U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

90% Compliance Pilot Studies

Final Report

June 2013

Executive Summary

As part of the American Recovery and Reinvestment Act of 2009, the U.S. Department of Energy invested unprecedented levels of funding for energy code implementation and compliance measurement. As a condition of the Recovery Act, each of the 50 states accepting funding issued assurances to implement a plan to achieve 90% compliance with model energy codes by 2017, including active training and enforcement programs, and annual measurement of the rate of compliance. In early 2010, the DOE announced an opportunity for states to participate in energy code compliance evaluation pilot studies. The intent of the studies was to help states with their energy code compliance measurement efforts and to provide valuable insights into the effectiveness and suggestions for improvement of the procedures and tools developed by DOE for measuring compliance. The pilot studies provided a valuable structure to identify potential national trends with respect to building energy code compliance.

DOE worked with the five Regional Energy Efficiency Organizations (REEOs, formerly referred to as Energy Efficiency Partnerships, or EEPs)[1] to select from states that met the criteria for selection. All state proposals were evaluated based on the degree to which their proposal demonstrated an effective test of the DOE procedures and tools and adhered to the selection criteria and conditions as posted on the DOE website, which included:

- Implement the study within the allocated time
- Collaborate and communicate with DOE and their REEO in the design, development, and deployment of the pilot study
- Work with a broad group of stakeholders in the state
- Use the DOE procedures and tools to evaluate compliance
- Provide resulting building evaluation data to DOE for analysis
- Provide final reports summarizing lessons learned and containing suggested improvements to the DOE-developed procedures and tools.

DOE and the REEOs funded eight energy code compliance evaluation pilot studies covering nine states[2] designed to measure code compliance based on the procedures and tools DOE had developed.[3] The pilot studies were implemented over a 10-month period, with final reports from the studies due in June 2011.

The U.S. Department of Energy hoped to gain information from the studies that could aid in the refinement of the procedures and tools, including:

- Lessons learned and feedback on DOE procedures and tools
- Data to be collected through application of the evaluation checklist
- Information on the logistics of evaluating large commercial buildings

[1] REEOs include the Northeast Energy Efficiency Partnerships (NEEP), the Southeast Energy Efficiency Alliance (SEEA), the Midwest Energy Efficiency Alliance (MEEA), the Southwest Energy Efficiency Project (SWEEP), and the Northwest Energy Efficiency Alliance (NEEA).
[2] Studies were completed for Georgia, Iowa, Massachusetts, Montana, Utah, Wisconsin, Northwest Commercial Lighting Study (Washington, Oregon, Idaho, Montana), Northwest Jurisdictional Survey.
[3] All studies except the Utah study were funded through the REEOs.

- Increased understanding of the time required to complete a single building evaluation
- Identification of additional procedures and tools that would further assist the states in ensuring energy code compliance.

This document is DOE's consolidation of the individual state reports into a comprehensive final report covering all of the pilot studies. It contains conclusions stated in the individual state reports, as well as conclusions drawn by DOE based on their oversight of the pilot studies, and based on discussions held with the REEOs and representatives from the pilot study states and their contractors. The Building Codes Assistance Project (BCAP) also evaluated the results of the pilot studies, and contributed their analysis to this report.

Overview of Findings

Although none of the states participating in the pilot studies followed the DOE protocols completely, valuable feedback can be drawn from each study's individual experiences. At the core of all of the difficulties faced was the inability to generate a perfectly random sample size. Given the still recovering construction market, the time and resources available, and the various code enforcement cultures seen in each of the states, many of the buildings used had to be hand-picked as opposed to randomly generated. Generating samples for residential renovation was particularly difficult, as most homeowners do not obtain a building permit for home modifications. Even facing these difficulties however, all of the states were able to successfully complete their studies and generate some rate of compliance. These studies can contribute to a baseline moving forward; states can build on these previously used methodologies when making an official compliance certification as opposed to starting from scratch. These studies **cannot** represent a national compliance rate, as that was not the original intent of the studies.

