What Makes a HERS Home So Special, Anyway?

A Comparison of Field-Tested Homes

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Executive Summary

The availability of comprehensive Home Energy Rating System (HERS) data for the same states where the US Department of Energy (DOE) has conducted residential energy code in-field compliance studies provides a unique opportunity to compare the energy features of HERS rated homes to "typical" homes in a given state. For the past three years, the US DOE has sponsored residential compliance studies to evaluate how well homes comply with local or state building energy codes. These studies provide a robust and consistent dataset that establishes the "typical" level of compliance within each of eight states, and identifies the specific energy saving opportunities available through improved compliance.

This paper focuses on homes in Kentucky, comparing data collected from Phase I of the DOE residential compliance study with the statewide HERS data collected over a similar timeline. By mapping these two datasets, we were able to highlight key similarities and differences, and gain a better understanding of if and how these homes meet the energy code.

In general, our findings demonstrated that on the average, HERS homes are constructed with more efficient home components. They tend to outperform traditional homes more in areas that drive the biggest energy savings, such as the rate of air leakage, location of ducts, and heating and cooling equipment efficiency. Additionally, HERS homes tend to have slightly more efficient windows, more insulation in above grade walls, and better insulation installation practices. However, HERS homes are also larger on average, which requires more resources to build and likely more energy to heat and cool over the lifetime of the home.

Assessing code compliance for HERS rated homes is difficult with this analysis as many use the performance compliance path, enabling flexibility with prescriptive measures. However, we saw a trend where HERS rated homes met and often exceeded mandatory and most prescriptive measures but likely traded off the efficiency of foundation and ceiling insulation. Phase I homes met or exceeded most mandatory and prescriptive measures but had difficulty installing insulation per manufacturer's instructions and demonstrated a relatively high rate of non-compliance with air sealing. Both sets of homes had high rates of non-compliance with efficient lighting and could lack sufficient means of ventilation, as bath fans were listed in a majority of cases.

As HERS scores become more prevalent in the overall residential market and as a path for energy code compliance, this data is a valuable resource to better understand construction practices and identify areas where code compliance could be improved. This analysis provides a better understanding of the interaction between these datasets, compares compliance levels for mandatory and prescriptive energy code requirements, and provides recommendations for further research.

Background Info

Residential Baseline Field Studies

In 2014, the US DOE funded a study to better understand the energy use associated with residential energy code compliance in single-family detached dwellings. Eight states were funded as part of the DOE Residential Energy Code Field Study (Study). The multi-phase Study was comprised of three components – a baseline study, a training and education program, and a post-study analysis to determine the impact of the program. Although an entire paper could be written on the study, this paper will only assess data from the initial baseline analysis (Phase I) of the study in Kentucky (Bartlett, 2017).

The DOE methodology called for an in-field data collection team to visit a random statewide selection of homes and assess compliance levels for the eight energy code requirements, or "key items" determined by DOE to have the biggest energy impact on residential buildings. These eight key items were:

1. Foundation insulation (R-value and installation quality)
2. Above grade wall insulation (R-Value and installation quality)
3. Ceiling insulation (R-value and installation quality)
4. Window U-factor
5. Window SHGC[1]
6. Envelope air leakage rate (ACH50)
7. Duct leakage rate (CFM25/100 sq. ft.)
8. High efficacy lighting (%)

These key items were used in the analysis to determine the level of statewide code compliance and the potential energy savings associated with improved compliance. Field teams also collected additional critical pieces of information which help determine the level of efficiency in a home. These include: heating and cooling equipment efficiency and type, location of duct work, ventilation type, and home size.

Each project team was required to collect sixty-three observations for each of the eight key items to maintain statistical statewide significance. Key measures were collected at two points of construction, so although only sixty-three observations were required, teams had to visit at least 126 homes. Collected data creates a robust and statistically significant dataset which can be used to determine current construction practices of a typically code-built, or average home. It also allows for comparisons to other datasets, such as data from homes seeking a HERS Index.

HERS Data

Homes that are HERS rated earn a performance-based number (0-100) indicating its overall level of efficiency. Many builders of HERS rated homes strive to achieve an Energy Star certification or other above code program to qualify for a utility rebate or federal tax deduction, or to boost the value of the home by demonstrating low operating costs. Since 2006, builders have also

[1] All of Kentucky is in Climate Zone 4 and the state energy code is based in the 2009 IECC. There are no SHGC requirements in Climate Zone 4 in the 2009 IECC.

been able to follow a performance path largely based on a HERS-equivalent metric to comply with building energy codes. The two latest model residential energy codes, the 2015 and 2018 International Energy Conservation Code (IECC), explicitly allow the HERS Index to be used for compliance through the Energy Rating Index (ERI) path. The performance-based software used by HERS raters requires a consistent set of observed and measured inputs from the field to determine a HERS score. These inputs include the eight key items observed in Phase I of the DOE study, as well as many other home components that affect efficiency.

The Kentucky HERS dataset includes data inputs for new single-family homes rated from 2014-2016.[2] While some states in this dataset have more HERS rated homes than others (e.g. Indiana has over 60% of new single-family homes rated) each state's dataset is valuable for researchers hoping to better understand HERS rated homes (RESNET, 2018).

Analysis: Phase I vs. HERS homes in Kentucky

This paper will analyze home component level data collected in Phase I of the DOE Kentucky study and compare it to the statewide dataset of HERS rated homes during the same year (2015). Kentucky was chosen for this analysis because MEEA was the lead agency in the DOE study and thus had access to all the collected data. Additionally, the entirety of the commonwealth is a single climate zone (climate zone 4), so code requirements are consistent across the state, making a component level comparison to the code more direct.

Kentucky Data Collection

The Commonwealth of Kentucky references the 2009 IECC as their statewide residential energy code. This code has been in effect since 2011, four years before the DOE study which started in the spring of 2015. In 2015, Kentucky builders applied for 6,606 permits to build single-family detached homes (Census, 2015). Data was collected based on a randomized sampling plan to ensure that the data was representative of homes being built in all parts of the state. To collect 63 complete datasets, the research team in the field visited 140 houses at two points in the construction process. Although three compliance paths are available in the 2009 IECC, builders of all 140 homes visited used the prescriptive path in the 2009 IECC to comply with the state code.

That same year, 1,616 new single-family homes received a HERS rating in Kentucky, creating a robust dataset of HERS scores and the home components used to determine each score. This HERS dataset represents 24% of all single-family homes that were permitted in 2015. Figures 1 and 2 below compare the sampling plan for Phase I of the baseline study with the number and location of HERS rated homes throughout the state (Bartlett, 2017; RESNET, 2015). As shown in the two maps, the biggest percentage of data collected in Phase I, as well as the greatest number of HERS rated homes, coincide with the most populous areas in the state. Although a significant percentage of the data was collected in urban areas, both datasets are similar in distribution across both urban and rural areas throughout the commonwealth. The allows for a meaningful comparison between datasets, especially when factoring in potential regional differences in construction practices.

