had fewer post-built (yet pre-COVID) years of data.

Table 16. Pre- and Post-COVID New Homes Usage

| State | Fuel | Code Version | Data before COVID | | | Data during COVID | | |
|---|---|---|---|---|---|---|---|---|
| | | | # of Homes | WxN Use | Base WxN Use | # of Homes | WxN Use | Base WxN Use |
| OR | Electricity | OR2011 | 3,162 | 8,199 | 8,215 | 3,077 | 8,716 | 8,865 |
| OR | Electricity | OR2014 | 5,513 | 8,098 | 8,435 | 5,233 | 8,865 | 9,214 |
| *OR* | *Electricity* | *OR2017** | *811* | *7,736* | *8,381* | *1,861* | *8,158* | *8,388* |
| OR | Gas | OR2011 | 3,141 | 514 | 564 | 3,134 | 528 | 579 |
| OR | Gas | OR2014 | 5,890 | 506 | 540 | 5,697 | 498 | 530 |
| *OR* | *Gas* | *OR2017** | *877* | *728* | *754* | *2,048* | *489* | *503* |
| WA | Gas | WA2012 | 502 | 551 | 563 | 482 | 547 | 569 |
| *WA* | *Gas* | *WA2015** | *1,483* | *579* | *640* | *1,859* | *514* | *554* |
| OR | Electricity | All | 9,522 | 8,105 | 8,359 | 10,207 | 8,692 | 8,956 |
| OR | Gas | All | 9,928 | 528 | 566 | 10,900 | 505 | 539 |
| WA | Gas | All | 1,987 | 572 | 621 | 2,343 | 521 | 557 |

* Note the large discrepancy between number of included homes for pre-COVID and post-COVID scenarios

The calculated realization rates in the two scenarios are shown in Table 17. For the comparable groups (OR2011, OR2014, WA2012), savings and realization rates were similar using either data set, albeit slightly lower using the pre-COVID data. The increase in usage in both program and non-program homes offset, resulting in very little change to savings. For the groups limited by the post-period data available, realization rates are higher using only the pre-COVID data. The resultant values for overall realization rates were highly similar in Oregon. For Washington natural gas, realization rates using pre-COVID data were higher, 41% vs 30%. These results are inclusive of the differing groups sizes for OR2017 and WA2015 code homes.

Table 17. Pre- and Post-COVID New Homes Savings and Realization Rates

| State | Fuel | Code Version | Savings (data before COVID) | Savings (data during COVID) | RR before | RR during |
|---|---|---|---|---|---|---|
| OR | Electricity | OR2011 | 16.1 | 149.1 | 2% | 16% |
| OR | Electricity | OR2014 | 336.2 | 349.4 | 22% | 23% |
| *OR* | *Electricity* | *OR2017* | *644.8* | *229.6* | *48%* | *16%* |
| OR | Gas | OR2011 | 49.9 | 50.8 | 30% | 31% |
| OR | Gas | OR2014 | 33.8 | 32.0 | 19% | 18% |
| *OR* | *Gas* | *OR2017* | *26.1* | *14.3* | *15%* | *8%* |
| WA | Gas | WA2012 | 12.3 | 21.8 | 7% | 13% |
| *WA* | *Gas* | *WA2015* | *61.5* | *39.3* | *60%* | *38%* |
| OR | Electricity | All | 254.4 | 263.6 | 20% | 20% |

| State | Fuel | Code Version | Savings (data before COVID) | Savings (data during COVID) | RR before | RR during |
|---|---|---|---|---|---|---|
| **OR** | Gas | All | 38.2 | 34.1 | 22% | 19% |
| **WA** | Gas | All | 48.9 | 35.4 | 41% | 30% |

* Note the large discrepancy between number of included homes for pre-COVID and post-COVID scenarios.

Ultimately, these results are complicated by the results from the persistence analysis in Section 5.4.6. Realization rates improve over time further out from the original construction date, which may offset any reduction in realization rates caused by changes in behavior due to COVID19. Given that the overall impacts are small, we recommend using the full pre- and post-COVID usage data as the basis for reported results.

# 6. Exploratory Interviews

To corroborate the drivers identified in the analysis or develop new hypotheses explaining variances in the results compared to expected, Apex conducted interviews with program staff (Energy Trust, PMC, and PDC), program verifiers, and trade ally builders. The staff interviews focused on understanding what may have influenced the energy use differences and savings realization rates, while the builder interviews focused on understanding building practices and how they relate to above code construction. A discussion of the key findings from the interviews is found below.

## 6.1 Staff Interview Findings

Program verifiers believe the primary driver of the low realization rates found in this analysis is the accuracy of the software used to model program homes. Essentially, the models are built on several assumptions including occupancy and other non-controllable factors which lead to inaccurate projections of a home's energy use. Internal program staff believe that the program likely experiences a certain amount of "massaging". Staff expressed that "some modelers are savvier with software", and that verifiers know that different software and model types (custom vs standard) will result in different incentive amounts, and they manipulate model inputs to take advantage of this.[17] This idea was corroborated by one verifier who indicated that there are "ways to massage a model to make it pass…kind of a game". This verifier expressed that things are generally accurate, but that it is dependent on the "integrity of the verifier". Another issue identified by both verifiers and staff is that verifiers used to pay more attention and take more time in the testing and verification process, and that to a certain extent complacency in the process had set in. Considering this, some program staff advised for "100% QA on every home", to

[17] The segmentation analysis included exploration of specific verifier and builder realization rates, and while there was individual variation (some better or worse than others), we did not identify singular outliers or notable companies as having "massaged" the energy model system.

ensure that models are accurately representing homes, and that nobody is "gaming anything".[18]

Concerning the low realization rates, internal staff and verifiers agreed with a sentiment shared by builders that non-participating home builders had increased the efficiency and performance of their homes, which contributed to the low realization rates found in the analysis. Interviewees identified several potential drivers for why code homes are not the market baseline, including builders trying to stay ahead of code changes, spillover among subs who work with both program and non-program builders, and a general increase in interest among home buyers.

Verifiers also agreed with builders in identifying durability and longevity as a key differentiation between program homes and non-program homes, indicating that program homes are more strongly built, deteriorate more slowly, have fewer issues with mold and ventilation, and lead to fewer callbacks, so that builders "have a better house to sell". Builders believed the higher quality builds associated with program homes also translated into improved energy efficiency, as the better built homes have less issues with poorly installed insulation, and other factors that can impact air leakage, among others. This sentiment was verified in the analysis, as the evaluation found that over time, program homes' energy use for both natural gas and electricity increased by less than their matched comparison homes.

Verifiers and builders both noted that it is difficult to collaborate with trade workers/subcontractors on a home, and there is a lack of training for this group.[19] One verifier noted that, while the program is focused on construction as it should be, it could do more to get involved in the design side, including assistance designing around the issues found onsite (i.e., framing, ductwork and placement), and early design assistance, adding that subs never talk directly to architects or structural firms or HVAC designers. Program staff noted that when subs are better trained, they do better work, and that in previous years there was a more concerted effort to provide outreach, training, and engagement on program requirements, to both subs and builders, but the program moved away from this model after 2016.

## 6.2 Program Builder Interview Findings

Apex staff completed six interviews with Oregon-based builders, representing both large-production and moderate-sized builders. The interviewed builders' companies represented 15 percent of all New Homes projects. The objectives of the interviews were to learn about standard building practices, how the program may have influenced these building practices, gain an understanding about homes built outside of the program, and identify strengths and opportunities for program improvement.

