Derby Reins & Midnight Trains

Improving Residential Energy Code Compliance in Kentucky and Georgia

Chris Burgess & Sareena Nagpal

October 2018

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Abstract

Are adopted energy codes actually implemented? While the journey of energy codes starts with development and adoption, true success can only be measured by code compliance in the field. As part of a multi-state, DOE-funded project, Kentucky and Georgia participated in parallel studies that identified the incidence and extent of typical non-compliant energy code measures in new, single-family home construction. Each state then independently established programs to directly improve compliance with the specific non-compliant measures identified. Understanding the resulting measure-level compliance changes will allow utilities, policymakers, state and local jurisdictions, and other stakeholders to enact more effective policies, training, and compliance practices that respond to the local residential construction environment, thereby maximizing the impact of existing programs.

This paper will describe the baseline case established in each state, examine the selected interventions and compare the post-intervention findings from Kentucky and Georgia. The paper will detail how typical non-compliant measures were identified, review the process and rationale for the particular interventions enacted, and evaluate the changes found in the pre- and post-intervention measure-level data. Questions regarding the strengths, weaknesses, effectiveness, and replicability of the interventions will also be addressed.

Introduction

In 2014, the United States Department of Energy (DOE) funded new residential construction studies in eight states in order to better understand the energy implications of typical construction practices in new, single-family homes relative to the energy code.[1] The studies also sought to determine if state-specific interventions could improve energy code compliance. The goal of the studies was to document baseline practices, target areas for improvement and quantify related savings.

The studies were structured as three-year, three-phase efforts with each state following the same data collection and analysis protocols. However, the interventions were individually determined by the project teams in each state. Phase I established a baseline compliance level with the key measures that drive residential energy use. The potential savings from improved compliance were also calculated. Phase II was the design and implementation of training and education programs that were informed by the findings of Phase I. Phase III collected and analyzed post-intervention data to determine what, if any, improvement in compliance had occurred as a result of Phase II. This paper discusses and compares the findings from the Kentucky and Georgia studies and focuses on the impact of compliance training and code support activities. However, as noted below, in Kentucky data was also collected and analyses performed beyond the formal scope of the study.

Data Collection Protocol

Prior to funding the studies, DOE conducted a sensitivity analysis based on the prescriptive and mandatory provision of the 2009 International Energy Conservation Code (IECC) to determine the important energy use drivers in new single-family homes. Eight code measures, or "key

[1] The states included in the study were Alabama, Arkansas, Georgia, Kentucky, Maryland, North Carolina, Pennsylvania, and Texas

items", were identified by DOE as the major code requirements impacting energy use across all climate zones. The eight key items were:

1. Envelope Tightness (ACH50)
2. Window Solar Heat Gain Coefficient (SHGC)
3. Window U-Factor
4. Wall Insulation (R-value and Quality)
5. Ceiling Insulation (R-value and Quality)
6. High Efficacy Lighting
7. Foundation Insulation (R-value and Quality)
8. Duct Leakage (CFM25)

DOE then developed a data collection protocol that assured statistically significant results at the statewide level. The protocol required that a minimum of 63 unique observations of each key item be made – no assumed or default values could be used. In addition to the key item observations, data collectors would make additional measure-level observations of non-key items identified by DOE whenever possible.

In order to mitigate builder bias, the protocol required that each home be visited only once for data collection purposes. As a result, more than one home had to be visited to complete a data set. To put it another way, a minimum of 126 site visits were necessary in order to complete the required 63 data sets.[2, 3]

Lastly, the data collected would be anonymized with all site and personal identification scrubbed prior to the analysis. This assured builders and code officials that participation in the study would not result in negative consequences (e.g., citations) should non-compliant installations be observed during the data collection process.

Data Sampling Plan

The data sampling plan was designed to determine how many data sets were required to be collected from each county or jurisdiction in order to provide statistically significant results. Multiple data sampling plans were developed by the Pacific Northwest National Laboratory (PNNL) for each state. From the options provided by PNNL, a final plan was selected by the project team in each state. It should be noted that the state data sampling plans were generated through a randomized process rather than simply allocating sample requirements in proportion to new construction activity. Unique sampling plans were developed for Phase I and Phase III of the project using the most reliable data available. In the case of Kentucky, the source of data was the single-family permit database maintained by the Department of Housing, Buildings and Construction (state code agency). For Georgia, data was sourced from the US Census Bureau.