[2] This dataset was provided by the Residential Energy Services Network (RESNET).

Figure 1. Kentucky Phase I Study Sampling Plan

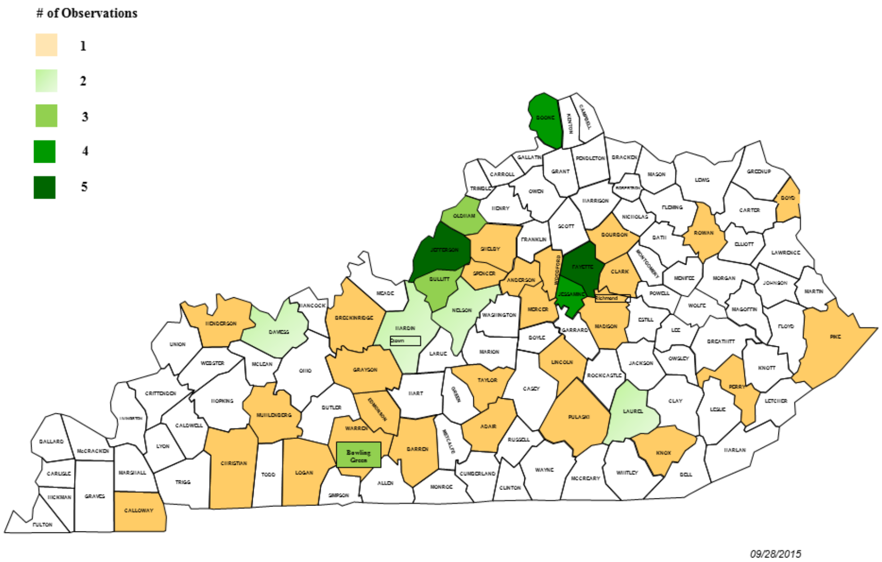
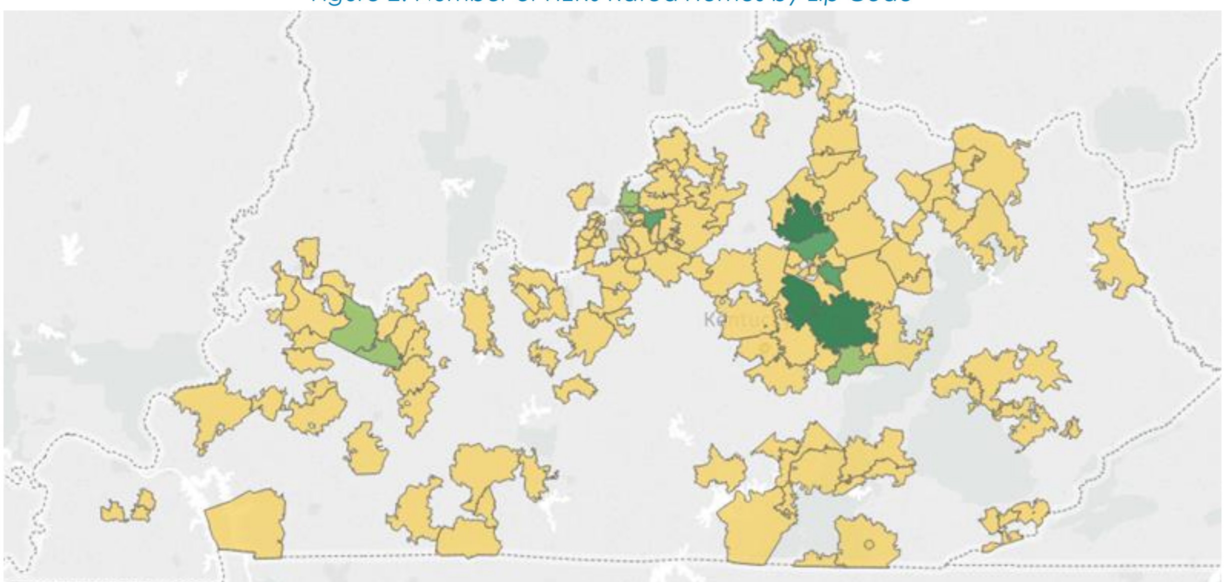


Figure 2. Number of HERS Rated Homes by Zip Code



Home Component Comparison

An initial review of the two datasets, reveals clear differences between a typical code-built home and HERS rated homes. Table 1 compares the average result for a number of home components for both the Phase I homes and 2015 HERS homes. Although averages don't tell the full story, we can immediately see significant differences in home characteristics. Notably, rated homes tend to:

- Be larger than study homes
- Include more continuous insulation in the foundation
- Have more insulation in the wood frame cavity
- Install moderately more efficient windows

- Have a less leaky envelope
- Install more high-efficacy lighting
- Install more efficient heating and cooling equipment