[18] The program completes a file quality assurance check on every home.

[19] Training could improve realization rates by ensuring trades are following best practices and understand key installation techniques that provide higher energy savings.

### 6.2.1 Building Practices

**Interviewed builders' insights were focused on homes built within the program, and all interviewed builders build above code both within and outside the program.** Most of the interviewed participating builders' new construction projects are built within the New Homes program: four builders said all of their homes qualified for New Homes incentives, one builder's homes were 85-90% New Homes-qualified, and the other builder stated that "most were." Builders were asked their reasons for building both program and non-program homes above code. The top reasons (not in any order and noting that builders often had multiple reasons) could be grouped as (1) an **industry standard and expectation**, (2) **higher-quality homes**, and (3) **program influence**.

#### 6.2.1.1 Building Above Energy Code as an Industry Standard

**Building above-code homes was desirable for home buyers in Oregon and became the market standard.** Two builders interviewed spoke of above-energy-code homes being the industry norm, with one stating:

> *"…everybody around here is going to build above code, some of them market it, some of them don't. It's not just a financial consideration, it's a demographic consideration. If you live in the Pacific Northwest, if you're not building a home that's considered energy friendly in some ways, then you are kind of behind the 8-ball. Everybody tries to exceed code one way or the other, some do it more, some do it less, but everybody's trying to achieve that above code status."*

This same builder spoke of adopting above-code practices back in 2012, as more "*of a marketing strategy back then, a way to separate ourselves from the competition."* Yet, this same builder reflected that this tendency to build above code has by now become standard practice: *"It's got to the point (by 2019) that everyone's doing it. It's expected now, for savvy homeowners, rather than a feature, it's almost expected.*" Other builders repeated this sentiment:

> *"We've always marketed ourselves as a high-performance builder, building at or above code in most areas. We don't ever do code minimum—I mean some things we do, but where it makes sense, we go above code."*

> *"As the standard, everything is above code."*

> *"At this point it's kind of become a default for us…we've been doing it so long now that most of our subcontractors are comfortable with it and know the routine and it's nothing out of the ordinary now."*

> *"Exceeding code in energy was a no brainer, so we were always that way. Even in these later years, as code took all the low hanging fruit, all the things that could be done without danger, just became base code. So that's where we are at right now."*

Other interviewed builders echoed the general market demand for higher-than-code specifications: "*They want energy efficiency, most of them are asking questions about it. They're concerned about energy and the world*." Therefore, building above energy code was influenced by external conditions like perceptions of market norms and the desire to differentiate oneself from other builders.

Yet, there were several builders who disagreed, and believed there was still plenty of residential new construction out there being built just to meet code. As one builder framed it, "*I don't know if I can speak to all around Oregon, but I would tend to think that as far as Oregon goes, it just kind of makes sense to build to code.*" Another builder echoed this sentiment, suggesting, "*Most of the builders just meet code. They do the most that they have to do and they just walk away.*" Another builder split the difference, noting that "*There's going to be some builders that will build to code, but in our market, and the buyers that we market to, our direct competition, are more ahead of code.*"

#### 6.2.1.2 Quality Associated with Above-Code Homes

**Builders believed higher-efficiency, above-code-built homes are also higher-quality homes.** As one interviewed builder expressed, "*so we as the builder have a better house to sell*." These other non-energy attributes associated with building above code included better build quality, durability, and less detrimental environmental impact. Two builders described this as:

> *"If you're going to build an energy efficient home it's going to be a better built home because of all the things you have to do. To get a blower test of 2.4 [ACH], you have to seal it well, that's quality you can feel when you leave the house."*
>
> *"We can argue the energy savings, one way or the other. But I still think that using certain insulation, I still think using heat pump water heaters, the overall benefit is still there."*

Building above code was perceived by one builder as a preventative opportunity to avoid future issues or callbacks about the project, namely to "*minimize any issues down the road. I think that's kind of what people are typically pretty mindful of when they go above and beyond the code*." The value associated with building above code was evident even after learning the results of the underperforming energy savings of the modeling software, one builder stated that, "*I still think it's worth building those homes, because they're sustainable and not going to come apart.*"

Interviewed builders cared deeply about higher-efficiency construction and were committed to building above code. Yet, some of the builders believed that the customers were indifferent to making investments in efficiency to get program homes qualified. Despite half the interviewed builders describing customer expectations as a reason to build above code, the other three builders believed customers have little interest in energy-related specifications when it becomes their choice (e.g., customization).

> *"We noticed that when we make it the buyers' options, they don't make the home green the way we'd like. We have a property that's stringently green, and one that's less green, but we build that one green because we want to be better for the environment, better for the world."*

Another builder echoed this sentiment about low customer interest:

> *"I don't think customers see value even when we have energy efficiency options available to them. Very few homebuyers will choose that because of the upfront financial investment it takes to get the return on the money. I would say 10-20% of homebuyers will see the value in purchasing these items. And it's going to depend on how long they live in their property."*

These builders perceived customer indifference and reluctance to investing in higher-efficiency options when available, but the builders nonetheless found quality and efficiency reasons to build above code. Above-energy-code homes were viewed as more durable and higher quality compared to homes built merely to code. And supporting builders' effort to build above code was the program.

#### 6.2.1.3 Program Influence

**Some, but not all, of the interviewed builders believed the program contributed to above-code building practices.** Four of the six builders appreciated the program's ability to shoulder some of the cost for high-efficiency practices, materials, and appliances to produce customer energy savings. One builder described the way the program supported their investment in higher-efficiency equipment, whereby the program incentives were highly influential in their decision to make higher-efficiency equipment purchases for the new homes, stating that:

> *"…we're always weighing the cost of adding something. I always weigh a [standard] furnace versus a super high efficiency furnace and it's $500 more. But the program has opened my eyes to the rebates which I think plays a big part in the decision making, when we're on the fence. Like hey this is an important feature, but it's going to cost us more. The next question is, can we get more rebate for that. We talk to our certifier, and they give us guidance on how much we can get back."*

Two builders echoed the importance of the incentives, noting how expensive the upgrades were to build and needing the incentives to offset this cost:

> *"…the program drove builders to [upgrade the efficiency of the new homes] by offering them a rebate, but sometimes to reach those rebates to even be worth it, the money that we were putting out was pretty, pretty significant."*

> *"The financial aspect, there came a point up until the last few years where our rebates were exceeding our cost to implement these Energy Trust guidelines. And so there was a financial benefit to it as well. We've seen that dissipate in the last two years, but prior to that, it was a very successful program for us financially and it was just an added benefit to the buyer. And just to build in this market, it made sense."*

Two builders felt differently about program influence and about their building practices. This was true to the point that one of them expressed they likely would have gone above energy code independently without program support: "*The way I look at the program, there's a lot of things we do on our homes as a standard anyways, so why not take advantage of it."* However, another builder's commitment to build above code in some ways was made possible through the program: "*Prior to 2019 I think there would be elements we would* *have done above code, specifically in areas of insulation. Outside of that, no I don't think we would have [built above energy code].*"

The program offered non-financial benefits to builders as well. Interviewed builders noted the importance of training and education and the overall support that the program provided. One builder remarked how the program has led to more of a green building "community", noting:

> *"It's also created a very big community in this area and just the brainstorming and the conversations that get had and the different ways we can come together to kind of figure things out has always been really fun for me. And I think the way that Energy Trust has worked with building officials to be more collaborative, has also been a benefit. I think those have been good things."*

The support, training, and education piece was also critical to another builder, who remarked, *"In the 2012-19 range there was quite a bit of improved practices by production builders, and that came about by improved subcontracting practices. And the home insulators, if they wanted to get contracts from production builders, they had to learn how to air seal…. If they're not in a certified program, they're not getting the training they need to meet those codes.*" This last item is topical, as it speaks to how the program offered support and benefits to address some of the challenges, especially centered on subcontractor/trades, which is discussed in greater detail below.