Data Analysis

For both Phase I and Phase III, PNNL conducted three separate analyses of the collected data – (1) a statistical analysis that examined the field data and data distribution, (2) an energy analysis

[2] A data set is one observation of each of the eight key items.
[3] The number of site visits required varied from state to state, ranging from 134 to 249, with a median of 189 site visits across all eight states.

that modeled the energy consumption representative of observed homes, (3) and a measure-level savings analysis that projected the potential savings associated with improved compliance. Since energy code compliance happens at the measure level, the results of the measure-level analysis are the main focus of this paper.

In the statistical analysis, the distribution of observed values of each key item were generated. These values were then compared to the code-required value to identify opportunities for potential improvement. This analysis resulted in a set of histograms showing the observed values of each key item relative to the code requirement.

Since the data collection protocol allowed only one site visit per home, a full data set could not be gathered for a given home. Therefore, PNNL created a series of "pseudo home" models using Monte Carlo and Boot Strapping processes to account for the frequency of each observation.[4] In aggregate, the models provided a statewide statistical representation of new single-family construction for each state. The Energy Use Intensity, or EUI (kBTU/sf), was calculated for each Monte Carlo model simulation and the average EUI from this distribution was compared to a minimally-compliant home. This allowed PNNL to determine if, on average, new homes used *more* or *less* energy than a minimally-complaint home.

The measure-level savings analysis examined all worse-than-code observations to determine the potential savings from improved compliance. All key items having more than 15% non-compliant observations were included in this analysis. An individual "as-built" model was created for each non-compliant value with all other code values kept at minimal compliance levels. This allowed each key item to be evaluated in isolation. The differences in energy use were weighted according to the frequency of each observation. State-specific construction volumes and fuel prices were then used to calculate the savings potential of full compliance for each key item included in the analysis.

The Kentucky and Georgia Studies

Kentucky is one of a very few states with a single climate zone – in this case 4A. A substantial majority of new home construction occurs in the "Golden Triangle", which is the area loosely bounded by Louisville, Lexington and the Cincinnati suburbs in northern Kentucky. Geographically, the Appalachian Mountain region makes up roughly the eastern third of the state with the remainder of the state mostly flat or rolling hills. Kentucky has a population of about 4.4 million people, and there were 7,345 new homes built in 2013.[5]

Georgia holds a strategic position in the southeast due to its central location and new construction growth in the state. Although the state has three climate zones (2A, 3A and 4A), the vast majority of new residential construction takes place near Atlanta (3A). Indeed, 88% of the homes visited were within a 45-mile radius of the metro-Atlanta region, and more than 80% of the sample sets were from the climate zone 3A. Geographically, northern Georgia is mountainous whereas the central region is characterized by the rolling hills of the Piedmont

---

[4] Monte Carlo analysis is a multivariate modeling technique that allows researchers to run multiple trials and define all potential outcomes of an event. Bootstrapping is any test or metric that relies on random sampling with replacement. Bootstrapping allows assigning measures of accuracy to sample estimates.

[5] 2013 data was used in the baseline study for both Kentucky and Georgia.

Plateau, and southern Georgia is a nearly flat coastal plain. Georgia has a population of about 10.2 million people and there were 27,755 new homes built in 2013.

Phase I

In Kentucky, Phase I data collection began in April 2015 and concluded in August 2015. During this time, data collection teams visited 140 homes in various locations across the state in accordance with the approved data sampling plan. The data was then anonymized and QC'ed prior to uploading to PNNL for analysis. Based on Kentucky's annual new construction volume of 7,345 homes (2013), the PNNL analysis showed an annual total potential energy savings of 62,508 MMBtu, equivalent to an annual total energy cost savings of approximately $1.2 million. The results of the Kentucky measure-level savings analysis are shown in Table 1.

Table 1. Kentucky - Phase I measure-level savings analysis

Measure	Electricity Savings (kWh/ home)	Natural Gas Savings (therms/ Home)	Total Savings (kBtu/ Home)	Number of Homes	Total Energy Savings (MMBtu)	Total Energy Cost Savings ($)	Total State Emissions Reduction (MT CO2e)
Envelope Air Leakage	442	22	3,701	7,345	27,182	484,314	3,092
Ceiling Insulation	213	8	1,548	7,345	11,372	215,656	1,080
Exterior Wall Insulation	163	7	1,263	7,345	9,277	171,044	1,102
Foundation Insulation	195	15	2,153	7,003	6,800	108,156	668
Lighting	300	-2	782	7,345	5,742	197,544	1,427
Duct Leakage	46	1	291	7,345	2,135	43,142	284
TOTAL	1,359	51	9,738	Varies	62,508	1,219,856	7,653

Source: PNNL, 2017.