Lessons learned from applying the BECP procedures and tools in the pilot studies include the following observations:

- BARRIERS: The top barriers to compliance continue to be:
  1. Lack of training
  2. Lack of resources
  3. Lack of compliance information on plan submissions
     - Documentation produced by software tools addresses this barrier, which might partially account for the correlation with higher compliance.
- RESOURCES: Consistency is difficult to obtain across studies and among individual evaluators. Suggestions for improving consistency include additional guidance and instructions on DOE compliance checklists, evaluator training, and quality assurance of gathered data.
  - The checklists developed by DOE were valuable tools for third-party evaluators, and could be valuable tools for state and local staff involved in code compliance during their normal course of code enforcement.
  - Software tools, such as RES*check* and COM*check*, which are associated with trade-off and performance-based compliance approaches, demonstrated a strong correlation with higher compliance rates.

- DATA: Data sources for generating sample sets are not always accurate and, in some cases, are not available (e.g., residential renovations). Generating valid sample sets was further complicated by the economic climate and the fact that new housing starts are significantly lower than past data predicted.
- ACCESS: Access to buildings under construction is a major problem in some locations. Early engagement of state and local governmental agencies is important in securing their cooperation.
- COSTS: State compliance measurement studies are costly and require multiple visits to the building while under construction. Timing these onsite visits to observe all code requirements is difficult for third-party evaluators. Post-construction evaluations were implemented in one study in an effort to reduce costs, but many code requirements cannot be evaluated post-construction. The DOE procedures were designed to be used during building construction and did not work well as written in a post-construction situation.

It is important to acknowledge that the studies occurred during a period of time not favorable for evaluating new construction, as the housing market was still suffering from the economic downturn, and construction starts were low in most parts of the country. In many states the study was conducted during a time of transition to the 2009 IECC; some had not yet finalized adoption of the updated energy codes, and others had so recently updated them that they were not yet fully implemented in all jurisdictions. Study implementers enacted creative solutions to overcome such challenges, which may have biased the final compliance score derived in each state.

The pilot study project was an initial attempt to assess the DOE procedures and resources for evaluating energy code compliance rates in states. However, in order to stay within the timeframe desired by DOE, several participants were allowed the flexibility to create individual programs for measuring a state's progress toward 90 percent compliance using various modifications of the DOE recommended methodologies. As a result, the scores determined by the pilot studies cannot be interpreted to represent compliance rates at national, state, or local levels. Within the state studies, results varied considerably, depending on which analysis methodology is used to report the final results. In addition, deviations from the DOE procedures make comparison of results between states impossible and make it difficult to identify trends nationally.

A Path Forward

While the Compliance Pilot Studies did not generate consistent energy code compliance rates nationwide, they did have a positive impact on future compliance activities. During the completion of these studies, states increased dialogue with local jurisdictions, educated and heightened the awareness about energy codes to building departments, and helped identify and execute training needs. The studies provided a platform for increasing knowledge about energy code compliance activities across the state on the local level. A greater understanding at this level can help inform policymakers as they consider ways to improve the status and procedures of energy code compliance in their states.

The experience from the pilot studies has led to a number of recommendations for changes to the draft methodology as well as its overall approach towards compliance. This report discusses a large portion of those recommendations. However, DOE will publish a request for information to allow interested parties to provide suggestions, comments, and other information to address the methodology and the overall approach to compliance.

Acronyms and Abbreviations

ACCA	Air Conditioning Contractors Association
ARRA	American Recovery and Reinvestment Act
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BEC	Building Energy Codes
BTO	Building Technologies Office
DCA	Department of Community Affairs (Georgia)
DFCM	Department of Facility Construction Management (Utah)
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
HERS	Home Energy Rating System
HVAC	heating, ventilating, and air-conditioning
ICC	International Code Council
IECC	International Energy Conservation Code
IESNA	Illuminating Engineering Society of North America
LPD	lighting power density
MEEA	Midwest Energy Efficiency Alliance
MTBIA	Montana Building Industry Association
NEEA	Northwest Energy Efficiency Alliance
NEEP	Northeast Energy Efficiency Partnerships
NFRC	National Fenestration Rating Council
NWE	NorthWestern Energy
NYSERDA	New York State Energy Research and Development Authority
ORSC	Oregon Residential Specialty Code
QA	quality assurance
REEO	Regional Energy Efficiency Organization
SEEA	Southeast Energy Efficiency Alliance
SHGC	solar heat gain coefficient
SWEEP	Southwest Energy Efficiency Project
UA	U-factor times area
WSEC	Washington State Energy Code

