The Marriage of Residential Energy Codes and Rating Systems: Conflict Resolution or Just Conflict?

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ABSTRACT

After three decades of coexistence at a distance, model residential energy codes and residential energy rating systems have come together in the 2015 International Energy Conservation Code. At the October, 2013, International Code Council's Public Comment Hearing, a new compliance path based on an Energy Rating Index was added to the IECC. Although not specifically named in the code, RESNET's HERS rating system is the likely candidate Index for most jurisdictions. While HERS has been a mainstay in various beyond-code programs for many years, its direct incorporation into the most popular model energy code raises questions about the equivalence of a HERS-based compliance path and the traditional IECC performance compliance path, especially because the two approaches use different efficiency metrics, are governed by different simulation rules, and have different scopes with regard to energy impacting house features. A detailed simulation analysis of almost 15,000 house configurations reveals a very large range of HERS Index values that achieve compliance equivalence with the IECC's performance path. In this paper we summarize the results of that analysis and, by evaluating those results against the specific Energy Rating Index values required by the 2015 IECC, find those ERIs to be very similar to the conservative (lower) end of the range of HERS values identified as corresponding to compliance with the traditional performance path, suggesting that many if not most homes built to the new ERI path's requirements would have better energy performance than if built to the traditional performance compliance path. Finally, based on the home characteristics most likely to result in disparities between HERS-based compliance and performance path compliance, potential impacts on the compliance process, state and local adoption of the new code, energy efficiency in the next generation of homes subject to this new code, and future evolution of model code formats are discussed.

Background and Introduction

At the International Code Council's 2013 Public Comment Hearing a new compliance path was added to the International Energy Conservation Code (IECC). For the first time, the 2015 IECC will allow compliance via an Energy Rating Index (ERI) as an alternative to the existing prescriptive and performance-based paths (ICC 2013a). The ERI is somewhat loosely defined, but is clearly designed to be compatible with, if not modeled after, the Home Energy Rating System (HERS) maintained by the Residential Energy Services Network (RESNET 2013). RESNET, in addition to maintaining the technical definition of its HERS, provides an extensive infrastructure of certifications for raters, rating providers, rating software, and trainers. RESNET's website lists 104 Accredited Energy Rating Providers in 40 states (RESNET 2014a), 50 accredited Energy Rating Training Providers (RESNET 2014b), and four Accredited Rating Software Programs (RESNET 2014c).

For a number of years RESNET's HERS has been used, either directly or indirectly, in several national above-code programs, such as the Environmental Protection Agency's (EPA) Energy Star Homes program (EPA 2014) and the U.S. Department of Energy's Building America program (DOE 2014). RESNET's HERS is therefore familiar to many builders and has been used by those builders in parallel with their code compliance documentation. Indeed, RESNET maintains a certification system for software programs purporting to demonstrate IECC compliance via its performance approach, currently listing four such accredited programs (RESNET 2014d). RESNET's HERS is therefore the likely go-to system for builders desiring to use an ERI for IECC compliance.

This new marriage of the IECC and energy ratings may not be smooth, initially. For years, many working with beyond-code housing have observed that HERS Index values do not correlate directly with the results of energy performance evaluations conducted for other purposes. For example, the EPA's Energy Star program developed a Size Adjustment Factor (SAF) that must be multiplied by the HERS Index of the Energy Star Reference Home to determine the target HERS Index value for a candidate home for Energy Star qualification (EPA 2011). The necessity of this adjustment reflects the observation that the HERS Index and energy performance calculated for code compliance vary differently as the size of a home changes. Some such differences are to be expected because of the plethora of building components, simulation assumptions, and other considerations that can impact the estimated energy consumption of a home. Similar effects can be observed with systems other than HERS. DOE's Building America program, for example, developed an adjustment factor that is applied to the projected energy use of its Benchmark Home to determine the value against which BA homes' savings are compared (Hendron 2010). Finally, a recent study by Fairey (2014) quantified the home-size effect on HERS Index values and developed a straightforward correlation between the two.