Table 1. Average home characteristics: Phase I homes vs. 2015 HERS homes

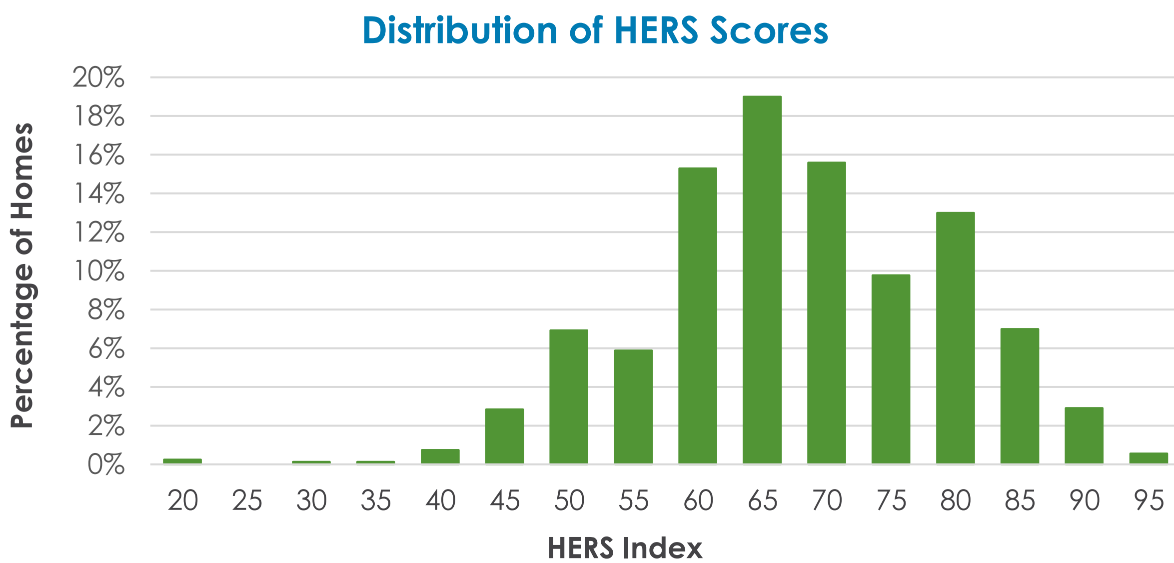
Kentucky		Phase I Homes	HERS Homes
HERS Score	Average Score	NA	66
Conditioned Size	Square Feet	2,433	2,881
	Volume (cu. ft.)	21,706	25,949
Rooms	Bedrooms (#)	3.3	3.4
Foundation Insulation	Continuous (R-Value)	.5	5.7
	Cavity (R-Value)	10.3	1.7
	Quality (1-3)	NA	1.0
Wall Insulation	Continuous (R-Value)	0.5	0.8
	Cavity (R-Value)	13.9	15.1
	Quality (1-3)	1.8	1.3
Ceiling	Continuous (R-Value)	37.7	37.2
	Quality (1-3)	1.6	1.1
Window	Efficiency (U-Factor)	0.32	0.31
	Glazing (SHGC)	0.26	0.27
Air Leakage	Leakage Rate (ACH50)	5.6	3.6
Duct Location	100% Conditioned Space (%)	33	49
Lights	High Efficacy Bulbs (%)	27.3	51.4
Equipment Efficiency	AC Efficiency (SEER)	13.6	13.9
	Furnace Efficiency (AFUE)	89.4	93.0

In general, HERS homes appear to have more efficient components than homes that were tested in Phase I of the Study. However, to gain a more complete understanding of these differences and possibly determine why HERS homes are constructed with more efficient components, it's important to assess each component individually. The next section of the paper will analyze specific differences in the datasets, compare homes to the mandatory and prescriptive provisions in the state energy code, and determine trends in the data.

HERS Scores

The average HERS score for homes built in Kentucky in 2015 is a 66 and a distribution of these scores is shown in Figure 3 below.[3] The HERS rating scale goes from 0-100, with 100 being equivalent to a home built to the 2006 IECC and 0 being a zero-energy home; thus, the lower the score, the more efficient the home. Although it is difficult to directly compare a rated home to prescriptive code requirements in this analysis, RESNET found a 2009 IECC equivalent home to be a HERS 82 in CZ 4. This roughly means the average HERS score of 66 in Kentucky is 16 percent more efficient than a home built to the 2009 IECC, at least according to RESNET. (RESNET, 2014) However, a large percentage of the energy savings in a HERS home are likely attributed to credit being given in the HERS software for the more efficient HVAC systems that are being installed. In a nutshell, the software compares the installed HVAC to the minimum federal efficiency standard for HVAC equipment. In some cases, such as a gas fired furnace, the federal standard has only been improved by 2% over the last thirty years, so homes built for the current market (which demands higher equipment efficiency) are gaining significant efficiency credit, improving their overall HERS score. In some cases, builders are using this credit to trade off longer lived efficiency measures in other parts of the home, such as insulation or windows, albeit, not for code compliance because although the 2009 IECC performance path (R405) allows efficiency to be traded with some code measures, it does not allow the efficiency of HVAC equipment to be traded off in the calculation.

Figure 3. Distribution of 2015 HERS Scores in Kentucky



Home Size

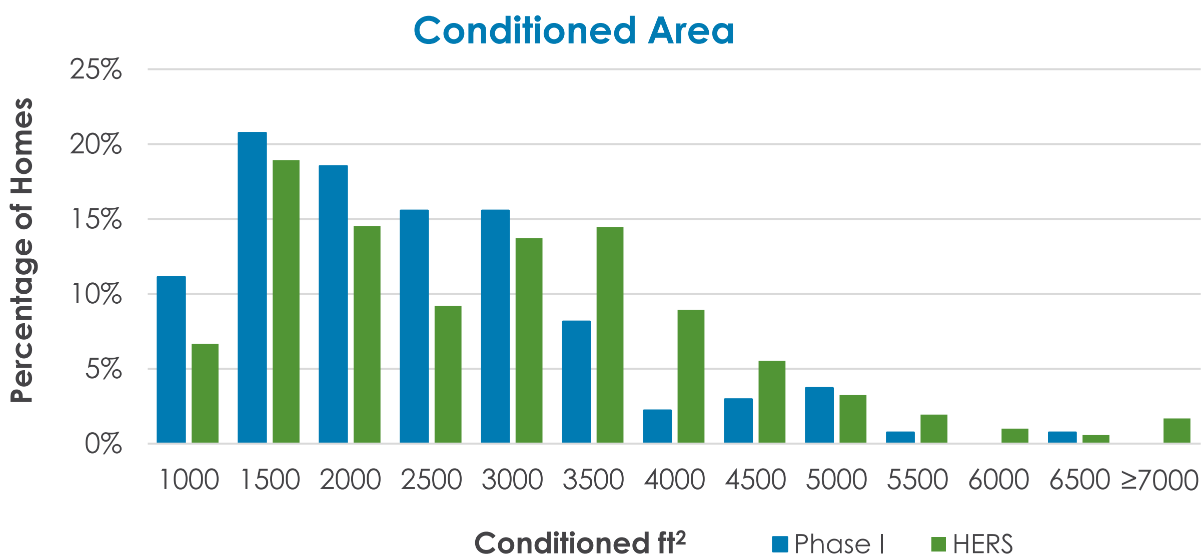
The average home in Phase I of the study had approximately 2500 sq. ft of conditioned space, slightly larger than the average single-family detached home in the south. (EIA, 2015) However, HERS rated homes are 18% larger than homes in the Phase I dataset. The trend in large HERS

[3] Scores were derived by using REM/Rate v. 14.6 or older. RESNET now requires homes be rated using REM/Rate v. 15 or newer. The updated software has been shown to increase HERS score by 2-3 points on average.

rated homes can be seen in Figure 4. For example, homes 3500 sq. ft. or above, comprise 37% of the HERS rated homes, but only 19% of Phase I homes.