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1.0 Introduction

Buildings account for almost 40% of the total energy consumption in the United States, two-thirds of our electricity consumption, one-eighth of our water use, and almost 40% of our carbon dioxide emissions. Residential and commercial buildings together use more energy and emit more carbon dioxide than either the industrial or the transportation sector, therefore reducing building energy consumption is an important objective for our nation. Energy-efficient buildings provide energy, economic, and environmental benefits for many years, and enhance our national security by reducing our dependence on foreign oil. Building energy codes are a key component of a sustainable future for our country; codes set minimum requirements for energy-efficient design and construction of new and renovated buildings that impact energy use and emissions over the lifetime of the building, and raise the baseline by which green building programs advance their standards.

To encourage the adoption and implementation of updated building energy codes, the U.S. Department of Energy (DOE) made funding available as part of the American Recovery and Reinvestment Act of 2009 (Recovery Act). The funding opportunity conditions included implementation of a plan to achieve 90 percent compliance with updated energy codes by 2017, to include active training and enforcement programs, and annual measurement of the rate of compliance. The baseline energy codes against which to measure were specified as the 2009 International Energy Conservation Code for residential buildings and the ANSI/ASHRAE/IESNA Standard 90.1-2007 for commercial buildings (or equivalent codes). The excerpt below is from section 410 of the Recovery Act:

> *(2) The State, or the applicable units of local government that have authority to adopt building codes, will implement the following:*
>
> > *(A) A building energy code (or codes) for residential buildings that meets or exceeds the most recently published International Energy Conservation Code, or achieves equivalent or greater energy savings.*
> >
> > *(B) A building energy code (or codes) for commercial buildings throughout the State that meets or exceeds the ANSI/ASHRAE/IESNA Standard 90.1–2007, or achieves equivalent or greater energy savings.*
> >
> > *(C) A plan for the jurisdiction achieving compliance with the building energy code or codes described in subparagraphs (A) and (B) within 8 years of the date of enactment of this Act in at least 90 percent of new and renovated residential and commercial building space. Such plan shall include active training and enforcement programs and measurement of the rate of compliance each year.*

Recovery Act funding was made available to states for these activities through the State Energy Program (SEP) Formula Grants American Recovery and Reinvestment Act Funding Opportunity, Number DE-FOA-0000052, which was also issued in 2009.

To help states uniformly measure their energy code compliance rates, DOE's Building Technologies Office (BTO) developed procedures and tools that states could readily apply in support of this effort. The final DOE compliance evaluation procedures were developed for buildings under construction, and recommended that the following four building populations be evaluated separately:

- New residential
- New commercial
- Residential renovations
- Commercial renovations.

The DOE procedures and resources are explained fully in the *Measuring State Energy Code Compliance*[4] guide, and summarized in the following section of this report.

In an effort to test the procedures and resources, in early 2010 DOE announced an opportunity for states to participate in an energy code compliance evaluation study. BTO worked with the five Regional Energy Efficiency Organizations (REEOs) to select pilot states from those that responded to the opportunity notice and that met the criteria for selection.

This report succinctly consolidates the individual state pilot studies. Their primary objective was to test, evaluate, and identify improvements to DOE procedures and tools, and identify lessons learned for future studies. **The studies should NOT be interpreted to represent national or state compliance rates.**

[4] Available online at http://www.energycodes.gov/sites/default/files/documents/MeasuringStateCompliance.pdf

2.0 Overview of DOE Procedures and Resources

In order to save states the resources and funding that would be required to develop a methodology from scratch, DOE developed procedures and resources to help states and jurisdictions measure and report compliance with building energy codes. The resources are summarized in the Table 2.1 and described in greater detail following the table.