### 6.2.2 Challenges

Participating home builders described various challenges during their participation between 2012 through 2019, challenges both program-related and other challenges more broadly about the industry in general. Although program staff make significant effort to prepare builders and verifiers in advance of changes, one builder stated that **advance notice of program changes** and time to adjust to new program requirements could be helpful. As they described, "*a little more, hey this is coming, not bam, here you go*..."[20] Two builders spoke of the **difficulty collaborating with trade workers/subcontractors** and the absence of training and program support for this group. One builder described that those working in the trades often lacked the training necessary to meet New Homes requirements, which affected the building process regardless of the education of the home builder. This builder went on to state:

> *"[W]e often had to be the ones to initiate that conversation with our trades to get educated. I don't necessarily need more certifiers, but I need the trades to be more educated and I think it would be great if we weren't the ones constantly having to initiate that education. I think there just needs to be a little more collaboration on that part, especially with the HVAC and the plumbers as those are the two main trades that have the most impact ultimately on what we end up getting score wise."*

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[20] For the past two code changes, program staff have worked with builders for over a year in advance of code changes, providing trainings on measures to change and when program updates will take place. This builder may not have been monitoring program communication channels and overlooked outreach.

One builder supported this perception that trade contractors could have difficulties in the New Homes program, although they did not name it outright as a program negative. They stated that, *"Home designers don't work with the HVAC contractors who install the ductwork, so you end up with beams in the way. And they're trying to stick everything in the attic. It's just all wrong. If they're not in a certified program, they're not getting the training they need to meet those codes."*

Another builder spoke of the difficulty in collaborating with subcontractors, but within the context of the complexity of New Homes criteria. They reported trade workers' difficulty in deciphering codes, stating that:

> *"Many times, the trades struggle with the codes, either by Oregon or Energy Trust. Inspectors struggle, especially when requirements change. Sometimes you need energy consultants to help guide the trades and the builders."*

To aid in the ambiguous language, the company used contractors and engineers to help translate new codes and program requirements, which was "*expensive and time consuming*" for the company.

Two builders felt that the **program requirements were too high** due to the ever-rising state code requirements. For one of the two builders, this meant that they often struggled to find trades contractors to carry out that work and there could be high unintended costs in reaching the code requirements:

> *"I'd say that sometimes to reach certain percentages above code, the expectations were set a little too high. Sometimes I think that they went into it, what their intent is: let's drive builders to do this and by offering them a rebate. But sometimes to reach those rebates to even be worth it, the money that we were putting out was significant. And the lack of trades in our area that's specialized in certain things like the heat pump water heaters and things of that nature. I think that there was a miss on the trajectory of what they wanted us to be above code in order to maximize our rebates, compared to the market, the distribution, and the labor force we had. I don't think that they ever quite intersected 100%, which often made it difficult."*

**Builders also identified the disconnect between a well-built high-efficiency home and the likelihood the occupants will adhere to requirements to ensure the home uses less energy**. Several of the builders believed homeowners are unlikely to have interest in, or lack the knowledge of, and are possibly indifferent to understanding the necessary conditions for optimal home performance. Citing one common example, builders noted the challenges of getting occupants to learn how to use and program their smart thermostats correctly. Further, as one builder stated:

> *"In the past, it pretty much addressed the things that could be accomplished, and not be onerous for the owner. But now, you're changing the way people live in a house. I think that's the biggest challenge. How do they teach those people how to live in the house? They have to help builders do that. It also takes cooperation from the owner. If you tell the owner you have to take a class that's 3 hours a week once a month, they're not going to do that."*

# 7. Benchmarking

The analysis presented in this evaluation is comprised of three primary analytical comparisons:

1. Program home weather normalized billing data compared to program home building simulation data
2. Program home weather normalized billing data compared to non-program home weather normalized billing data
3. Non-program home weather normalized billing data compared to non-program home building simulation data

Apex sought to identify comparable studies that utilized each of the comparisons; however, we were unable to identify another study that did so. Furthermore, we were only able to identify three studies that compared the weather normalized billing data of participant homes to non-participant homes, which is necessary to calculate realization rates.

The studies documented in the benchmarking effort are thus comprised of some combination of these three analytical comparisons, and also include some comparisons of program home building simulation data to non-program home building simulation data. We also include discussions of any identified market effects, either quantifiable or anecdotal. The benchmarking analysis is divided into: 1) methodological comparison; 2) realization rates of billing analysis compared to building simulation models; and 3) market effects.

## 7.1 Methodological Comparison

The evaluated programs and analysis approaches are documented in Table 18.

Table 18. Analysis Approaches of Benchmarked Programs

| Utility/Program | Year | Analysis Approaches | Energy Comparison | Matching Criteria |
|---|---|---|---|---|
| PG&E – California Advanced Homes Program (CAHP) | 2019 | 1, 2 | Total EUI | Non-participating homes constructed during similar years as the participant sample, within a local radius, binned by home size (sf), clustered by climate zone and distances on a city level. |
| New Jersey's Clean Energy Program | 2009 | 1, 2 | Electric and gas analyzed separately, normalized by HH SQFT | New non-participating homes that matched selected participant homes in terms of housing unit characteristics and demographics, segmented into four groups: Age-Restricted One-Story, Age-Restricted Two-Story, Other Single Family, and Other Townhomes. |
| Wisconsin – Focus on Energy Residential New Construction | 2019-2022 | 2, 4, 5 | Electric and gas analyzed separately, normalized | New residential addresses in similar geographic areas as Program homes that matched selected participant homes in terms of housing unit characteristics and were not certified by the New Homes Program. |

| | | | | |
|---|---|---|---|---|
| Offering and Market Effects Study | | | by HH SQFT | |
| NEEA – Next Step Homes | 2016-2021 | 4 | NA | NA |
| Energize CT – Connecticut Residential New Construction | 2018 | 4, 5 | NA | NA |
| Massachusetts Residential New Construction | 2014 | 4, 5 | NA | NA |

Analysis Approach Key
1: Program-Home Billing compared to Program-Home Building Simulation
2: Program-Home Billing compared to Non-Program-Home Billing
3: Non-Program-Home Billing compared to Reference Home
4: Program-Home Building Simulation Compared to Reference Home
5: Delphi Panel

Each of the benchmarked studies are discussed in greater detail below.

- **PG&E:** PG&E commissioned this study to assess actual energy performance of occupied program homes compared with performance of non-participant homes built in the same geographic cluster (30-mile radius), normalizing results by conditioned floor area (CFA).
- **New Jersey:** The analysis compared usage for homes that received ENERGY STAR incentives to those that did not receive incentives. In general, comparison homes matched ENERGY STAR homes in terms of the most important household and housing unit characteristics.
- **Wisconsin:** The Evaluation Team conducted billing analyses of Program and non-Program homes to estimate the program's net electric and natural gas savings. Using a year of post-construction billing data from utilities where Program homes were constructed in CY 2018, the Team determined energy consumption for Program and non-Program homes. The Team used the difference in consumption per square foot between the two home types to determine the CY 2019 electric and natural gas net-to-gross (NTG) rates.
- **NEEA**: The study relied on comparing modeled results of program homes to modeled code baseline homes. With respect to the program homes, this effort incorporated a unique Northwest version of the commercially available home rating software, REM/Rate.