This trend of larger HERS rated homes is not unique to Kentucky – it has been seen in all other states in the Midwest, and it has been well documented by RESNET. This may in part be because larger homes have an easier time achieving a lower air leakage rate (ACH50), [4] which has a significant impact on a HERS score. In fact, HERS homes that are 2000 sq. ft. or less, have an average air leakage rate of 4.6 ACH50 and HERS score of 73.3, while homes with 3000 sq. ft or more have an average air leakage rate of 2.7 ACH50 and HERS score of 59.5! RESNET recently addressed this issue by modifying RESNET/ICC 301 to incorporate an Index Adjustment Factor (size adjustment) based on the square footage of the home. (RESNET, 2018)

Figure 4. Comparison of Conditioned Area



Foundation Insulation

The type of foundations and quantity of f insulation installed varied significantly between the datasets. For Phase I homes, conditioned basements were installed in 56% of homes and the rest were either a slab or uninsulated basement or crawl space. In HERS homes, 66% were installed with a conditioned basement.[5] In conditioned basements, Phase I homes were constructed primarily with cavity only insulation, with continuous insulation installed in only 24% of the homes. On the other hand, HERS rated homes were almost the exact opposite, with continuous insulation installed in 65% of these homes. However, 72% of Phase I homes complied with R-10/13

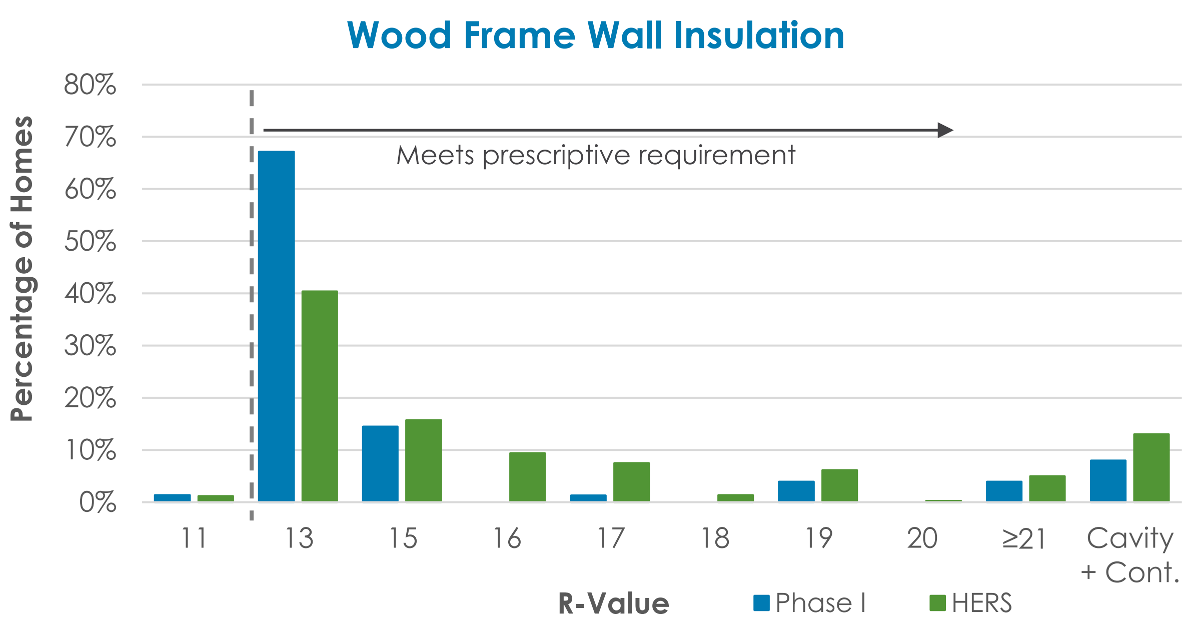
[4] A key reason for this is because ACH50 is calculated by dividing the leakage at the surface (or along the building envelope) of a home by its volume. As homes become larger, the surface and volume grow, but volume grows much more quickly. As a result, smaller homes have a greater surface to volume ratio than larger homes do, so larger homes meet lower ACH50 rates more easily. See a post on Energy Vanguard by Alison Bailes for more on this: https://www.energyvanguard.com/blog/28204/Infiltration-Occurs-at-the-Surface-Not-in-the-Volume
[5] Data for foundations other than basements was not available in the RESNET dataset so for this analysis we only considered basements.

2009 IECC prescriptive requirement for basement insulation, while only 50% of HERS rated homes met or exceeded the requirement.

Wood Frame Wall Insulation

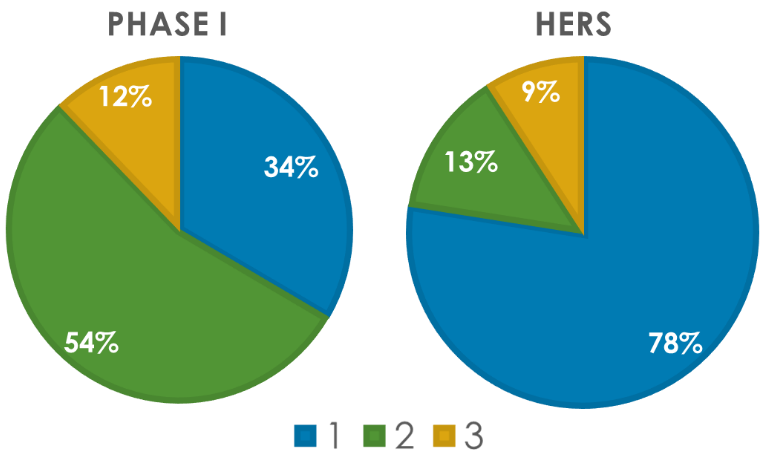
The comparison of insulation levels installed in wood frame walls reveals some interesting findings as can be seen in Figure 5. HERS rated homes had more efficient wood frame wall assemblies on the whole. HERS rated homes had moderately more cavity insulation installed on average (R-15) compared to Phase I homes (R-14). In addition to this small distinction, HERS homes also had more homes with continuous insulation (13% of homes) compared to Phase I homes (8%). Of the homes with continuous insulation, the average R-value for continuous insulation in Phase I homes was R-6, while the average for HERS rated homes was R-4. However, when considering all homes in each dataset, the average amount of continuous insulation installed for Phase I and HERS homes is .5 and .8, respectively. Both sets of houses met the R-13 prescriptive requirement in the code 99% of the time, but in terms of overall wall efficiency, given the difference in average cavity insulation and the higher percentage of homes that installed R-19 or better, HERS homes outperformed the Phase I homes for this measure.