Table 2.1. Pilot Study States and Focus of Their Studies

Key DOE Resources	
***Measuring State Energy Code Compliance* guide**	BTO's complete directions on how states can conduct an energy code compliance study, including detailed instructions on how to use BTO resources. Available in PDF format online; 74 pages.
State Sample Generator	An online software tool that generates a representative sample set distributed across building size and climate zones for each state.
Compliance Checklists	Available for both residential and commercial energy codes, checklists are used for conducting onsite building evaluations. Each checklist item is linked to the applicablin ie energy code language.
Score + Store	An online software tool that collects checklist data as input by evaluators,[5] determines individual building scores, and calculates an average compliance score for the sample set.
Jurisdictional Survey	An online survey with a set of ready-made (and customizable) questions to be used to gather information on energy code implementation and common practices from local jurisdictions.
Other DOE Resources	
Jurisdictional Flyer and Letter	A ready-made (and customizable) flyer and letter used to inform local jurisdictions about compliance evaluation efforts, solicit their cooperation, and advise them of what to expect.
***90 Percent Compliance* Webcast**	A 100-minute webcast from August 2010 that describes the DOE procedures, provides guidance for partnering with local jurisdictions, and demonstrates the resources available to help implement a state study.
Building Energy Codes Training Materials	Online training materials for evaluators tasked with measuring energy code compliance. The training materials provide step-by-step instructions for using the DOE checklists to conduct both residential and commercial building evaluations.
Measuring State Energy Code Compliance: Step-by-Step Companion guide	A flyer-like document of the main steps in Measuring State Code Compliance guide. Available in PDF format online; four pages.

[5] Note that throughout this report, the terminology "evaluators" refers to the individuals tasked with conducting the data collection during studies.

2.1 Measuring State Energy Code Compliance Guide

The *Measuring State Energy Code Compliance* guide is DOE's full set of recommended procedures on how to measure 90 percent compliance with energy codes. DOE acknowledges that there is not one single methodology for conducting an annual measurement of code compliance. However, the DOE procedures make it easier for states to conduct a study, rather than starting from scratch.

The guide outlines the approach a state should use to measure compliance with energy codes, in order to better understand how close or far they are to full compliance with energy codes, and in order to help identify the "weak spots" in compliance that should be addressed through training efforts.

DOE's *Measuring State Energy Code Compliance* guide puts forth the procedures for conducting a compliance study. While the guide largely focuses on the procedures for a formal evaluation of compliance (Section 5 of the guide), it also offers these steps to measure compliance annually, while building toward a full formal compliance study:

Step 1: Establish a Compliance Working Group. A group of stakeholders is extremely beneficial in assisting a state as it develops a plan for evaluating compliance and is essential to "opening doors" with local building departments. The group may include representatives from the state energy office, state code agencies, state or local code official associations, home builder associations, American Institute of Architects (AIA) chapters, ICC Chapters, contractor associations, ASHRAE chapters, and/or others.

Step 2: Perform Self-Assessments. Local jurisdictional staff can compare the current construction and enforcement practices against the target codes using the DOE evaluation resources even without conducting a full formal evaluation. The Compliance Working Group can design the process, which might include: self-assessments as part of a field training program; conducting spot checks of some jurisdictions; and/or a survey of local jurisdictions. The process will draw attention and awareness to jurisdictional staff and builders regarding compliance and enforcement issues.

Step 3: Evaluate Results. The Compliance Working Group should compile the results and identify barriers to compliance. Self-assessments made over a one-year period can be consolidated to report an estimate of the annual measurement of compliance.

Step 4: Train and Educate. The Compliance Working Group should address the barriers identified during the self-assessments via training or other outreach. Steps 2-4 can be repeated each year until the state is comfortable that they may be achieving a 90 percent or higher compliance rate, at which time the state should develop a more formal evaluation study.

Once the state is comfortable with a self-assessment of its compliance rate it should move to step 5.