In Georgia, Phase I data collection began in April 2015 and was completed in November 2015. In all, 216 homes were visited in order to collect the required 63 data sets. The data was then anonymized and quality controlled prior to uploading to PNNL for analysis. Based on Georgia's annual new construction volume of 24,810 new homes (2013), the PNNL analysis showed an annual total potential energy savings of 102,627 MMBtu, equivalent to an annual total energy cost savings of approximately $3 million. The results of the Georgia measure-level savings analysis are shown in Table 2.

Table 2. Georgia - Phase I measure-level savings analysis

Measure	Electricity Savings (kWh/ home)	Natural Gas Savings (therms/ Home)	Total Savings (kBtu/ Home)	Number of Homes	Total Energy Savings (MMBtu)	Total Energy Cost Savings ($)	Total State Emissions Reduction (MT CO2e)
Exterior Wall Insulation	181	11	1,711	27,503	47,069	1,151,262	5,023
Lighting	214	-2	574	27,503	15,774	799,065	3,837
Duct Leakage	122	5	923	27,503	25,387	685,683	3,005
Ceiling Insulation	62	3	523	27,503	14,397	371,110	1,635
TOTAL	579	17	3,731	27,503	102,627	3,007,120	13,500

Source: PNNL, March 2017.

Phase II

The design of the Phase II implementation was based on the findings of the Phase I measure-level savings analysis. Given the extreme distribution of observation values for many of the key items (e.g. Envelope Air Leakage ranged from 0.51 ACH50 to over 20 ACH50 in Kentucky, and the Duct Leakage Test results ranged from 1.9 CFM25 to 31.5 CFM25 in Georgia), both project teams decided to build the Phase II interventions around proactive circuit rider programs in order to address the wide range of builder and code official energy code understanding implied by the Phase I data distributions.[6] In Kentucky, the focus was on providing opportunities for in-depth individual education and training. In particular, the circuit rider program provided support to individual code officials and builders and was supplemented with in-person trainings, an online training program, an energy code assistance hotline and a concerted stakeholder outreach effort.

In Georgia, the focus was on understanding the underlying challenges in energy code adoption and to inform code officials of industry best practices. To accomplish this, a multi-faceted approach was designed, including a combined circuit rider/energy codes training program, an energy codes hotline, a state energy code hub, an online learning management system, ongoing stakeholder engagement and the development of custom energy code resources. In addition, Georgia distributed questionnaires to code officials at the time of contact to create a feedback loop that would inform the development and refinement of Phase II activities.

Circuit Rider

The central idea of the GA and KY circuit rider programs was to have an energy code expert proactively reach out to code officials and builders, and offer energy code assistance based on the compliance findings of Phase I. In addition to discussing the Phase I results, the circuit rider also asked what issues or questions the code official or builder had regarding energy code

[6] ACH50 is air changes per hour in a home at a pressure differential of 50 pascals. The code required value in both states is 7 or less. CFM25 is a measure of duct leakage defined as the air flow (in cubic feet per minute) needed to create a 25 Pascal pressure change in the ductwork.

compliance. Both project teams focused more on code officials, in the belief that educating and assisting code officials would have a bigger effect, since these officials review and inspect every home in a jurisdiction, offering a compelling energy-savings opportunity.

In Kentucky, the circuit rider was charged with directly reaching out to individual code officials and builders and meeting them in-person at their place of business or construction site. This process assured that the circuit rider would contact officials and builders that were less likely to attend a group meeting or training. The intent was for the circuit rider to become a trusted advisor on energy code issues. This intent was then reinforced by the circuit rider making return visits to offer more detailed and in-depth assistance. A retired code official from western Kentucky was hired half-time as the circuit rider starting in August 2015 and ending in September 2017.

In Georgia, the circuit rider would travel across the state, contact code officials in individual jurisdictions, and determine their interest in hosting classroom trainings or presentations on the findings of the study, thereby combining the circuit rider and classroom training into a single program. This combined structure was designed to reach the greatest number of stakeholders possible. If the jurisdiction agreed, a training or presentation would be scheduled, and local officials and builders were invited to attend. Southface Energy Institute (Southface) was hired to fill the circuit rider role and to provide the classroom training effort.