The HERS system is also of particular interest because as a viable ERI it now effectively sits alongside the IECC's Simulated Performance Alternative compliance path (hereafter called the "traditional performance path"), which uses a very different set of rules for conducting energy performance calculations to determine compliance, some of which are discussed in detail below. In prior work, we conducted an extensive analysis of the manner in which HERS and the IECC performance path differ, not only as a function of house size (conditioned floor area), but including the effects of window-floor ratio, foundation type, glazing orientation, number of stories, appliance efficiency, and HVAC type and efficiency (Taylor and Mendon 2014). That work, hereafter referred to as the PNNL analysis, was based on simulation of energy performance and calculation of HERS Index values for buildings with many combinations of several levels of those characteristics. While the methodologies for calculating the HERS Index were based on the published calculation procedure (RESNET 2013), the PNNL analysis did not use RESNET-certified software to conduct calculations.

The PNNL analysis involved energy simulations of almost 1000 unique combinations of home characteristics in each of 15 climate locations representing the 15 distinct climate zones of the IECC (eight numbered, temperature-oriented zones and one to three moisture regimes per numbered zone). Treating IECC's traditional performance path as a base, for each home configuration a Corresponding HERS Index, defined as the HERS Index value corresponding to a home minimally complying with the IECC's traditional performance path, was identified.

Summaries across building characteristics revealed the ranges of HERS Index values that might correspond to similar compliance verdicts under the prior (ERI-less) IECC. In this paper we highlight the important findings of the PNNL analysis and discuss their potential impact on the building industry and associated regulatory infrastructures when the 2015 IECC becomes available to building code jurisdictions.

The IECC and HERS: A Summary of Differences

Although the IECC's traditional performance path and RESNET's HERS are both based on a comparison of two prototype homes, one being a predefined baseline configuration and the other reflecting the builder's actual home, the two systems differ in several ways. First, and perhaps most importantly, they use different metrics to grade the energy performance of a building. The IECC requires comparison of a candidate home's estimated annual energy cost[1] with that of a baseline home having the same geometry but configured to comply with the IECC's prescriptive path. The RESNET system bases its comparison on a quantity known as the Normalized Modified End Use Load (nMEUL). The HERS Index is computed as a ratio of the nMEUL value for the Rated Home and the total load of the Reference Home; it equals 1.0 for a home roughly complying with the 2006 IECC and drops to zero for a net-zero energy home.[2]

Second, the IECC and RESNET systems, though they both require simulation of two prototype homes, define those prototypes differently. There are differences in the energy efficiency features of the baseline prototypes, in the rules for how the two prototypes are simulated and compared, and in many operational assumptions. Details are available (Taylor and Mendon 2014), but some of the key differences are mechanical equipment efficiency, mechanical ventilation, thermostat set points, crediting of thermostat setbacks, baseline glazing areas, and internal heat gains. Not only are the specific parameters describing these assumptions different, but there are often different rules about how they are applied. For example, the HERS Index gives credit for glazing area smaller than a defined threshold and penalizes homes with glazing above that threshold. The IECC, in contrast, gives no credit below its threshold but does penalize glazing areas above it.

Finally, the scope of what is included in the two systems' calculations is different. The HERS index is a whole-building performance measure, including the impacts not only of building envelope, HVAC, and water heating, but also other home appliances and onsite generation. The calculations in IECC's traditional performance path include only the elements otherwise regulated by the code, excluding home appliances and, significantly, the efficiency of HVAC and DHW equipment. The PNNL study analyzed the impacts of a number of these differences.

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[1] Source energy may be used as an alternative to energy cost.

[2] Although the IECC requires only a simple comparison of two energy cost values and doesn't formally define a ratio, the PNNL analysis defined such a ratio called the "Compliance Ratio" to facilitate direct quantitative comparisons with HERS Indexes.