Step 5: Launch Third-party Compliance Verification. Launching a formal evaluation study is the focus of Section 5 of the guide, which includes a full description of the necessary elements and behind-the-scenes algorithms used in measuring 90 percent compliance. The method of conducting a formal evaluation to calculate a state metric includes inspections on a minimum of 44 buildings in each of these four categories:

- New Commercial
- New Residential
- Commercial Renovations
- Residential Renovations

The guide provides step-by-step directions for designing a formal state evaluation study to include: using the State Sample Generator to develop a random sample set of buildings to be evaluated; utilizing ready-made checklists during evaluations of plans and onsite inspections; and inputting data into the Score + Store tool to determine a statewide compliance metric. It addresses the different approaches a state might take to conduct an evaluation study, including considerations such as: staffing needs, qualifications of evaluators, and funding.

2.2 State Sample Generator

The procedures set forth in the *Measuring State Energy Code Compliance* guide require the evaluation of a random sample of residential and commercial buildings in each state. DOE's State Sample Generator is an online software tool that helps states get started in developing a random sample of residential and commercial buildings across climate zones and counties in the state.

For new construction and commercial renovations, the tool generates random samples from areas with construction activity based on several data sources, such as F.W. Dodge (Dodge) data for commercial buildings, or Census data for residential buildings.[6] The generated sample sets display the number of samples needed from each county. For commercial new construction, it specifies samples by building size.

2.3 Residential and Commercial Evaluation Checklists

The residential and commercial checklists of energy code requirements can be used by evaluators to gather data during plan checks and onsite inspections. Checklists are available as paper forms, Excel spreadsheets, or online for direct input into a database and/or for use with PDAs.[7] There are customized checklists available for each of the eight IECC climate zones. For the evaluator's convenience, the checklist items are organized into sections that correspond to the typical construction phases when such items would normally be inspected.[8] Guidelines for using the checklists can be found in Section 6 of the *Measuring State Energy Code Compliance* guide.

Due to the nature of timing challenges common during construction, it may not be possible for one building to be evaluated through all five phases of construction. Therefore, the procedures allow evaluators to create "composite" samples – that is, multiple buildings can be used to derive a single

[6] Residential samples are derived using the average of the three most recent years data from the U.S. Census Bureau, although states may select options using data only from the previous one or two years if they feel that would provide a more accurate assessment of new construction activity.
[7] PDA stands for Personal Digital Assistant; such a handheld device used by code officials during onsite inspections.
[8] The five inspection phases of construction are: (1) Pre-inspection / plan review; (2) Foundation; (3) Framing/Rough in; (4) Insulation; (5) Final.

"equivalent" building evaluation. This approach can be used where multiple buildings of the same type are being simultaneously constructed, with construction in varying stages occurring at the same time.[9]

Some code requirements are subjective, requiring evaluators to make a judgment call. For such items, the checklists contain a grading scale so that evaluators can mark a code requirement as compliant, and then rate the installation quality as Good, Fair, or Poor.

2.4 Score + Store

For each home or commercial building evaluated, a compliance score is determined by Score + Store - a secure online software application that makes it easy for states to collect, store, and evaluate compliance data and to calculate their overall compliance rates.[10] If evaluators use the paper checklists (described above) to record data, they will need to re-enter the data into Score + Store by hand; if they use spreadsheet checklists, DOE can provide a way to automatically upload the checklist information into Score + Store.

While overall compliance can be determined manually for individual buildings and groups of renovations, Score + Store provides automated building scores and statewide consolidation of data.

Each energy code item on the checklist is assigned a weighted value of one, two or three points. For each item, evaluators record one of the following entries: Yes (complies); No (does not comply); N/A (item does not apply to a given house); Not Observable (item applies to the house, but cannot be verified, often because the home could not be visited during all stages of construction). To determine building-level compliance, the total points marked "compliant" are divided by the total points marked either "compliant" or "non-compliant." Any items marked "not applicable" or "not observable" are excluded from the calculation.[11]

Individual building scores will remain confidential (available only to the state and their contractors), but storing data nationally is intended to yield insights on compliance across the country and changes in compliance over time.