Figure 5. Comparison of Wood Frame Wall Insulation



Homes in both datasets were also graded on the ability to correctly install insulation so it performs as intended. Field observers for both sets of homes used the RESNET insulation installation grading scale (1-3), where Grade 1 is generally installed according to manufacturers' instructions and Grade 3 has more than 3% missing and/or more than 10% compressed insulation in the cavity area. (RESNET, 2013) As shown in Figure 6, in the HERS rated homes, energy raters input the insulation as a Grade 1 78% of the time, while Phase I homes were graded at a 1 only 34% of the time.

Figure 6. Comparison of Wood Frame Wall Insulation Installation



There could be several reasons for the significant disparity of these findings. Although there are quantitative requirements, grading insulation is fundamentally subjective. It is possible that raters and the Phase I field team had different conceptions of a Grade 1 installation. It is also possible that, knowing the HERS rating software assesses an energy penalty for Grades 2 or 3, the rater might have a more difficult time using the strictest definition of Grade 1 knowing it will negatively affect their client. Lastly, builders with HERS rated homes could be installing products, such as dense pack cellulose or spray foam, that more easily meet the Grade 1 standard. Regardless of the reason, this is a striking difference between these datasets and warrants further investigation.

Ceiling Insulation

The average amount of ceiling insulation that was installed in the Phase I and HERS homes was nearly identical (R-38 vs R-37). When breaking down all homes in the datasets we also see a similar trend, with the 2009 IECC prescriptive requirement (R-38), being installed most frequently. However, Phase I homes installed R-38 70% of the time, while HERS homes installed it 41% of the time. A larger percentage of HERS homes (41%) installed less insulation than the prescriptive requirement, meaning the resulting efficiency loss would be made up elsewhere to ensure code compliance. Ceiling insulation is one of the only components where Phase I homes exceeded the level of efficiency of HERS homes.

Window Efficiency

The minimum prescriptive code requirement for window efficiency in Kentucky is a U-factor of 0.35. As seen in Figure 8, all but 2% of homes are meeting or exceeding that requirement in both datasets. However, the biggest difference is in how many homes install windows with a U-factor of 0.30 or lower, meeting energy star requirements. Over half the HERS homes installed windows meeting or exceeding this U-factor, while only 30% did so in the Phase I homes. Therefore, although the average window efficiency numbers are similar (in part due to the spread of U-factors for HERS homes), HERS homes tend to install more ENERGY STAR-rated windows than Phase I homes.

Figure 7. Comparison of Ceiling Insulation

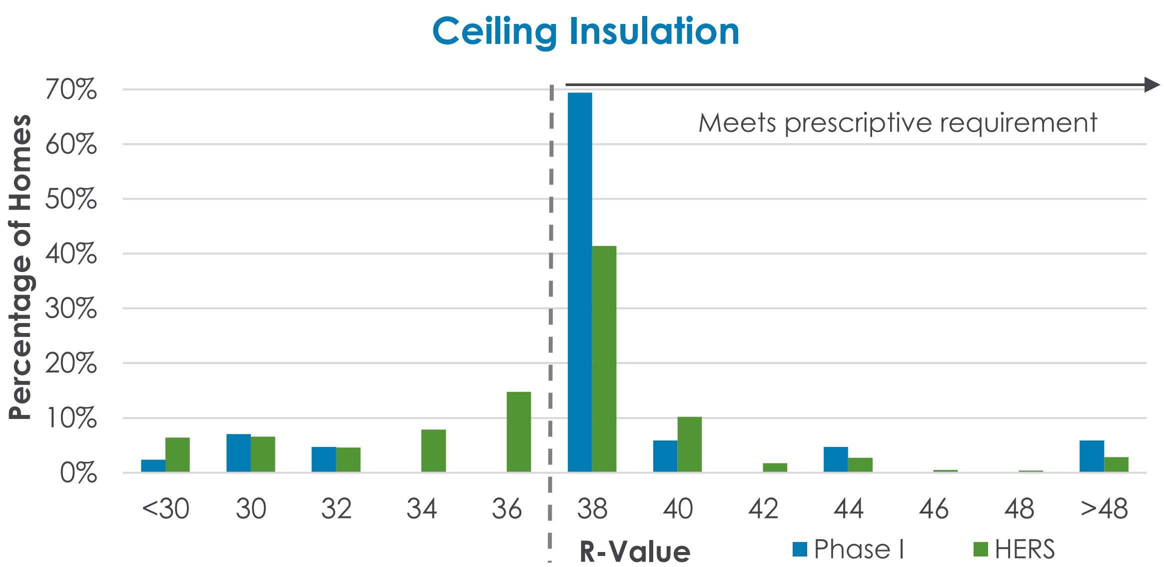
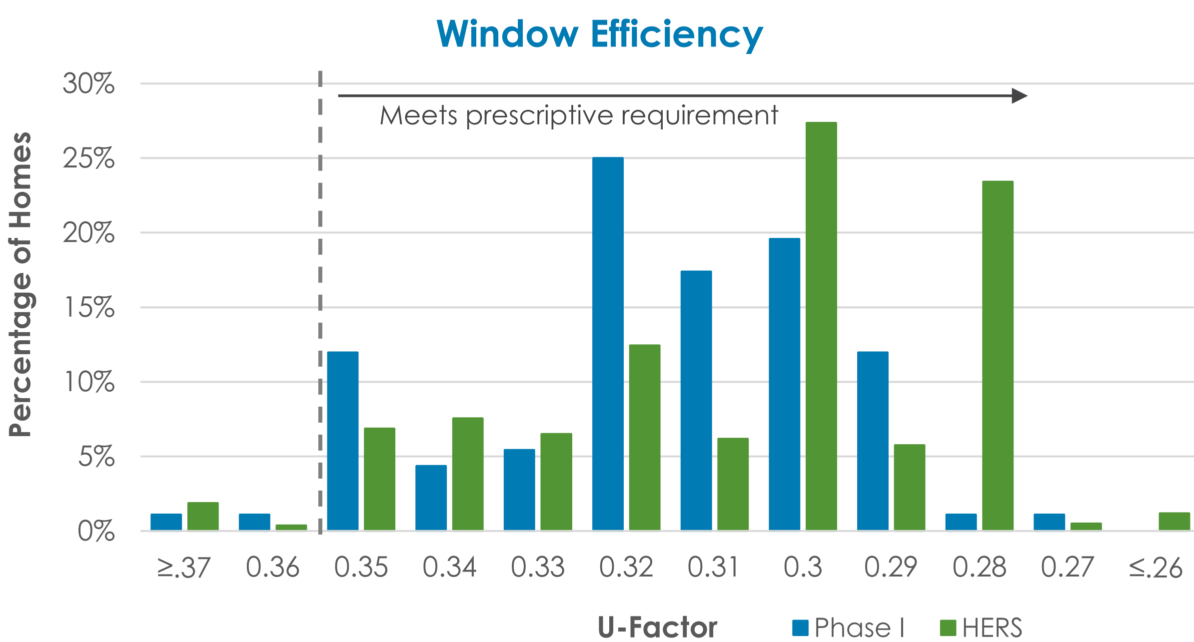