Key Results of the PNNL Analysis

The PNNL analysis has both good news and bad news for the IECC/ratings marriage. The good news is that specific ERI values (which, as we've pointed out, are likely to be based on RESNET's HERS Index values for many if not most homes) specified in the new IECC compliance path are more or less corroborated by the PNNL analysis when viewed from a conservative perspective that seeks to minimize the number of homes that would comply under the new ERI path but not under the existing paths. The bad news is that the differences in how HERS and the IECC performance path calculate energy performance are nontrivial and may impact states' adoption of the 2015 IECC and jurisdictions' enforcement of compliance.

PNNL's analysis resulted in a database of Corresponding HERS Indexes for a large number of house configurations. For a given home, the Corresponding HERS Index is the HERS Index corresponding to minimal compliance with the IECC's traditional performance path. For many home configurations, the Corresponding HERS Index is lower than might be expected because the traditional performance path doesn't recognize some energy-saving features, high-efficiency equipment being a prominent example. By choosing a sufficiently low HERS Index as a compliance threshold, an energy code can ensure a large majority of homes complying by that threshold will also comply by the traditional performance path. Table 1 shows how the IECC's new ERI path's thresholds compare to the low end of Corresponding HERS Index values computed in the PNNL analysis.

The four data columns of Table 1 can be interpreted as follows. The leftmost column contains the ERI thresholds that will be in the 2015 IECC. The next two columns are the lowest Corresponding HERS Index values from the PNNL analysis for the two parallel cases of homes with Federal minimum HVAC efficiency and those with very high HVAC efficiency. It is important to know both of these values because the IECC's traditional performance path does not credit HVAC improvements, so a lower HERS Index is necessary to ensure compliance via that performance path if the home is equipped with high-efficiency HVAC equipment. The rightmost column shows the size of the range of HERS Index values calculated by PNNL; that range applies to both the Federal-minimum and high-efficiency HVAC columns. For example, in Climate Zone 1-Moist, the highest Corresponding HERS Index value among all the home configurations analyzed is 25 HERS points higher than the lowest. For a home with Federal-minimum equipment efficiencies, that would be 82 (57 + 25). For a home with the highest equipment efficiencies analyzed, it would be 72 (47 + 25).

The Corresponding HERS Index values computed in the PNNL analysis are home-specific HERS values calculated for prototype homes of various configurations. The values shown in Table 1 are the lowest values seen among the large number of configurations analyzed—hence, each value represents a conservative threshold to the extent the configurations analyzed cover the range of characteristics expected in real homes.

Table 1. Comparison of the PNNL analysis and the 2015 IECC ERI thresholds

Climate Zone	Moisture Regime	Maximum Allowable ERI in the 2015 IECC	Lowest Corresponding HERS Index from PNNL Analysis (lowest observed value among all house configurations)		Range of Corresponding HERS Index from PNNL Analysis (difference between highest and lowest observed values, not including HVAC efficiency differences)
			With Federal Minimum HVAC Efficiencies	With Highest Analyzed HVAC Efficiencies[3]	
1	Moist	52	57	47	25
2	Moist	52	62	54	21
	Dry		59	49	21
3	Moist	51	55	47	22
	Dry		58	50	19
	Marine		56	52	26
4	Moist	54	56	48	23
	Dry		56	48	21
	Marine		58	54	24
5	Moist	55	55	47	26
	Dry		58	53	24
6	Moist	54	55	48	24
	Dry		58	51	23
7	N/A	53	53	44	24
8	N/A	53	55	45	23

The first major takeaway from the PNNL analysis is that the ERI thresholds in the 2015 IECC are reasonable from the standpoint of ensuring that homes complying via the ERI path also comply via the traditional performance path (assuming, of course, that RESNET's HERS is used as the ERI). In every climate zone, the 2015 ERI is equal to or below (more stringent than) the lowest HERS Index identified by PNNL for homes with HVAC efficiencies at Federal minimums. This means that virtually all such homes complying via the ERI path will meet or exceed the IECC's requirements as embodied in the traditional performance path. By contrast, in most zones, the 2015 ERIs are higher than the lowest Corresponding HERS Index PNNL found for homes with high-efficiency HVAC equipment. However, the high-efficiency HERS Index values in Table 1 are for an extreme case—a home configured with equipment at or near the highest efficiencies available and hence subject to maximum trading down of envelope and system requirements.