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[9] According to the guide: "Each checklist item must be selected as compliant (Y), not compliant (N), not observable (N/O), or not applicable (N/A). N/O and N/A options are intended for very different circumstances. N/A is a valid option for any code requirement that does not apply to a given building (e.g., basement requirements for a building that has a slab-on-grade foundation). N/O is an option for cases where it is impossible to evaluate a code requirement on a given building because it is hidden or otherwise unavailable for observation. Evaluators should limit the use of the N/O option. The DOE evaluation methodology was designed as a random sampling of buildings, and if a large number of code requirements are marked N/O, the evaluation methodology no longer provides a valid observation of an entire building. However, it is acceptable to use multiple buildings of the same type but in different stages of construction to comprise a single building sample. When evaluating a renovation or addition, it is appropriate to select N/A for code provisions that do not apply to the specific renovation or addition. N/A should ***not*** be selected for cases where the code provision cannot be inspected because it has been covered or can't be observed – instead select N/O."

[10] "Score + Store" can be accessed at: https://energycode.pnl.gov/ScoreStore/login

[11] See Figures E.11 and E.12 in this document. More analysis is needed to better determine the impact of removing items from the scoring methodology.

2.5 Jurisdictional Survey

A survey of code officials can help a state better understand the needs of local jurisdictions. Since a survey is subjective, it cannot be compared to the value of making visual inspections in the field. However, Recovery Act requirements direct states to make annual measurements on compliance, and a survey is one low-cost way to gain insights on the status of energy codes in years where a full formal compliance study is not being conducted. Gaining insights to local jurisdictions' energy code plan review, inspection, and administrative processes can provide an indication of the extent of local enforcement of various energy code requirements. Results can provide insights to help inform decisions on targeting training and education activities. Surveys can also serve as a means of generating a preliminary understanding of the jurisdictions in the state, or as a way to follow-up after an onsite evaluation to assess change.

DOE provides an online survey tool with a default set of standard questions and an additional list of suggested sample questions states may choose to add or leave out. States are encouraged, however, to use the standard questions as provided in order to have consistent and comparable results across states. States may distribute the survey by regular mail, email, or in person. Regardless of which approach is used, DOE can assist states in adding their survey results into a centralized database, where results can be aggregated to provide various views of state, regional, and national results. Survey results can help correlate jurisdictional practices with measured code compliance rates.

2.6 Jurisdictional Flyer and Letter

A ready-made, customizable, jurisdictional flyer and letter are available to inform local jurisdictions about compliance evaluation efforts, solicit their cooperation, and advise them of what to expect from activities prior to and during the in-the-field portion of a visit from state compliance evaluators. Two formats are available: a one-page flyer and a brief letter.

2.7 90 Percent Compliance Webcast

In August 2010, DOE hosted a 100-minute webinar during which PNNL staffers provided in-depth explanation and demonstration for compliance evaluators participating in the pilot study to effectively use the DOE procedures and resources. The presentation was followed by an interactive online question-and-answer session. The webcast transcript and PowerPoint slides are available online.

2.8 Training Materials

DOE offered training materials for evaluators tasked with measuring energy code compliance. The Building Energy Codes website offers training in a variety of formats and media types; from self-paced online training to live webcast events to tailored on-site training. Course topics cover the entire spectrum of building energy codes at all levels. The compliance evaluator training materials provide step-by-step instructions for using the DOE checklists to conduct both residential and commercial building evaluations.

2.9 Step-by-Step Companion Guide

This resource is a four-page document summarizing the main steps for conducting a formal compliance evaluation study. The purpose of this document is to market a compliance verification program to decision makers as opposed to getting into the technical details of what the study would entail.

3.0 Pilot Studies

The six states selected for individual pilot studies were Utah, Iowa, Massachusetts, Georgia, Wisconsin, and Montana. Additionally, NEEA completed two Northwest Regional studies which included surveys of Washington, Oregon, Idaho, and Montana.[12] The primary purpose of these studies was to evaluate the effectiveness of the DOE tools and to provide suggestions for their improvement. **The studies should not be interpreted to represent national or state compliance rates.** Table 3.1 shows the eight pilot studies that were funded and provides brief focus statements and links to more detailed summaries of each study.