In-Person Training

Similar to the circuit rider program, the in-person training program was designed to reach all parts of the state, not just the population centers. In Kentucky, classes were full day (eight-hour) sessions and offered in three distinct but overlapping curricula – Air Sealing and Insulation Principals, Common Compliance Challenges and HVAC Design and Sizing Principals.[7] In Georgia, classes were between one and five hours long, depending on jurisdictional requirements, and focused on the major challenges observed during Phase I. In both states, all classes emphasized the reasoning and building science principals behind the code requirement. If attendees understood why a given requirement was included in the code, as well as the potential consequences of non-compliance, it was believed that they would be more are likely to employ compliant construction practices in the field.

Online Training

As part of Phase II in Kentucky, a series of 14 energy code adoption videos were updated to become energy code compliance education videos.[8] These short videos (4-14 minutes each) were uploaded to YouTube to provide viewers with 24/7 access to an overview of energy code requirements.[9] Importantly, these videos also afforded the circuit rider an easy "ice-breaker" when visiting code officials and builders. The circuit rider could quickly access the video(s) related to the questions being asked at the meeting, review it with the participants, and then begin a dialogue about the information in the video.

[7] Class slides can be found at energy.ky.gov/efficiency/Pages/energycodesurvey.aspx
[8] Videos were originally developed by the Kentucky State Energy Office and updated by the project team
[9] Videos can be viewed at www.youtube.com/playlist?list=PLkWlq0Kgprm7oXX5zm6_Jh6l6mlnU6TTv

In Georgia, the purpose of the Online Learning Management System (LMS) was to provide online training opportunities to individuals interested in an overview of the energy code.[10] Three specific training modules were developed on the issues promising the greatest energy savings – Duct Sealing for Construction Professionals, Energy Efficient Lighting for Construction Professionals and High Efficiency Insulation for Construction Professionals. Each course was about an hour long and required users to register in order to access the resources. All of the courses were offered at no cost and continuing education units (CEUs) were available to participants who chose to take a short exam at the end of the course. Along with the videos, various "Tech Tip" sheets and informational guides were also developed and housed on the LMS.

Energy Code Hotline

In Kentucky, the hotline and email inquiry resource line went live in September 2015 and remained active through September 2017. Both means of communication promised a quick response (within 24 hours) by the circuit rider. These two resources were consistently promoted by the circuit rider, the in-person classes and through stakeholder outreach.

A virtually identical resource was independently setup in Georgia to provide assistance on energy code queries. To inform stakeholders about the hotline, Southface distributed hotline business cards through the circuit rider and at the in-person trainings. The hotline information was also posted on the Georgia Department of Community Affairs (DCA) website, and contact information was included on all other resources and materials developed for the project.

Stakeholder Outreach

Both project teams worked consistently to keep all stakeholders informed on the progress and findings of the study. Stakeholder groups were formed in Georgia and Kentucky to review and guide study efforts. Stakeholder meetings were generally held on a quarterly basis to provide project updates and discuss next steps. Project updates were also given at the code official association meetings, rater conferences, home builder association meetings and other appropriate venues throughout the course of the study.

In addition, both states created and distributed custom handouts, infographics, guides and similar resources to builders, code officials, homeowners and other stakeholders. In aggregate, between 1,200 and 1,500 copies of these resources were distributed in each state. The circuit rider in Kentucky also distributed energy code books on an as needed basis. Inspection verification forms developed for code official in-field use were distributed in Georgia.
Two additional actions were also carried out in Georgia. DCA, along with the Southeast Energy Efficiency Alliance (SEEA), created a list of updated and relevant energy code resources and posted the information on DCA's website. At the same time, DCA updated their website to make it more user friendly. The Energy Codes Hub went live on the DCA website in April 2017 and remains active.[11] Questionnaires regarding the key requirements identified in Phase I were also developed and distributed to all training attendees. These surveys identified the existing barriers to key item compliance. The surveys included questions regarding the code official workload, energy code knowledge and resources currently used for energy code compliance. The surveys

[10] The coursework can be found here: https://southface.learnupon.com
[11] https://dca.ga.gov/local-government-assistance/construction-codes-industrialized-buildings/construction-codes/energy

were used to provide feedback to the circuit rider and help design solutions to the issues identified.