[3] For gas-heated homes, these were SEER-20 and AFUE-80 in climate zones 1-2, SEER-20 and AFUE-96 in zones 3-4, and SEER-13 and AFUE-96 in zones 5-8. For homes with heat pumps, they were SEER15 and HSPF-8.2 in zones 1-2, SEER-15 and HSPF-9.0 in zones 3-4, and SEER-14 and HSPF-9.0 in zones 5-8.

The second important observation is that the range of possible Corresponding HERS Index values is quite large in all zones, ranging from 16 to 26 HERS points, where each point corresponds to about a one percent change in energy performance. This is arguably huge. The HERS whole-building nMEUL metric clearly scores energy performance differently from the IECC's traditional performance path as house characteristics change. The result is that where HERS is used as the ERI, a code will have two compliance paths that can appear to differ by up to 26% in the energy performance of complying homes. However, the differences in scope between the two systems complicate interpretation of that percentage, and the conservative level of the 2015 ERI thresholds ensures that most of the complexity falls out to the benefit of efficiency.

In summary, the PNNL analysis shows that while there are certainly some homes that might comply under the IECC's ERI path but not under its traditional performance path, the number of those homes and the amount by which they fail compliance are relatively small. However, the large range of Corresponding HERS Indexes identified by PNNL show that there are many home configurations for which the new ERI path would require much better energy performance than would the traditional performance path.

Potential Implications

It is encouraging that the 2015 ERI thresholds are conservative; homes complying by the new path will almost always be at least as efficient as those complying by the traditional performance path and, in many if not most cases, more efficient. However, the large range of Corresponding HERS Index values suggests that for many if not most homes, higher ERI thresholds would result in home efficiencies at least equal to the traditional performance compliance path. In other words, the 2015 ERI thresholds are, on average, very conservative. This might raise several questions for states considering adoption of the 2015 IECC and for the compliance and enforcement processes related to the new path, including:

- Will the presence of the ERI path improve compliance with the code?
- Will the incorporation of HERS raters into the process improve code officials' ability to enforce the code?
- Will builders balk at the conservative ERI thresholds and ignore the new compliance path?
- Will states adopt the 2015 IECC as is or will they consider raising the ERI thresholds to less conservative levels?
- Will the conservative thresholds encourage more efficient homes?
- Will the additional flexibility of a new compliance path grease the skids on state adoption of the 2015 IECC?

Although most of these require some level of speculation to answer now, we engage discussion of these and similar questions to consider how the information in the PNNL analysis might apply to them, if not by answering them, perhaps by providing tools to the various decision makers in the adoption/compliance processes.

Adoption

The inclusion of the ERI path in the 2015 IECC could be met with mixed reactions. On one hand, many builders may be relieved to have an alternative for compliance that is based on whole-building energy performance and allows them more flexibility in their design decisions on a case-by-case basis. The ERI's explicit accounting for equipment efficiency is of particular interest to many builders. On the other hand, the conservative nature of the 2015 ERI thresholds may not be welcome to some builders. Efficiency advocates may be pleased with the stringent thresholds, but may have concerns about the consistency of ERI ratings across different types and sizes of buildings and the corresponding effect on code compliance and energy savings.

Many states are likely to consider the 2015 IECC for prompt adoption because of its potential to mollify builders who have opposed earlier IECC editions for their lack of HVAC efficiency trade-offs. But the conservative nature of the 2015 IECC's ERI thresholds could result in pressure to adopt the code with amendments that raise those ERI thresholds to less stringent levels. Advocates of such amendments would have at least one precedent to cite—a public comment submitted to the ICC by the original author of the ERI code change proposal that would have raised those thresholds in the 2015 code by seven to nine ERI points (ICC 2013b). That public comment did not prevail at the ICC hearings, but the numbers are available in the ICC's record of proposed code changes for a state to embrace should a compromise be considered.