The other two studies (Connecticut and Massachusetts) utilized builder surveys and interviews to develop a hypothetical scenario in which the program had been canceled at the end of 2011. Findings were presented to a Delphi panel, where the panelists estimated how much less efficient homes would have been without the program. The results were compared to the programs' gross savings to estimate an overall NTG ratio.

## 7.2 Realization Rates and Market Effects

Realization rates and NTG research are two sides of the same coin when it comes to residential new construction evaluation. New Homes benchmarking proved to be challenging to attempt to isolate or disentangle realization rates from NTG rates. For this benchmarking, realization rates are discussed according to the application of the same approach used in this study, namely a matched comparison group and weather normalized billing analysis. So, realization rates are focused purely on the quantified—and validated—energy savings. Yet, by running a quasi-experimental design analysis, with a matched comparison group, the resulting realization rates are considered net savings, in that the analysis should reflect at least partial freeridership (FR) and participant spillover (SO) values.[21] For other benchmarked studies, however, the research is often split, one focused on more of a gross savings analysis from an engineering review of the energy impacts using calibrated building simulation models, and then secondly on program influence (i.e., NTG). This alternate approach uses a combination of freeridership and participant spillover, and possibly non-participant spillover (NPSO), to estimate overall NTG as the program realization rate. A deeper exploration of each of these topics are reviewed in Table 19 below.

Table 19. Gross and Net Realization Rates and Market Effects

| | Gross | Net | | | |
|---|---|---|---|---|---|
| Evaluation Approach | Gross RR | FR | Participant SO | NPSO (market effects) | Other Market Effects (not NPSO) |
| Engineering building models | Based on calibrating building models | Surveys | Surveys | Surveys/ interviews | Delphi panels, interviews, market research |
| Quasi-experimental (matched comparison using billing) | Based on quasi experimental design (assumes most of the FR and SO are included w the match comp group) | | | Surveys/ interviews | Delphi panels, interviews, market research |

### 7.2.1 Realization Rates of Billing Analysis Compared to Building Simulation Models

Consistent with the glossary definition, realization rates in this study are defined as the ratio of 1) evaluated energy savings (program home weather normalized billing data compared to non-program home weather normalized billing data), and 2) program claimed savings (the difference between building simulation modeled energy use of a program home and reference code home). None of the benchmarked studies implicitly discussed realization rates; the realization rates for the New Jersey study were thus assumed by dividing the evaluated energy savings (gas and electric) by the program claimed savings (calculated by dividing reported gross gas savings by the gross gas realization rate). The realization rates

[21] For a more detailed discussion of this, please see Uniform Methods Project, Chapter 21: Estimating Net Savings – Common Practices, available online at https://www.nrel.gov/docs/fy17osti/68578.pdf

for the Wisconsin study are extensions of the reported NTG values, which utilized the expected program (claimed) savings as the gross savings value and the evaluated energy savings as the net savings value.

The realization rates provided in each evaluation were quite low (Table 20), with the New Jersey evaluation reporting a realization rate of 51% for gas and 17% for electric, while the Wisconsin evaluation found realization rates of 5% for gas, and -67% for electric.[22] Each evaluation found substantially higher realization rates for gas savings compared to electric, while the New Jersey study found much higher realization rates overall.

Table 20. Benchmarked Program Realization Rates

| Utility/Program | Realization Rates |
|---|---|
| New Jersey's Clean Energy Program | Gas: 51%<br>Electric: 17% |
| Wisconsin – Focus on Energy Residential New Construction Offering | Gas: 5%<br>Electric: -67% |

## 7.3 Market Effects

Several of the benchmarked studies included spillover research to quantify market effects. The ensuing market effects of new home construction programs are important to consider when evaluating program impacts. New home construction programs can influence markets in several ways, including but not limited to the increased availability and lower cost of efficient products to builders through equipment suppliers and distributers, increased competition between builders, and increased demand for efficient products among homebuyers.

Only two of the benchmarked studies (Energize CT, Massachusetts) attempted to quantify the market effects—via estimation of non-participant spillover—of the evaluated programs (Table 21). Each of these evaluations found high levels of non-participant spillover, with Energize CT and Massachusetts reporting values of 1.3 and 1.4 respectively[23]. We present these values alongside their respective NTG values to illustrate how inclusion of non-participant spillover greatly impacts a program's NTG value and, in turn, the effective realization rate: the high levels of non-participant spillover found in the Energize CT and Massachusetts evaluations contributed to substantially higher NTG values than those found in the New Jersey and Wisconsin evaluations, which modeled energy impacts of non-participating homes but did not attempt to quantify spillover.

[22] Note that none of the realization rates presented account for freeridership or non-participant spillover in their calculations; later in the Market Effects section, we discuss how the inclusion of these metrics would likely lead to substantially higher NTG values and realization rates.

[23] The non-participant spillover values represent the net savings ratio produced by Delphi-panel builders. The ratio was determined by estimating REM/Rate energy use of homes built outside of the program built with (numerator) and without (denominator, or baseline) the program.

Table 21. Market Effects of Benchmarked Programs

| Utility/Program | Non-participant Spillover | NTG | Market Effects Discussion |
|---|---|---|---|
| Energize CT – Connecticut Residential New Construction** | 1.3 | Overall:1.6 | Yes |
| Massachusetts Residential New Construction** | 1.4 | Overall:1.9 | Yes |
| New Jersey's Clean Energy Program | NA | Gas: 0.5<br>Electric: 0.3 | Yes |
| Wisconsin – Focus on Energy Residential New Construction Offering | NA | Gas: .05<br>Electric: -.67 | Yes |

***It is worth noting, the CT and MA studies showed NTG values pre-market NPSO/market effects of 0.3 and 0.5, respectively. This is more indicative of high freeridership, as these studies did not include non-program comparison group to derive realization rates.*

While the New Jersey and Wisconsin evaluations did not attempt to quantify the market effects impacting their respective programs, the New Jersey evaluation included a discussion of the evidence of non-participant spillover, while the Wisconsin evaluation convened a Delphi panel to qualify the impacts[24]. Each evaluation concluded that, to some extent, the program had likely changed both the behavior of non-participating builders and the desires of buyers of non-program homes to the point that non-program homes are being built above code in both markets.