Comparative Analysis of Phase II

At the conceptual level, Kentucky and Georgia implemented similar programs during Phase II – both had a circuit rider program, conducted in-person trainings and established an online presence. The similarities and differences in the focus, structure, and implementation of these programs in each state provides insight for effective program design.

Circuit Rider Program

By the time the circuit rider program in Kentucky ended in September 2017, the circuit rider had travelled over 32,450 miles across the state, met individually with 310 code officials and builders, made an additional 255 in-field contacts with on-site building crews, and distributed over 1,450 pieces of code support literature. The Kentucky program focused on individual outreach and assistance. The circuit rider traveled across the state in a sequence developed by the project team and vetted through the stakeholder group. Prior to visiting each area, the circuit rider directly contacted the local enforcement jurisdictions, home builders, sub-contractors and other stakeholders to arrange one-on-one meetings.

In Georgia, the circuit rider contacted code officials in 17 jurisdictions, investigating their interest in hosting an in-person training. As a result of this outreach, more than 1,000 hours of technical assistance and support was provided by Southface and DCA. Technical assistance was provided on a wide variety of topics, ranging from insulation installation to duct sealing.
Both Georgia and Kentucky consider their circuit rider program a success. The circuit riders reached their respective outreach targets and established a trusted advisor relationship with code officials and builders across the state. Both project teams believe that making the effort to travel to the doorstep of the stakeholders allowed the assistance to be viewed as a genuine effort, not a perfunctory gesture.

In-Person Training

In 2016 and 2017, Kentucky conducted a total of 28 full-day trainings for builders and code officials. There was a modest fee of $25 charged per class, and classes were held in 14 different counties in the state, specifically selected so anyone interested in the class could attend without requiring an overnight stay. Southface developed the curricula and taught all the classes. The total class attendance was 381 students, resulting in over 3,000 contact hours with builders and code officials.

Trainings were conducted in 17 different jurisdictions in Georgia, including at least one training in each climate zone. The first class was given in April 2016 and the final class was conducted in October 2017 with a total attendance of 606 people. As noted earlier, Southface also developed and taught the classes in Georgia.

In Kentucky, the in-person classes supported the work of the circuit rider – another resource the circuit rider could offer to builders and code officials. The classes also offered state-required CEUs for code officials and HVAC contractors. In Georgia, the classes were more integral to the circuit rider program and sought to offer the necessary training and education to the greatest possible number of people. In Kentucky, the attendees received bound copies of the class slides and other resources relevant to the topic to assist with improving compliance. In Georgia, fact sheets with graphical representation of the content were distributed.

While both states understood that class attendees are a largely self-selected group – generally only someone interested in the topic would attend the class – the value of in-person training was believed to be substantial. The experience of the Southface instructors allowed the topic discussion to be adjusted in real-time so that questions specific to a given locations or those foremost in attendee's minds could be addressed in-depth. The conversational structure of the classes inspired active student engagement, and attendees consistently reported that they had learned something new and that the class was worthwhile.

Online Training

The Kentucky online videos posted on YouTube have received just over 735 views to date. It should be noted that this is the total number of views and does not necessarily represent unique viewers. Nevertheless, views far exceeded expectations. The videos synced nicely with the information provided by the circuit rider and classroom trainings, which may explain the higher than expected number of views. While these videos are a long-term resource for the state that other programs can utilize, in the short term, the project team generally felt that the impact of the videos wasn't worth the unexpectedly substantial effort the modification required – tens of thousands of dollars and hundreds of hours.

In Georgia, the development of the LMS required a significant allocation of resources and has not yielded the expected results. To date, only about 20 people have registered for courses. There are many possible reasons for this underutilization, including the effort required for registration, inadequate promotion of course content and lack of interest in pursuing CEUs online. SEEA is investigating these questions and plans to modify the LMS approach based on the findings.

Energy Code Hotline

Both states developed hotlines to provide expert advice – either via phone or email – with a guaranteed response within 24 hours. Southface was the responder in Georgia and the circuit rider was the responder in Kentucky.

In Kentucky, even though the hotline and email inquiry line were consistently promoted by the circuit rider and through stakeholder outreach, these resources remained stubbornly underutilized with a total of just four questions during the two years of Phase II. Even though the cost of setting up and monitoring the hotline was minimal, the structure and value of this resource needs to be investigated. One possible reason for this disappointing result could be that Kentucky builders and code officials infrequently encounter energy code issues that require third-party intervention, or it could be that builders saw little value in the circuit rider's opinion since the circuit rider could not issue formal code interpretations.