If history is any indicator, any such compromise would be met with vigorous opposition by efficiency advocates. But the PNNL analysis may provide a source of information that could turn the controversy into a regulatory win-win. That analysis evaluated the database of widely varying Corresponding HERS Index values to identify the building characteristics that most influence the magnitude of those Indexes. The results are presented in the form of tabular "decision trees" that may be the guidance that would support such a compromise without diminishing the potential efficiency gains the ERI path offers—a kind of mediation for this potentially troubled marriage of codes and ratings. The decision trees are designed to show how ERI thresholds might vary if certain building characteristics were accounted for, in contrast to the 2015 IECC's ERI thresholds, which are the same for all homes regardless of characteristics.

Table 2 is an example decision tree, taken directly from the PNNL report, for Climate Zone 1-Moist. The tree is read from left to right, with the two columns at the far right showing the minimum and maximum Corresponding HERS Indexes identified for the class of building configurations described to the left. Those configuration classes are described in terms of what building characteristics are accounted for in a hypothetical table of HERS (ERI) thresholds. At far left, for example, spanning the whole table from top to bottom, is the label "None," which means none of the analyzed characteristics is accounted for (exactly like the ERI thresholds in the 2015 IECC). The range of Corresponding HERS Index values for that scenario is defined by the top left and bottom right values within the vertical range described by the "None" label—in this case, 57 and 82, or a range of 25 HERS points. But if one major building characteristic—conditioned floor area (CFA)—is accounted for by separating homes with 5000 ft^2 into a separate category from the smaller ones, there are two smaller ranges involved: one from 57 to 71, for the larger homes, the other from 63 to 82, for the smaller homes. A simplistic outcome of this single cut in the tree might be a dual-valued table of ERI thresholds for this zone: an Index of 57 for large homes and 63 for smaller ones.[4] Further refinements are possible by continuing to the right through the decision tree. Among the larger homes, for example, the next most important characteristic is the foundation type; homes with crawlspaces could have a threshold of 65 instead of 57. Note that the Index values cited here assume homes with Federal-minimum HVAC efficiencies and are for illustrative purposes only.

Table 2. Decision tree for homes with federal-minimum equipment efficiencies for climate zone 1-mMoist (Taylor and Mendon 2014)

<table>
<tr><th colspan="5" rowspan="2">Characteristics Accounted For</th><th colspan="2">Corresponding HERS Index Range</th></tr>
<tr><th>Min.</th><th>Max.</th></tr>
<tr><td rowspan="11">None</td><td rowspan="3">CFA = 5000</td><td rowspan="2">Slab or Basement</td><td colspan="2">1 Story</td><td>57</td><td>68</td></tr>
<tr><td colspan="2">2 Story</td><td>63</td><td>69</td></tr>
<tr><td colspan="3">Crawlspace</td><td>65</td><td>71</td></tr>
<tr><td rowspan="8">CFA = 1200 or 2400</td><td rowspan="4">CFA = 2400</td><td rowspan="2">ENERGY STAR Appliances</td><td>Slab or Basement</td><td>63</td><td>71</td></tr>
<tr><td>Crawlspace</td><td>70</td><td>73</td></tr>
<tr><td rowspan="2">Standard Appliances</td><td>Basement</td><td>66</td><td>74</td></tr>
<tr><td>Crawlspace or Slab</td><td>71</td><td>77</td></tr>
<tr><td rowspan="4">CFA = 1200</td><td rowspan="2">ENERGY STAR Appliances</td><td>Basement</td><td>66</td><td>74</td></tr>
<tr><td>Crawlspace or Slab</td><td>72</td><td>77</td></tr>
<tr><td rowspan="2">Standard Appliances</td><td>Basement</td><td>71</td><td>78</td></tr>
<tr><td>Crawlspace or Slab</td><td>78</td><td>82</td></tr>
</table>

Continuing the refinement for the smaller homes, the HERS indexes are more sensitive to, first, a further segregation by size, then to the presence or absence of energy-efficient appliances, and finally to foundation type. It is not surprising that appliance efficiency is more important to determining HERS ratings for smaller homes, since smaller homes tend to have a higher percentage of whole-house energy dedicated to appliances than larger homes, meaning the presence of energy-efficient appliances results in a bigger improvement in the HERS Index for a smaller home than it does for a larger home.