- **New Jersey:** Due to resource limitations, the study was not able to quantify freeridership or spillover. However, one interpretation of the programs low realization rates and NTG values is that non-participating builders in the same market segments as program home builders have had to upgrade their construction practices to effectively compete. Under this scenario, the spillover to new homes market has resulted in far greater energy and electric demand savings than were quantified in the evaluation. There is evidence that the market in New Jersey has been transformed to the point that all new homes in the current program market segments are being constructed to minimum ENERGY STAR standards.
- **Wisconsin:** The 2019 evaluation found that non-Program homes are being built above code and to a high level of efficiency. Furthermore, builder and contractor interviews suggest the Program's longevity and use of building performance contractors could be influencing residential construction practices beyond Program homes. The evaluation convened a Delphi panel, which concluded that over the course of its history the Residential New Construction offering has had an impact on the construction of non-Program homes. Panelists decided that, in the absence of the offering, a new counterfactual home would be less airtight, have a less efficient furnace, have lower insulation quality, be less likely to have a correctly sized heating or cooling system, and have a lower saturation of efficient lighting technology. A 2021 update to this

[24] The panel is reconvening at the end of the 2019-22 quadrennium to quantitatively assess market impacts, and a value is not currently available.

study[25] found additional supporting evidence for market effects, though the estimated market effects impacts were low. The 2021 study included additional interviews with program builders, delved into greater detail on builders' decisions regarding building practices, and described how the program "*may influence the efficiency of non-program homes by raising homebuyer demand for energy-efficient homes.*" This study went on to also suggest homebuyers show little interest in higher-efficiency construction, consistent with the builders interviewed in this study. As the Cadmus Focus on Energy study mentions, "*However, builders noted demand outstripped supply for new homes and homebuyers showed low interest in energy efficiency. Under these conditions, the primary pathway for market effects is likely to be contractor skills carryover*." Apex used the additional energy savings from the market effects findings from the Focus on Energy program, estimated at 2,700 MMBtu per year, and found the incremental market effects represented only 4.3% of the gross evaluated energy savings. Resulting from the findings from the above studies, FOE New Homes program is planning on adjusting the assumed code baseline home for their future program building simulation models to account for the lower observed energy use associated with these homes.[26]

- **Connecticut:** Panelists estimated that the program strongly improved duct leakage, air infiltration, and insulation installation quality in Connecticut homes; and modestly impacted insulation R-values and efficient lighting. Panelists described the program as only slightly affecting mechanical system efficiencies, and they saw limited impact on market adoption of solar PV and Net Zero designs. The program trains Connecticut market actors and requires panelists to meet advanced building practices; word-of-mouth helps spread these best practices from well-trained market actors, such as HERS raters and program builders, to those working on non-program homes.
- **Massachusetts:** The Delphi panel estimated that, if the Program had not existed between 2004 and 2011, homes completed in 2011 would have been quite a bit less efficient—both those that would have participated in the program and those that would not have participated. The Program has a moderate freeridership rate (0.53) and estimates high non-participant spillover (1.87). As a result, non-program homes are responsible for 75% of net savings in terms of MMBtu (68% of electric savings and 71% of natural gas savings). The Delphi panelists noted that the program has had a particularly strong effect on air infiltration, duct leakage, lighting, insulation installation grades[27], and some heating system efficiencies.

[25] Cadmus, July 2021, Focus on Energy Residential New Construction Market Effects, available online at https://s3.us-east-1.amazonaws.com/focusonenergy/staging/inline-files/Potential_Study-Market_Effects-Residental_New_Construction.pdf

[26] Based on conversations with the Cadmus group, the lead evaluator for this program.

[27] Raters evaluate insulation on a 1-3 scale (i.e., grades) based on the quality of the install.

# 8. Conclusions and Recommendations

Since 2009, Energy Trust's New Homes program has supported residential builders—through training, education, and incentives, among other support—to construct high-efficiency homes that exceed building code. The program has grown to represent approximately one-third of all new construction in Oregon.[28] Historically, to determine energy savings, the program has relied on building simulation modeling to estimate program home energy use and compare this use against a reference code-specified home, determined through a combination of REM/Rate and AXIS project tracking software. This evaluation used weather normalized billing data for program and matched comparison non-program homes, focusing on determining the accuracy of building simulation modeling and ultimately energy savings claimed by the program.

## 8.1 Conclusions

**Conclusion 1: Building simulation modeling does not accurately reflect weather normalized energy use for program and non-program homes.** This evaluation showed program homes use more energy than predicted by the building models, and are therefore less efficient, while non-program homes use less energy – and are therefore more efficient - than predicted by the building models. Analysis of weather normalized billing data showed that the REM/Rate building simulation models moderately underestimated residential electric use and significantly underestimated residential natural gas use in program homes, while slightly overestimating use in reference homes. Inconsistencies in gas use estimation between weather normalized usage and simulation model usage were likely attributable to a combination in discrepancies in the REM/Rate inputs, model updates, or outputs. These findings are consistent with a former New Homes study,[29] which also showed energy consumption estimates were inaccurate for some segments of homes, though not consistently in the same direction.

**Conclusion 2: Homes built through the New Homes program save energy compared to non-program homes, though not at levels reported.** The combination of divergent factors—that program homes use more energy and non-program homes use less energy than expected—means that program homes are saving less energy than expected and the program has a relatively low savings realization rate. Overall per home electric savings were 241 kWh versus 1,313 kWh claimed, resulting in a **18% electric savings realization rate**. For natural gas, overall per home savings were 35 therms versus 165 claimed, resulting in a **21% natural gas savings realization rate**. Negative realization rates for mixed-fuel households (gas space heat with electric water heat, or electric space heat with gas water heat) may be more reflective of issues with building simulation or tracking data rather than true energy use differences. Nonetheless, savings for single-heating-fuel homes also fell well below typical claimed savings, at about 60 therms per gas-heated home and 340 kWh per single heating fuel (either electric or gas) home. Claimed savings were 1129 kWh and 180 therms,

[28] The program has worked for a shorter period and in a smaller region in Washington.

[29] Cadeo Group, April 2018. EPS-HES Comparison Analysis

respectively, for realization rates of 30% for electric savings and 33% for natural gas savings.

**Conclusion 3: While household attributes may drive some differences in achieved energy savings, they are not sufficient, alone, to drive the discrepancy between measured and reported energy savings.** Apex segmented the analysis to investigate whether household or demographic indicators helped explain differences in energy savings and realization rates. Some groups tended to show improved realization rates over others, though no subgroups had realization rates aligned with program claims. The highest and lowest priced home groups tended to show poor realization rates, with moderate and moderate-high priced homes performing better. Realization rates increased, albeit inconsistently, with square footage, suggesting that larger homes were either less behavior-dependent or better represented by the building simulations.

**Conclusion 4: The low savings realization rate across the New Homes program may be a function of a multitude of factors: poor building simulation modeling calibration, program tracking errors, uncertainty around unidentified occupancy and behavioral characteristics, increased demand for energy-efficient homes among consumers in general, and spillover to non-participating homes.** This confluence of issues contributing to the low realization rates is indicative of the complexity of the new home construction process and the wide range of experiences of the various market actors. The range of experiences is evident in the limited consensus among market actors with regards to the impact and prevalence of the factors identified as impacting realization rates: for example, divergent opinions among builders with regards to the demand for efficiency among homebuyers in the market, and somewhat conflicting opinions regarding the program's contribution to above-code building practices overall.

**Conclusion 5: The New Homes program may have contributed to the market transformation of residential new construction in Oregon and Washington, though more research is needed to validate this claim.** This analysis found significantly lower savings relative to program claims, which is at least partly due to the lower-than-anticipated energy use of non-program homes. What is unknown at this time is the degree to which program support, incentives, training, and education may have contributed to statewide transformation of the new homes market, including homes built outside of the program. Evidence collected from program trade partner interviews suggested that the program was at least partially influential in transforming the new homes market in Oregon and Washington, while benchmarking similar programs revealed substantial support for market effects considerations. Interviews with program trade partner builders suggest the program indeed offered substantial—and sustaining—support to allow expansion of high-efficiency new construction practices. Interviewed builders believed customer indifference and unwillingness to invest meant that it was up to builders to deliver higher efficiency new construction. Some of the builders also believed the program incentives allowed them to build above code homes, making the difference in key purchasing and upgrade decisions. Yet, similar conversations with other builders revealed their motivations to build above code were based on inherent business decisions, a desire to meet or exceed market expectations, and the overall quality of above code-built homes. Further, a review of other new homes evaluations provided additional evidence that suggests programs like Energy Trust are causal drivers for transformation of new construction markets.