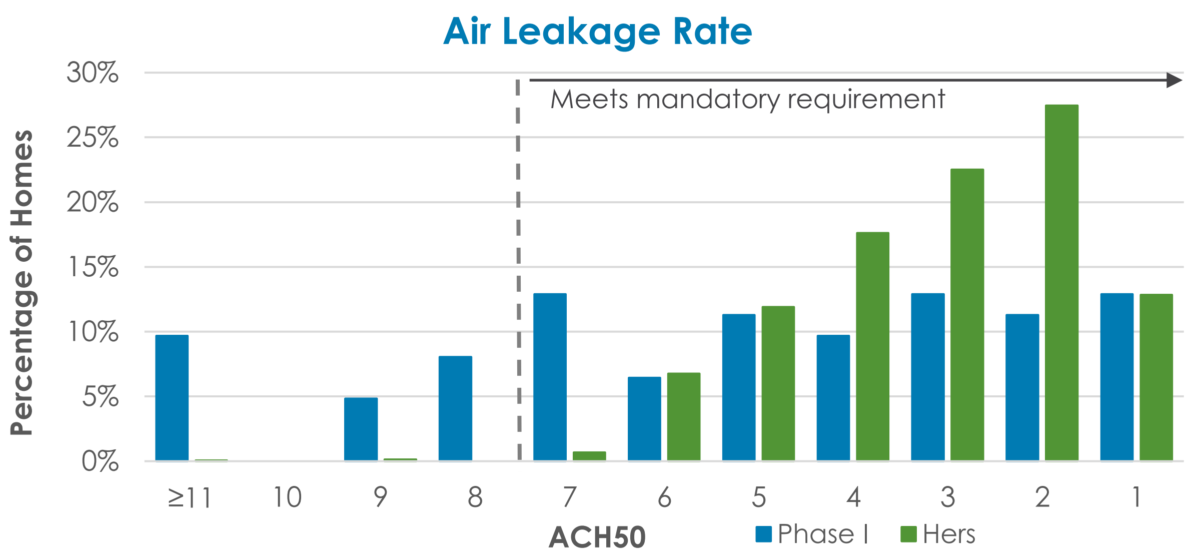
Figure 8. Comparison of Window Efficiency



Air Leakage Rate

HERS homes consistently have a tighter envelope than Phase I homes, as shown in Figure 9. This is expected, given the fact that HERS homes have their envelope leakage tested 100% of the time, while a typical home built to the 2009 IECC isn't required to be tested. When compared to the 2009 IECC, HERS homes met the mandatory code requirement of 7 ACH50 100% of the time, and even meet the more stringent 2018 IECC requirement of 3 ACH50 or better 63% of the time. In contrast, Phase I homes met the 2009 IECC requirement 82% of the time and met the 2018 IECC only 37% of the time. Importantly, although builders of HERS rated homes built tighter envelopes more frequently, most builders in the Phase I dataset (58%) are building homes at 5ACH50 or better, at leakage levels where adequate mechanical ventilation is required by code but may not be installed. These builders are likely unaware of this situation since it is estimated that over 80% of the homes in Kentucky comply with air sealing requirements via visual inspection only. The ability to build a home tighter than the code requirement is great from an efficiency perspective, however, it raises questions about whether the level of ventilation being installed can provide appropriate levels of fresh air into the home.[6]

Figure 9. Comparison of Air Leakage Rate



Ventilation

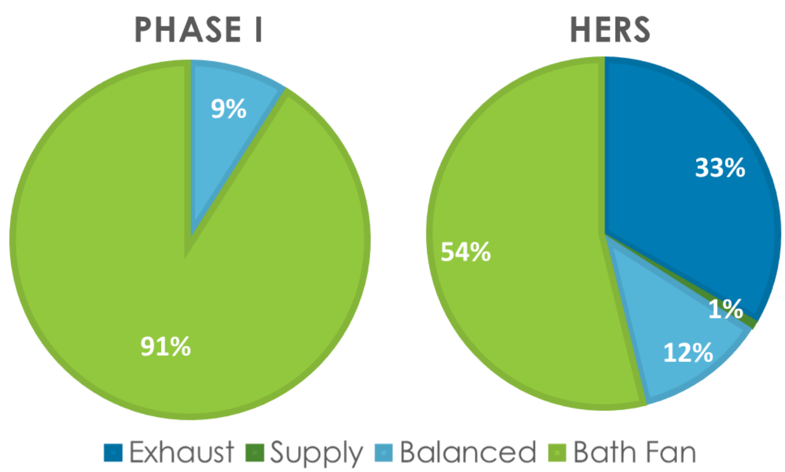
In addition to the eight key items collected during Phase I of the study, the field team also assessed whether mechanical ventilation was being installed and if so, the type being installed. RESNET requires that the type of ventilation, as well as the amount of airflow, be input to the HERS software. Although Kentucky references the 2009 IECC for energy use considerations, the state mechanical code refers to the 2012 version of IRC (or IMC).

When comparing the datasets for ventilation type, we see that the most common type of ventilation noted by the field team collecting Phase I data was a bath fan. This was found in 91% of the homes that were studied.[7] When comparing that to HERS homes, we found that 54% of the homes in that dataset only had a bath fan installed and the rated flow rate was not included to determine if those fans provided adequate exhaust ventilation. The remaining 46% of ventilation types in the HERS dataset included flow rates that achieved compliance with the 2012 IRC/IMC ventilation requirements. As shown in Figure 10, HERS homes that had ventilation other than a bath fan included 36% exhaust, 12% balanced and 1% supply. Although it is troubling that 54% of HERS homes did not indicate whether adequate ventilation was installed, those homes appear to be more ventilated than Phase I homes. Of the homes in each dataset

[6] The 2012 and newer mechanical code requires homes tested at 5ACH50 or lower be equipped with mechanical ventilation. Kentucky follows the 2012 mechanical code.
[7] Data collectors only noted that bath fans were installed. No sizing or operational information was collected.

that were tested at 5ACH50 or lower, the threshold which would require some form of mechanical ventilation, 83% of Phase I homes and 52% of HERS homes did not install ventilation that would meet the 2012 IMC requirements.