The Georgia program received significantly more hotline use. The hotline went live in September 2017 and remains active. To date, Southface has received over 120 hotline requests via phone and email. An analysis of the inquiries indicates no discernable pattern in either subject matter or geography. One likely reason that the hotline was received well is that Southface is a trusted source of information on energy codes throughout the region, whereas the circuit rider and hotline were new resources in Kentucky and were provided by a previously unknown entity.

Stakeholder Outreach

Both states made a concerted effort to keep key stakeholders informed of study progress and seek their guidance on next steps through regular stakeholder group meetings. These meetings were generally held quarterly and provided stakeholders with the opportunity to hear program updates, review results and analysis to date, as well as have an opportunity for input on future program efforts. Additional outreach efforts were made as well in each state.

In Kentucky, the project team gave program updates at 37 meetings with a total attendance of 1,128 people. These updates included presentations at code official association conferences and board meetings, home builder association board meetings, energy rater conferences and presentations to the design community. In Georgia, the results were presented at code official meetings and conferences. A total of 11 presentations were given to more than 300 participants between April 2016 and October 2017. The project team believed that keeping the "buzz" going about the project's objective of improved compliance contributed to success in each state. Scheduling outreach activities around existing conferences and events was seen as particularly helpful since a large contingent of stakeholders was already present.

Both states also developed a substantial body of resources to address the needs identified in Phase I. In Kentucky, the suite of resources included both custom materials (e.g., batt insulation installation guide) and information developed by others (e.g., code books and fact sheets). These materials were distributed by the circuit rider and made available on the project website.[12] In Georgia, resource materials were distributed through the in-person trainings or posted online. These materials included fact sheets on air sealing key points, duct and envelope tightness, and lighting.

The Georgia State Energy Codes Hub continues to be used as an active resource. This may be due to the hub's energy code hotline information, which directs users to a live hotline that can address their concerns in detail.

Phase III

PNNL created a new set of randomized sampling plans for Phase III based on the most recent full year of permit data. As in Phase I, the Kentucky and Georgia project teams selected a final sampling plan for data collection and vetted it through the stakeholder group. Otherwise the Phase III data collection process was identical to Phase I with 63 observations of the same eight key items required. In Kentucky, the distribution of observations indicates a significant improvement in compliance with many key item code measures, but unexpected backsliding with a few measures, as shown in Table 3.[13]

[12] Resources distributed included 734 compliance guides, 380 blank compliance certificates, 254 code books, 49 insulation guides, and 49 resource cards

[13] The SHGC "key item" is not listed in the table because there are no SHGC code requirements in the 2009 IECC for Climate Zone 4, which encompasses all of Kentucky

Table 3. Kentucky - Non-compliance comparison: Phase I to Phase III

Measure	Phase I Non-Compliance	Phase III Non-Compliance	Improvement
Envelope Air Leakage	32%	2%	30%
Ceiling Insulation (quality)	58%	40%	18%
Exterior Wall Insulation (quality)	66%	58%	8%
Foundation Insulation (R-value)	19%	30%	-11%
Foundation Insulation (quality)	86%	76%	10%
Lighting	67%	60%	7%
Duct Leakage (unconditioned space)	32%	39%	-7%

Source: PNNL, March 2018.

When comparing the Kentucky Phase I baseline to the Phase III results, the PNNL analysis found a 25% improvement in energy savings, a 24% improvement in cost savings, and a 20% reduction in CO_2 equivalent emissions.

In Georgia, the Phase III data collection is ongoing as of this writing, and therefore any results should simply be viewed as indicative of a trend, not final or even preliminary results. Preliminary observations show substantial compliance improvement with two key item code measures, and modest to negative gain with the remaining measures, as shown in Table 4.[14]

Table 4. Georgia - Non-compliance comparison: Phase I to Preliminary Phase III

Measure	Phase I Non-Compliance	Phase III Non-Compliance	Improvement
Ceiling Insulation (R-value)	17%	20%	-3%
Ceiling Insulation (quality)	81%	38%	43%
Exterior Wall Insulation (quality)	83%	83%	0%
Foundation Insulation (quality)	89%	100%	-11%
Lighting	62%	9%	53%
Duct Leakage (unconditioned space)	31%	21%	10%

When comparing the Georgia Phase I baseline to the Phase III preliminary results, a preliminary MEEA analysis, based on the incomplete data collected to date, found a 37% improvement in energy savings, and a 52% improvement in cost savings.