## 8.2 Recommendations

In light of the findings presented in this study, there are some unresolved questions and recommendations for Energy Trust to consider. Given the multitude of factors likely explaining the low realization rates, it will be important for the program to focus on—and to prioritize—those factors that are actionable in the short term versus those addressable through ongoing research. We have differentiated the recommendations accordingly.

1) **Recommendation to direct downstream savings impacts of the program: Future efforts may consider examining the annual energy use of new homes built during the same timeframe but in other communities outside of program areas.** The analysis did not include homes built in communities outside of the areas that included New Homes projects, by design. The benchmarked Wisconsin Focus on Energy evaluation cited above added non-program groups outside of the program areas and found marginally higher baseline non-program energy use, improving the realization rates.

2) **Recommendation to support market effects: Energy Trust may consider additional research to help identify market effects and how influential the program may be in advancing above-code construction.**

    a. **Energy Trust should consider conducting outreach from voices not covered in this evaluation, namely from tradespeople (more broadly) and builders operating outside of the program**: The builder interviews were limited to six builders (though they represented 15% of New Homes projects), and more importantly, the interviews included only participating trade ally builders. Given the interviewed builders built almost exclusively within the New Homes program (so few if any homes built outside of the program), coupled with 65% of the New Homes market built outside of the program, gaining insight into building practices from builders outside of the program would be critical to compiling evidence to establish market effects. Furthermore, given the prevalence of subcontractors and tradespeople doing much of the mechanical, envelope, and other key energy-efficiency installations, the program could benefit from hearing from this group, as this group has not been included in historical program efforts and evaluation.

    b. **Energy Trust may also consider benchmarking stringent building code states that lack new homes programs in order to refine baseline code homes.** Research could include benchmarking other states with more stringent code (per Figure 1, could include several New England states, PA, NY, MD, and DE) that LACK new construction programs. Further, this research in other regions could include builder interviews for large-production and moderate-sized builders to assess differences between regional practices relative to non-program practices. The goal of this research would be to examine whether buildings in stringent code states that lack New Homes programs still build above code (or not) to help refine the assumed code baseline home.

    c. **Energy Trust may consider collecting primary data through onsite research.** Similar to other Energy Trust research, including recent code compliance studies, Energy Trust could also consider conducting a site study, whereby technicians visited construction sites in both program and non-program homes to verify meeting or exceeding codes. While expensive, this study could help determine how building practices differ between program and non-program homes, with the primary objective to validate this reports findings. Alternatives or complementary research could also include ride-alongs with key trades people on sizing and quality installs of equipment.

3) **Recommendation to address some of the program-side drivers behind savings realization rates: Energy Trust should conduct an internal review and validation of the process associated with AXIS database data entry and program verifiers.** As noted in the conclusion above, a multitude of factors may be impacting the simulated energy use and resulting energy savings, including poor building simulation modeling calibration, program tracking errors, and the massaging of model inputs by verifiers. In particular, the assignment of gas heat fuel appeared to be a key driver in producing negative realization rates, potentially indicating the misclassification of system types.

4) **Recommendation to adjust the assumed baseline "code" home**: If the program is unable to garner sufficient evidence to support substantial market transformation impacts, Energy Trust may also consider taking steps to calibrate the REM/Rate models with the energy use values reported here. This could include revising the assumed baseline code home accounting for the lower weather normalized energy use found in this study. Adjusting baseline "code" homes in building simulation models is what the Wisconsin Focus on Energy program is doing after several years and multiple studies attempting to explain lower than anticipated evaluated realization rates.

5) **Recommendation to evolve and futureproof the program: Consider alternate program design opportunities to advance building practices beyond current program requirements.** Energy Trust may consider pioneering more advanced new construction opportunities like net-zero building paths, microgrid enabled communities, passive-house design and developments, or even greater tiered options to exceed current stretch code requirements. These efforts should include establishing baseline building practices and logic models with key performance criteria to support future market transformation claims.

# Appendix 1: Analysis Attrition

Table 22. Program Home Attrition

| Step | Total Sites | Gas Sites | Electric Sites | Bills per Site | Percent Remaining |
|---|---|---|---|---|---|
| Initial UCI Data | 26,416 | 24,862 | 18,192 | 126 | **100%** |
| Calendarized UCI Data | 26,347 | 24,813 | 18,078 | 123 | **100%** |
| After Data Quality Filters (negatives, zero kWh, < 15 days) | 26,345 | 24,813 | 18,076 | 120 | **100%** |
| After Outlier Filters | 26,337 | 24,808 | 18,066 | 119 | **100%** |
| Found in Estated Data | 23,130 | | | | **88%** |
| After Modeling | 21,823 | 20,476 | 16,043 | | **83%** |
| After Joining with Matches | 21,552 | 20,213 | 15,822 | 108 | **82%** |
| After Filtering Out Solar and >1 Match | 17,491 | 15,958 | 13,481 | 103 | **66%** |
| After Screening for Matching Heating Fuels | 14,569 | 13,532 | 10,663 | | **55%** |

Table 23. Non-Program Home Attrition

| Step | Total Sites | Gas Sites | Electric Sites | Bills per Site | Percent Remaining |
|---|---|---|---|---|---|
| Matches in Estated Data | 22,228 | | | | **100%** |
| Calendarized UCI Data | 20,015 | 17,615 | 13,582 | 129 | **90%** |
| After Data Quality Filters (negatives, zero kWh, < 15 days) | 20,014 | 17,615 | 13,580 | 126 | **90%** |
| After Outlier Filters | 20,009 | 17,611 | 13,575 | 124 | **90%** |
| After Modeling | 18,478 | 16,009 | 12,399 | | **83%** |

# Appendix 2: Staff Interview Guide

## Staff Interview Opening

Thank you for taking the time to talk with me today. As we approach solidifying the impact findings with this evaluation, we want to make sure we have a good understanding of the New Homes program. We understand you have been involved in the design or the day-to-day implementation of the program, and we want to hear your perspective on how things have gone so far.

Do you mind if I record our conversation? The recording is just to help with my notetaking. We won't share it with anyone, and we won't identify any individual respondents in our reporting.

Do you have any questions before we start?

## Background

1. Please tell me about your role for the New Homes program *[Probe on years at role – see if their role has changed]*
2. What have been the key changes to the New Homes program over the past decade that are likely to have influenced program participation?
    a. Similarly, what key changes may have impacted program savings claimed per home or modeled energy usage?
    b. [*If not addressed, probe on model details*] Can you speak to changes related to building simulation modeling or engineering related changes that could have driven changes in modeled energy usage and savings claims?
3. [*If not addressed:*] How, if at all, has the way the program works with builders and their subcontractors changed along with the program?
4. [*If not addressed:*] How, if at all, has the way the program works with verifiers changed with the program?
5. [*If not addressed:*] In what ways does the program anticipate or adapt to changes to building codes *[if needed, such as establishing new requirements*]?
6. In what ways does the New Homes program differ from other New Homes programs? [*Probe: in what ways do you believe this program is an improvement over others*]

## Changes to Building Practices

7. What differences, if any, have you seen over time in the types of homes in the program and the types of measures installed? [Probe on home type/size, home styles, neighborhood type, location, heating and water heating fuels and technologies]

1. *Similarly, what differences, if any, have you seen over time in non-program homes?*
2. *Similarly, what differences, if any, have you seen over time in the types of measures builders are installing?*
3. *How have code changes affected builder practices? How have these changes impacted program homes? Non-program homes?*
4. *To what extent does building a program-qualified home require the builders to modify their standard building practices?*

8. To what extent does building a program-qualified home require the builders to modify their standard building practices?
    a. Do you see New Homes projects and program activities influencing building practices outside the program? Why do you think that is?
    5. *Can you provide specific examples of program influenced changes to building practices?*
    6. *Has this effect increased or decreased over time?*
    7. *Probe on the most common reasons homes may fail to qualify*
9. What shifts, if any, have you seen in the ways builders are engaging with the program?
    8. [*If not addressed:*] Are there participating builders that have become more or less active in the program? [*If so:*] Why do you think that is?
    9. [*If not addressed:*] Have new builders sought to join the program? [*If so:*] What motivated them to join?