Figure 10. Comparison of Ventilation Type



These findings, as well as some additional research MEEA conducted on the Phase I data, demonstrate that a significant number of homes are not being adequately ventilated to provide makeup air as a result of their tight building envelope. (MEEA, 2018)

Duct Leakage

Comparing duct leakage between HERS rated homes and Phase I homes is difficult because HERS rated homes report duct leakage only to the outside of the home's conditioned space, while Phase I homes were tested for total duct leakage, either inside or outside the building envelope. Given this difference, the only true comparison that can be made regarding duct leakage is whether the ducts were in conditioned or unconditioned space and were therefore required to be tested.[8] HERS software attributes an energy penalty to ducts in unconditioned space so it's in a builder's best interest to install ducts in the conditioned building envelope to improve a HERS score and avoid the code requirement to test the duct work. The data shows that HERS homes have ducts in conditioned space 49% of the time compared to 33% of Phase I homes. It is somewhat surprising that there is only a relatively small 16% difference between the two datasets given the advantages gained by the builder by placing all ducts in conditioned space when pursuing a HERS rating. Some of this could be attributed to the fact that Kentucky has an almost even mix between homes with a slab on grade or crawl space and those with a basement, presenting builders with a challenge in placing ducts in conditioned space about half the time.

High Efficacy Lighting

When assessing the percentage of high efficacy lighting in homes we see two things in Figure 11. Study homes failed to meet the 2009 IECC prescriptive requirement 67% of the time, with over

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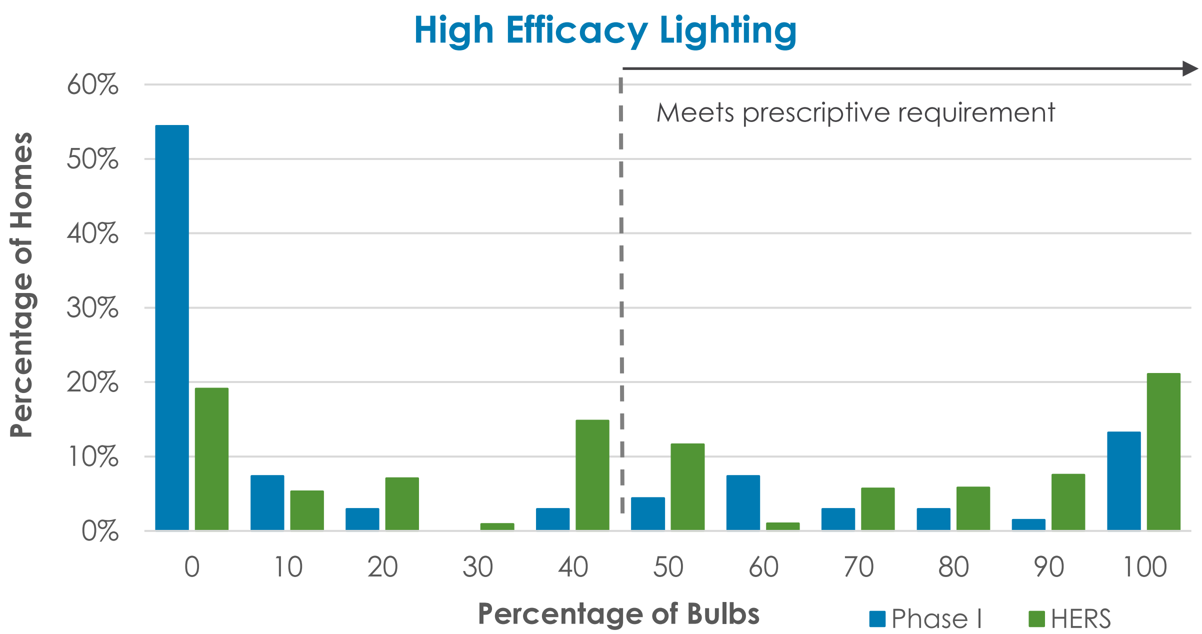
[8] Ducts entirely within conditioned space are exempt from duct leakage testing in the 2009 IECC.

50% of study homes not installing any high efficacy lighting. HERS rated homes fared significantly better, although builders still failed to meet the prescriptive code requirement in 46% of the homes. It was expected that most HERS homes would meet the high efficacy lighting prescriptive measure, given price competitiveness, quality comparability, and wide availability of LED bulbs. However, high efficacy lighting is not a mandatory requirement in the 2009 IECC and is not factored in to the performance path so the ambiguity around compliance could have an impact.

Figure 11. Comparison of High Efficacy Lighting Percentage



Equipment Efficiency

With the opportunity for a builder to receive significant efficiency credit for installing a high efficiency furnace in the HERS software – especially based on the dated comparison to the federal standard (80 AFUE) - it's not surprising that 95% of homes with a gas furnace installed a 92 AFUE furnace or better, as shown in Figure 12. The efficiency of furnaces in HERS homes is better than those in the study homes, but surprisingly, even without being required by code or receiving an efficiency credit, 83% of builders in Phase I installed a condensing furnace (90 AFUE or better).

Similar to furnaces, AC efficiency had some notable differences between the two datasets. In Phase I homes, while all AC units met the standard in place at the time of their installation, 50% of them also meet the recently updated federal minimum standard of 14 SEER.[9] In contrast, HERS homes installed AC units with 14 SEER or higher 71% of the time. Given the change in federal standards, if this same study were conducted today, the makeup of AC efficiency would likely be much different.

[9] A new minimum federal efficiency standard was established January 1, 2015 with an 18-month implementation grace period.

Furnaces and split AC units are not the only heating and cooling units being installed in Kentucky. Kentucky has a large percentage of homes that take advantage of the favorable climate by installing high efficiency air source heat pumps (ASHP), and in some cases ground source heat pumps (GSHP). According to the study data 46% of Phase I homes installed an ASHP with an average HSPF efficiency of 8 and SEER of 13.7. There was a similar breakdown of ASHP/GSHPs in the HERS rated homes as well, although the specific level of efficiency was unfortunately absent from the dataset.