Conclusions

While it is difficult to determine which individual programs drove the improvements observed in the Phase III analyses, it appears that the Phase II efforts in each state lead to meaningful energy

[14] The Georgia Phase III data collection is ongoing as of this writing. The data shown is based on 90 site visits and represents approximately 60% of the total data points to be collected.

code compliance improvements.[15] Both programs had strong improvement with certain measures, and middling improvement to actual backsliding in others. Further analysis will determine if these marginal improvements/backsliding are relevant indicators or statistical noise. It also appears that some program elements in each state appeared to have little effect, especially the hotline in Kentucky and the LMS program in Georgia.

In both Kentucky and Georgia, the project teams and stakeholders have provided feedback that they felt program was very successful and well-designed in each state. Involving stakeholders in the design and execution of the Phase I sampling and the Phase II program certainly contributed to the success.

The statistical significance of negative measure level results has not been determined. Nevertheless, the result for duct sealing in unconditioned space stands out. All ducts in unconditioned spaces are required to be performance tested and meet minimum standards. Therefore, the negative result may indicate something more than careless workmanship or lax enforcement, the skill and accurate reporting of the duct testers may be a concern as well. When looking at the measure level improvements, a distinct pattern is clear. Although the measures are different, both states had outsized improvements in one or two measures (>15%), while the rest were much more modest (≤10%). This disparity is difficult to explain since no greater effort was made to train on outsized improvement measures.

One possible explanation for the large air sealing improvement in Kentucky is that the circuit rider was often on-site with builders and code officials and able to specifically point out obvious air sealing opportunities that were being missed. In Georgia, the large lighting improvement may be due to an overall market transformation to LED bulbs, with the more modest Kentucky result being an outlier (additional results from other states will inform this hypothesis). The ceiling insulation improvement could be the result of a higher incidence of spray foam installations in Phase III, where quality is easier to control. In any case the same data collectors were used in Phase I and Phase III in both Georgia and Kentucky, so differential judgment is likely not a factor.

On the other hand, training on exterior wall insulation installation quality was offered in both states with little improvement shown. One note regarding improvement in insulation quality, the compliance rate alone does not tell the full story. There were often energy savings because the worst installations got better. For example, in Georgia 48% of the wall insulation observations received the worst grade, while only 36% did in Phase III, resulting in energy savings even though the compliance rate did not change.[16]

Also, there were measures with good compliance in Phase I that maintained good compliance in Phase III. While not included in the energy savings analysis, these measures do give rise to a more general question for the states to consider – if an energy code requirement is typically complied with, is it time to consider improving the energy efficiency of that measure?
These valuable studies have provided consequential insights into typical residential construction practices in each state and created a replicable model for future data collection efforts.

---

[15] Results indicate only overall improvement or gross savings. Normally occurring market adoption (NOMAD) and the effect of other compliance efforts have not been determined.
[16] See RESNET Insulation Grading. Only Grade I was considered compliant for the Kentucky and Georgia studies. https://www.resnet.us/uploads/documents/conference/2012/pdfs/Cottrell-RESNET_Insulation_Grading_Criteria.pdf

Perhaps most importantly, the studies have generated significant, quantitative data that stakeholders can use in developing more impactful outreach, education, and training efforts in the future – efforts that will continue to improve the energy efficiency of new homes.

References

Bartlett, R., J. Hathaway, M. Halverson, Y. Xie, V. Mendon, and M. Zhao. 2017. "Georgia Residential Energy Code Field Study: Baseline Report." Richland, WA: Pacific Northwest National Laboratory www.energycodes.gov/sites/default/files/documents/Georgia_Residential_Field_Study.pdf

———. 2017a. "Kentucky Residential Energy Code Field Study: Baseline Report." Richland, WA: Pacific Northwest National Laboratory www.energycodes.gov/sites/default/files/documents/Kentucky_Residential_Field_Study.pdf

Census Bureau. 2016. Censtats Building Permits Database. censtats.census.gov/

DOE (Department of Energy). 2018. Building Energy Codes Program Energy Code Field Studies (Residential). www.energycodes.gov/compliance/residential-energy-code-field-study