## Results of this evaluation

10. How do you anticipate that the electric and natural gas savings results from this impact evaluation will compare to what the program has reported? Why do you think that is?
    10. [*If not addressed:*] Are there other impact studies you are aware of that informed your perspective on the results? [*If so:*] What makes you think results for the Energy Trust New Homes program would (or would not) be different?
11. For this evaluation, our team developed a carefully matched comparison group of code-built, new construction, non-program homes that were as similar as possible to the program homes. We compared the energy use of both groups with the predicted energy use from program-generated building models. Then, we compared program home energy use to the non-program home energy use. The draft results show program homes are not as efficient as predicted by the building models, while non-

program homes are more efficient than predicted by the building models. The combination of these divergent factors means that program homes are saving less energy than expected and the program has a relatively low savings realization rate.

Is this surprising to you?

11. Please explain why the results are surprising [or not surprising].

12. What do you think could explain these results? What do you believe may be the key drivers behind these findings?

    12. Why do you think these factors are drivers behind the differences in actual versus predicted energy use?

13. What, if any, changes to the New Homes program do you think could improve these realization rates?

14. Our current plan is to provide results based on code/year, heating/cooling system type, state, home size, among other variables. Do you believe there may be other segments we should consider for reporting the savings? [*Probe: why do you believe this would help explain underlying differences in savings?*]

## Closing

15. What are the most important things you have learned about working with builders and verifiers for the New Home program?

16. What do you see as the greatest strengths of the New Homes program?

17. What do you see as the program's greatest challenges?

    13. How, if at all, would you change the program to better meet those challenges?

18. How do you see the New Homes program evolving as you look to the future?

19. What, if any, feedback do you have that may help this evaluation and other New Home programs improve?

20. Is there anything about specific builders that you are aware of to help us with interview sampling that isn't obvious from the list?

    14. For example, do we want to know if there are any smaller builders that are particularly engaged with the program?

21. Those are all the questions I had prepared. Is there anything else you think it's important for me to know as we move forward with the study?

# Appendix 3: Builder Interview Guide

## Interview Opening

Thank you for taking the time to talk with me today. We understand your company, [builder company name] has participated in the Energy Trust New Homes program, and we want to hear your perspective on your experience with the program and to learn more about your building practices in general. Do you have time now or should we schedule a time to discuss, we'll likely need between 45 minutes to an hour. [RESCHEDULE IF NEEDED]

Do you mind if I record our conversation? The recording is just to help with my notetaking. We won't share it with anyone, and we won't identify any individual respondents in our reporting.

Do you have any questions before we start?

## Background

22. Please tell me about your company [*Probe on: do they strictly build residential, primary types of homes built, how long in business, any certifications, ie LEED*]
    a. Approximately what percent of your residential new construction projects are spec versus custom homes?
23. How familiar are you with the New Homes program (probe on home qualification criteria, incentives, documentation).
    a. Approximately what percent of your residential new construction projects qualify for New Homes incentives? [Probe – do you have homes that may qualify yet are not submitted for the program?]
24. Have there been any program changes that affect qualifying program homes energy use and resulting energy savings?
25. (If yes and they describe) How does this change affect program homes' energy use and savings, compared to a typical newly built home outside of the program?

## Changes to Building Practices

26. In what ways, if any, do you design the homes you build that do not qualify for Energy Trust program incentives to exceed energy code?
    a. Describe to me some of the key upgrades or changes you might make to have a newly constructed home exceed code?
    b. How would this differ from homes built to meet New Homes program qualifications?
    c. Do these upgrades to meet New Homes requirements have an impact on the cost of these projects relative to just code-built homes?

   d. How challenging are program qualified new homes to build relative to code homes?

27. What decisions to meet New Homes guidelines does the homeowner make, versus you as the builder? (probe a known suggestion)
    a. What decisions are completely your decisions as the builder?

28. Have any of the building practices you developed to meet New Homes criteria been used for other, non-program homes? In what ways?
    a. Does this differ based on whether the home is a spec or custom-built home?

We are going to switch gears and speak more broadly about the construction industry and building code.

29. What are some trends in what consumers want in their new construction homes, in the last few years?
30. Do you believe building code has kept up, outpaced, or fallen behind building practices?
31. Is your belief that standard built homes are built to just meet code, or would there be rationale where homes may exceed code? In what ways?

## Results of this evaluation

32. Our company, Apex, has been conducting an evaluation to determine the energy impacts of this program. Our team developed a baseline comparison group of new construction, non-program homes that were as similar as possible to the program homes. We used this baseline comparison group to compare how well the program-generated building models predicted energy use in baseline homes. Then, we compared program home energy use to the baseline non-program home energy use. The draft results show program homes are not as efficient as predicted by the building models, while non-program homes are more efficient than predicted by the building models. The combination of these divergent factors means that program homes are saving less energy than expected.

    Is this surprising to you?
    a. Please explain why the results are surprising [or not surprising].

33. What do you think could explain these results? What do you believe may be the key drivers behind these findings?
    a. Why do you think these factors are drivers behind the differences in actual versus predicted energy use?

34. What, if any, changes to the New Homes program do you think could increase participating home energy savings?

## Closing

35. What do you see as the greatest strengths of the New Homes program?
36. What do you see as the program's greatest challenges?
    a. How, if at all, would you change the program to better meet those challenges?
37. What, if any, feedback do you have that may help this evaluation and other New Home programs improve?
38. Those are all the questions I had prepared. Is there anything else you think it's important for me to know as we move forward with the study?