In summary, a state or other adopting authority in this climate zone may use as much or as little of the decision tree as necessary to develop amendments that give more palatable ERI thresholds for certain common home configurations without compromising efficiency for other configurations, as would a single, blanket increase of the 2015 ERI threshold.

Decision trees for all 15 climate zone/moisture regime combinations, each showing the most important building characteristics affecting Corresponding HERS Index values in the zone/regime of interest, are available (Taylor and Mendon 2014). While the PNNL analysis does not attempt to provide a final answer—each state or adopting authority would have to analyze

[4] Specific definitions of "large" and "small" would be up to the adopting jurisdiction, but the PNNL analysis provides data on which to base such definitions.

the relevant decision trees and decide on the best compromises between palatability of the ERI thresholds and complexity of the threshold tables—the data may hold a resolution to the potential conflicts in this new marriage of codes and ratings.

Compliance

Any new compliance path has the potential to affect compliance and enforcement in several ways. Additional compliance options increase the overall complexity of the code, which may be a hindrance to code officials' effective enforcement. On the other hand, depending on the nature of the new path, it may lessen or eliminate prior difficulties, streamlining code officials' jobs. With any new compliance path comes increased opportunity for "path shopping," whereby cost-sensitive builders can choose the compliance path that results in the least stringent requirements for a particular home design. Path shopping, taken in isolation, usually lowers the average efficiency of homes subject to a code in a jurisdiction, but there may be balancing effects if the new path lessens any compliance or enforcement difficulties inherent in the prior code.

The new ERI path is unique in several ways. First, energy ratings, HERS in particular, have long been used by beyond-code programs such as EPA's Energy Star, so many builders (and some code officials) have been using HERS ratings for many years. According to RESNET, for example, 218,864 homes built in 2013, or approximately 30% of all homes permitted, were HERS-rated (RESNET 2014e). The familiarity with HERS through beyond-code programs could potentially lead to more builders choosing the ERI path for code compliance. Where code officials are familiar with HERS, this would have little impact, but where it introduces a new concept in the jurisdiction, it could complicate effective enforcement, at least temporarily.

A second uniqueness of the ERI path in general and the use of HERS as the ERI in particular is the requirement for third-party inspections. HERS brings with it the full RESNET infrastructure, including the detailed inspections HERS raters perform when assigning ratings to homes. Many code officials may welcome this as an opportunity to augment their own inspections, achieving better enforcement, potentially at lower cost to the jurisdiction. At the very least, the HERS inspections may relieve officials unfamiliar with the new ERI compliance path of the need to gain a full understanding of it before being effective at enforcing it. Beyond that, the additional inspections have the potential to move builders to better quality of installation and construction. One possible downside of the third-party inspection requirement is that some code officials may be reluctant to delegate their legal responsibilities to a third party or to trust such parties' inspection reports when granting occupancy permits.

With regard to the potential impacts of path shopping, the ERI path is probably less vulnerable to its bad effects than are many new compliance options (additional prescriptive packages, point systems, etc.). The aforementioned stringency of the 2015 ERI thresholds will ensure that the potential for efficiency degradations through path shopping is low. Path shopping could become a more significant issue if states and adopting authorities amend the code, adopting less stringent ERI thresholds. However, while the ERI path does give builders some welcome flexibility in complying with the code, the potential to find less efficient ways to comply is minimized by a backstop provision in the ERI path that prohibits reduction of envelope efficiency levels below those in the 2009 IECC and requires that all mandatory[5] provisions of the code be met.