Figure 12. Comparison of Furnace Efficiency

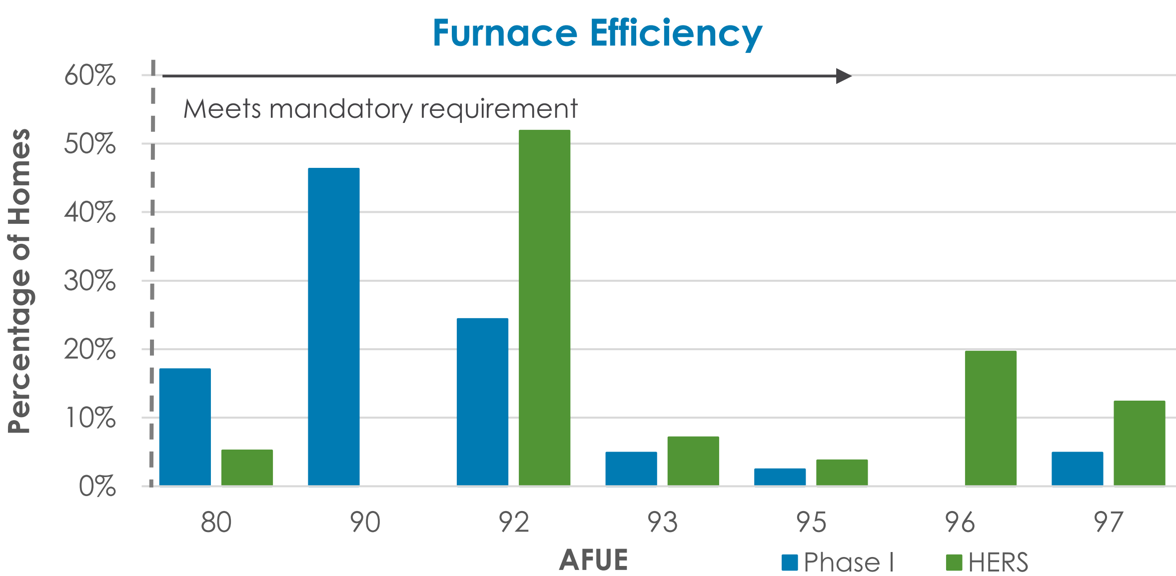
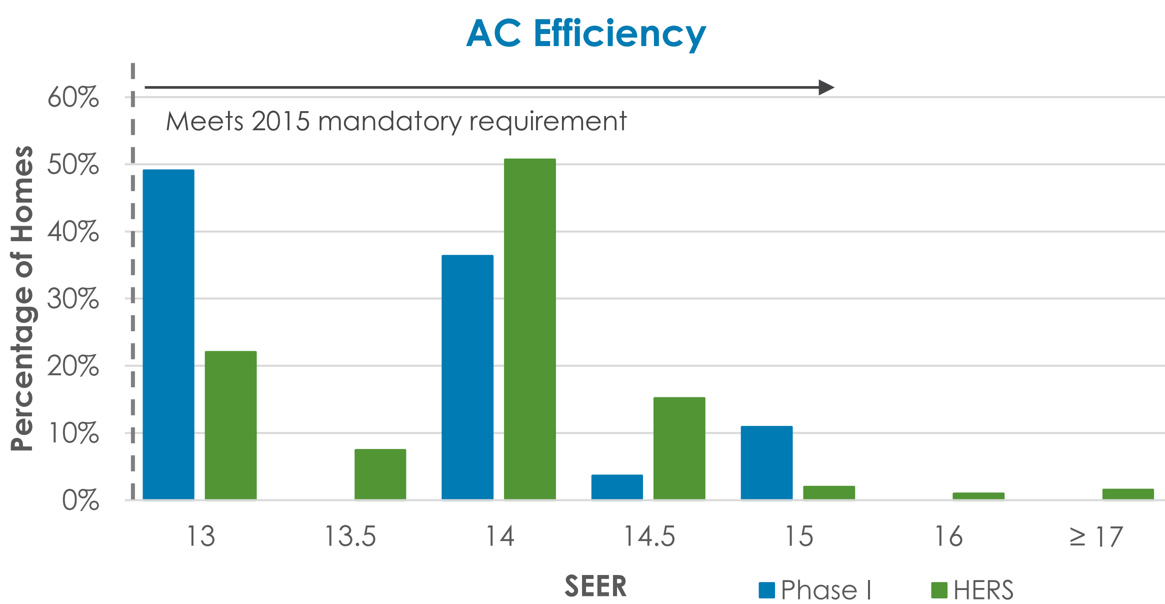


Figure 13. Comparison of Air Conditioner Efficiency[10]



[10] Includes SEER efficiency of ASHPs found in Phase I homes.

Conclusion

This simple breakdown of energy efficient home components demonstrates that HERS homes outperform a traditional home in most measures, but many of the eight key measures (specifically insulation and fenestration) that DOE factored into their analysis are similar. However, HERS homes tend to outperform traditional homes more in areas that drive the biggest energy savings, such as the rate of air leakage, location of ducts, and heating and cooling equipment efficiency. Additionally, HERS homes tend to have slightly more efficient windows, more insulation in above grade walls, and better insulation installation practices. Although, these homes are also larger – meaning more resources are used to build the home and more total energy is expended with heating and cooling.

In terms of code compliance, although difficult to assess for HERS rated homes with this analysis, most of HERS homes met or exceeded mandatory and prescriptive requirements with few exceptions. These exceptions included foundation and ceiling insulation where HERS homes installed prescriptive components that were less efficient than code, but assuming the energy loss is made up elsewhere, these homes will remain compliant. Phase I homes had difficulty installing insulation per manufacturer's instructions and displayed a relatively high rate of non-compliance with air sealing. Both sets of homes showed similar issues with compliance in terms of high efficacy lighting and ventilation practices, which warrant further investigation to understand why.

With this analysis, it's important to remember that this is a simple comparison of home components that affect energy efficiency; further energy modeling was not conducted on homes in either dataset which would provide a direct comparison to total home efficiency and a better sense of code compliance for HERS homes. Additionally, we only conducted this comparison in Kentucky and the results could be very different in other states. Kentucky builders in the Phase I dataset, exceeded the prescriptive code in several areas, including windows, air sealing, and heating and cooling equipment efficiency.

Assessing the reasons behind the differences between these two datasets within the parameters of this paper is difficult, but this paper has identified areas warranting further analysis and discussion. Specifically, we believe the use of these datasets can better inform current code compliance and construction practices within a state, provide context to 3rd party enforcement and inform future code development and adoption efforts.

Further Research

As discussed at the beginning of the paper, the DOE Study was split into three parts with the last component being a post-program study (Phase III) after two years of extensive training and education for builders. A preliminary analysis of the Phase III data indicates builders significantly improved the level of building tightness (ACH50), percentage of efficient lighting, and window u-factor as a result of the training program. Conducting this same analysis and comparing homes in Phase III of the study with HERS rated homes in 2017 might close the efficiency gap between the typical home and a HERS rated home.

Another impactful piece of research that could be conducted using these data sources is to determine if and to what degree HERS data could be used to support code compliance assessments in the future. This data would likely need to be accessed in real time by study teams to make a fair comparison between homes tested by HERS raters and those tested by field teams. Although it wasn't the focus of this paper, we think this comparison of field data collected in the same year will unearth some interesting questions and will help continue this discussion.

References

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