# Appendix 4: Additional Breakouts

Table 24. Program Home Annual Weather Normalized versus Simulated Natural Gas and Electric Usage, by Code Version and System Type

| State | Fuel | System Type | Code Version | Number of Homes | WxN Usage | Simulated Usage | WxN Usage vs. Simulated |
|---|---|---|---|---|---|---|---|
| OR | Electricity | All Electric | OR2011 | 307 | 12,004 | 12,055 | 0% |
| OR | Electricity | All Electric | OR2014 | 336 | 11,346 | 9,724 | 17% |
| OR | Electricity | All Electric | OR2017 | 139 | 10,422 | 8,747 | 19% |
| OR | Electricity | All Gas | OR2011 | 2,427 | 7,740 | 7,267 | 7% |
| OR | Electricity | All Gas | OR2014 | 3,394 | 7,711 | 7,530 | 2% |
| OR | Electricity | All Gas | OR2017 | 1,070 | 7,305 | 6,124 | 19% |
| OR | Electricity | Gas Heat Non-Gas WH | OR2011 | 429 | 8,821 | 8,926 | -1% |
| OR | Electricity | Gas Heat Non-Gas WH | OR2014 | 1,585 | 9,364 | 8,713 | 7% |
| OR | Electricity | Gas Heat Non-Gas WH | OR2017 | 634 | 8,735 | 6,637 | 32% |
| OR | Gas | All Gas | OR2011 | 2,690 | 563 | 482 | 17% |
| OR | Gas | All Gas | OR2014 | 4,036 | 591 | 445 | 33% |
| OR | Gas | All Gas | OR2017 | 1,347 | 582 | 478 | 22% |
| OR | Gas | Gas Heat Non-Gas WH | OR2011 | 429 | 259 | 234 | 11% |
| OR | Gas | Gas Heat Non-Gas WH | OR2014 | 1,612 | 337 | 289 | 17% |
| OR | Gas | Gas Heat Non-Gas WH | OR2017 | 694 | 338 | 295 | 15% |
| WA | Gas | All Gas | WA2012 | 445 | 583 | 402 | 45% |
| WA | Gas | All Gas | WA2015 | 1,800 | 518 | 393 | 32% |

Table 25. Non-Program Home Annual Weather Normalized versus Simulated Natural Gas and Electric Usage, by Code Version and System Type

| State | Fuel | System Type | Code Version | Number of Homes | WxN Usage | Simulated Usage | WxN Usage vs. Simulated |
|---|---|---|---|---|---|---|---|
| OR | Electricity | All Electric | OR2011 | 793 | 12,242 | 15,019 | -18% |
| OR | Electricity | All Electric | OR2014 | 637 | 12,734 | 14,002 | -9% |
| OR | Electricity | All Electric | OR2017 | 324 | 10,417 | 12,230 | -15% |
| OR | Electricity | All Gas | OR2011 | 6,661 | 7,728 | 7,897 | -2% |
| OR | Electricity | All Gas | OR2014 | 8,695 | 8,215 | 8,609 | -5% |
| OR | Electricity | All Gas | OR2017 | 2,706 | 7,669 | 6,720 | 14% |
| OR | Electricity | Gas Heat Non-Gas WH | OR2011 | 845 | 9,232 | 9,831 | -6% |
| OR | Electricity | Gas Heat Non-Gas WH | OR2014 | 2,883 | 9,335 | 10,333 | -10% |
| OR | Electricity | Gas Heat Non-Gas WH | OR2017 | 1,159 | 8,893 | 8,861 | 0% |
| OR | Gas | All Gas | OR2011 | 7,478 | 622 | 658 | -5% |
| OR | Gas | All Gas | OR2014 | 10,632 | 651 | 649 | 0% |
| OR | Gas | All Gas | OR2017 | 3,585 | 621 | 697 | -11% |
| OR | Gas | Gas Heat Non-Gas WH | OR2011 | 913 | 258 | 342 | -25% |
| OR | Gas | Gas Heat Non-Gas WH | OR2014 | 3,032 | 314 | 417 | -25% |
| OR | Gas | Gas Heat Non-Gas WH | OR2017 | 1,271 | 310 | 399 | -22% |
| WA | Gas | All Gas | WA2012 | 1,267 | 604 | 575 | 5% |
| WA | Gas | All Gas | WA2015 | 4,478 | 562 | 498 | 13% |

Table 26. Program Home Annual Weather Normalized versus Simulated Natural Gas and Electric Savings, by Code Version and System Type

| State | Fuel | System Type | Code Version | # of Homes | # of Matches | Simulated Savings | WxN Savings | WxN Savings CI (90%) | Realization Rate |
|---|---|---|---|---|---|---|---|---|---|
| OR | Electricity | All Electric | OR2011 | 307 | 793 | 2,964 | 239 | 1.5% | 8% |
| OR | Electricity | All Electric | OR2014 | 336 | 637 | 4,278 | 1388 | 1.2% | 32% |
| OR | Electricity | All Electric | OR2017 | 139 | 324 | 3,483 | -5 | 2.2% | 0% |
| OR | Electricity | All Gas | OR2011 | 2,427 | 6,661 | 631 | -12 | 1.8% | -2% |
| OR | Electricity | All Gas | OR2014 | 3,394 | 8,695 | 1,079 | 504 | 1.0% | 47% |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| OR | Electricity | All Gas | OR2017 | 1,070 | 2,706 | 596 | 364 | 3.4% | 61% |
| OR | Electricity | Gas Heat Non-Gas WH | OR2011 | 429 | 845 | 905 | 411 | 3.5% | 45% |
| OR | Electricity | Gas Heat Non-Gas WH | OR2014 | 1,585 | 2,883 | 1,620 | -29 | 1.1% | -2% |
| OR | Electricity | Gas Heat Non-Gas WH | OR2017 | 634 | 1,159 | 2,223 | 159 | 1.3% | 7% |
| OR | Gas | All Gas | OR2011 | 2,690 | 7,478 | 176 | 59 | 0.3% | 34% |
| OR | Gas | All Gas | OR2014 | 4,036 | 10,632 | 204 | 60 | 0.2% | 29% |
| OR | Gas | All Gas | OR2017 | 1,347 | 3,585 | 219 | 39 | 0.5% | 18% |
| OR | Gas | Gas Heat Non-Gas WH | OR2011 | 429 | 913 | 107 | -1 | 0.9% | -1% |
| OR | Gas | Gas Heat Non-Gas WH | OR2014 | 1,612 | 3,032 | 128 | -22 | 0.5% | -18% |
| OR | Gas | Gas Heat Non-Gas WH | OR2017 | 694 | 1,271 | 104 | -28 | 1.1% | -27% |
| WA | Gas | All Gas | WA2012 | 445 | 1,267 | 173 | 21 | 0.8% | 12% |
| WA | Gas | All Gas | WA2015 | 1,800 | 4,478 | 105 | 44 | 0.7% | 42% |

Table 27. Annual Weather Normalized versus Simulated Natural Gas and Electric Usage, excluding Dual-Fuel Homes, by Code Version and System Type

| State | Fuel | System Type | Code Version | # of Homes | Weather Normalized Usage | Weather Normalized Usage (Matches) | WxN Savings | RR |
|---|---|---|---|---|---|---|---|---|
| OR | Electricity | All Electric | OR2011 | 307 | 12,004 | 12,242 | 239 | 8% |
| OR | Electricity | All Electric | OR2014 | 336 | 11,346 | 12,734 | 1,388 | 32% |
| OR | Electricity | All Electric | OR2017 | 139 | 10,422 | 10,417 | -5 | 0% |
| OR | Electricity | All Gas | OR2011 | 2,427 | 7,740 | 7,728 | -12 | -2% |
| OR | Electricity | All Gas | OR2014 | 3,394 | 7,711 | 8,215 | 504 | 47% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **OR** | Electricity | All Gas | OR2017 | 1,070 | 7,305 | 7,669 | 364 | 61% |
| **OR** | Gas | All Gas | OR2011 | 2,690 | 563 | 622 | 59 | 34% |
| **OR** | Gas | All Gas | OR2014 | 4,036 | 591 | 651 | 60 | 29% |
| **OR** | Gas | All Gas | OR2017 | 1,347 | 582 | 621 | 39 | 18% |
| **WA** | Gas | All Gas | WA2012 | 445 | 583 | 604 | 21 | 12% |
| **WA** | Gas | All Gas | WA2015 | 1,800 | 518 | 562 | 44 | 42% |