Efficiency

Given that the ERI thresholds in the 2015 IECC have been shown to be generally conservative, a natural question is whether the presence of the new, efficient ERI path will result in more efficient homes. It is clear that if all homes were to comply via the ERI path, average efficiency would be considerably higher than if those same homes complied via the existing performance path. However, since builders are free to choose between the available paths (including two flavors of prescriptive path not discussed here), it is unlikely that such efficiency gains will be widespread. Builders trying to minimize first costs can choose the prescriptive or traditional performance path to avoid the increased efficiency implied by the ERI thresholds.

One possible effect is that builders who have not historically used energy ratings will find the ERI path to compliance sufficient incentive to begin using ratings as part of an overall marketing strategy. If the perceived benefits of advertising HERS ratings compensate for the increased first cost of homes, some builders might move to the new ERI path, increasing their homes' efficiency in the process. We know of no generally available data on which to base an estimate of how many builders might move in such a manner. As discussed above, many builders who already use energy ratings, perhaps as part of an above-code program such as Energy Star, will begin using the ERI path simply because they already have the rating and can avoid the additional compliance calculations needed for another compliance path. These builders might help popularize the ERI path and familiarize code officials with it, but because they are already building above code, are unlikely to have much direct impact on the overall efficiency of new homes in the jurisdiction.

It is conceivable that the path shopping effect described in the previous section would result in lower efficiency of some homes, but as shown above, the number of homes that could comply via the ERI path with lower efficiency than through the traditional performance path is very small, so this is unlikely to be a major effect. Consequently, it appears likely that the direct effect of the new ERI path on home efficiency will be positive, though its magnitude cannot be projected. As with any new code provision, there may be additional indirect effects, but those are difficult to anticipate.

Future Codes

Among the ERI path's mix of benefits and complexities, one intriguing possibility is that it may pave the way for an entirely new format for future codes. The existing prescriptive compliance path in recent versions of the IECC is reaching a point of diminishing returns, as evidenced by the recently concluded 2015 IECC code development cycle that resulted in virtually no improvements to the 2012 IECC's envelope provisions. Many involved in

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[5] In the IECC a *mandatory* provision is one that cannot be traded away for other features giving equivalent energy performance. Requirements that are subject to such tradeoffs are called *prescriptive* provisions.

advancing residential energy codes expect that additional efficiency gains are likely to be marginal until and unless the code is modified to provide a foundation more amenable to so called systems-designed homes. We believe home efficiencies well beyond those implied by the 2015 IECC are achievable, but likely require a code platform that acknowledges and encourages configurations and systems that are not easy to mandate in a prescriptively defined code. Even the current performance path is built directly on the code's prescriptive requirements. Therefore, the ERI path may be a first step toward a code based on an overall performance metric rather than a prescriptive list of features.

The 2015 IECC, with its alternative ERI compliance path and 2009 IECC-based backstops on prescriptive and mandatory requirements, may be an effective solution for advancing efficiency in residential buildings, but there may be challenges implementing it as intended. The success or failure of the ERI path may influence the nature of future codes for many development cycles to come. If the ERI path succeeds in achieving widespread adoption, driving effective compliance with the 2015 IECC, and maintaining efficiencies equivalent to other compliance paths, it may influence future versions of the code to take on a more performance oriented format. Time will tell, but the PNNL analysis seems to show that a long and successful marriage of codes and energy ratings is possible.

Conclusions

We have evaluated what is probably the single most significant change in the 2015 IECC—the inclusion an Energy Rating Index as an alternative path for code compliance. We have shown that RESNET's HERS system is likely to be the rating system most builders will choose to comply with the ERI path in the 2015 IECC. Evaluating prior work related to HERS Indexes and compliance through the IECC's traditional performance path, we conclude that the ERI thresholds in the 2015 IECC are conservative, thereby supporting the integrity of the code. We have further shown that the large variability in HERS Index values as a function of house configuration leaves open a substantial potential for states and other adopting authorities to feel pressure to amend the ERI thresholds to less stringent values. However, an evaluation of the prior PNNL analysis shows that if such amendments were to expand the ERI thresholds to be sensitive to a few key home characteristics, more palatable threshold values could be made available for many buildings without compromising the code's overall efficiency.

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