Table 3.1. Pilot Study States and Focus of Their Studies

State / (REEO)	Focus of Pilot Study
Georgia (SEEA)	Georgia reviewed 69 new commercial buildings which combined for a total of 44 commercial building evaluations. A jurisdictional survey was used as part of the Georgia study.
Iowa (MEEA)	Iowa reviewed 50 new residential buildings which combined for a total of 44 composite samples, evaluated against the 2009 IECC. The state used the sample generator in addition to updated construction data, as well as other PNNL methodologies including the DOE Residential Checklist.
Massachusetts (NEEP)	Massachusetts evaluated 100 newly occupied homes, 50 of which were built to the 2006 IECC and 50 built to ENERGY STAR. The samples were also evaluated against the 2006 IECC. Massachusetts reported compliance in a number of alternative formats, including Home Energy Rating System (HERS) scores.
Montana (NEEA)	The Montana study evaluated 125 new homes, half of which were from locations under jurisdictional control and half from locations where builders self-certify.
Utah (Independent)	Utah conducted a study in two phases. The Phase 1 study evaluated 11 new residential and 6 new commercial buildings against the 2006 International Energy Conservation Code (IECC) and ASHRAE/IESNA 90.1-07/2009 IECC respectively. The Phase 2 study evaluated 42 new residential buildings against the 2006 IECC. A jurisdictional survey was used as part of the Utah study.
Wisconsin (MEEA)	Wisconsin evaluated 44 new commercial buildings. Because the state's Buildings and Safety Division is responsible for enforcing the code statewide, samples were chosen using the existing construction database and evaluated by state inspectors.
Northwest Commercial Lighting Study (NEEA)	For the Northwest Commercial Lighting Study (Washington, Oregon, Idaho, and Montana), plans were reviewed for 91 commercial buildings to evaluate code lighting requirements, and field inspections were conducted on 29 buildings.
Northwest Jurisdictional Survey (NEEA)	The Northwest Jurisdictional Survey Study (Washington, Oregon, Idaho, and Montana) implemented a survey approach to determine current residential and commercial data collection, documentation, and storage practices and identify opportunities for improvement.

While *Measuring State Energy Code Compliance* describes the DOE procedures and resources for evaluating energy code compliance, it adds that states may design and implement their own methodology. Of the eight pilot studies funded by DOE, none followed the DOE-recommended protocol in its entirety. None of the states implemented all of the DOE procedures and utilized all resources; each chose a subset. Table 3.2 lists the primary DOE tools used by each state.

Table 3.2. Tools Used by Each State Pilot Study

Study	Compliance Checklists	State Sample Generator	Score + Store	Jurisdictional Survey
Georgia	Yes; commercial checklist	Yes	Yes	Yes
Iowa	Yes; commercial checklist	Yes	Yes	No
Massachusetts	Yes; residential checklist	No	No	No
Montana	Yes (modified)	Yes	No	No
Wisconsin	Yes	Yes	Yes	No
Utah	Yes	Yes	Yes	Yes
NW Commercial Lighting	No	Yes	No	No
NW Jurisdictional Survey	Yes (modified)	No	N/A	Yes

Data from building inspections was collected in the Score + Store online tool for residential and/or commercial buildings throughout the states of Wisconsin, Georgia, Utah, Virginia, Illinois, Iowa, and Massachusetts. All buildings evaluated as part of the pilot studies were new construction, except for the recently occupied residences evaluated as part of the Massachusetts study. Table 3.3and Table 3.4 summarize the number of buildings from each climate zone and the respective code that was used as the basis for evaluation of compliance. A total of 145 new commercial buildings and 256 residential buildings were entered into Score + Store. However, some of these buildings were partially completed or did not evaluate a sufficient number of checklist items to be considered valid.[13] The totals shown in Table 3.3and Table 3.4 represent the number of evaluated commercial and residential buildings used in the data analysis discussed in this section.

Table 3.3. Residential Buildings by Climate Zone and Energy Code

Climate Zone	2006 IECC	2009 IECC	*Total*
3	5	0	***5***
4	0	21	***21***
5	133	70	***203***
6	6	10	***16***
Total	***144***	***101***	***245***

[13] Any residential or commercial building that had fewer than 10 checklist items evaluated was removed from the building data used to inform the national analysis.

Table 3.4. Commercial Buildings by Climate Zone and Energy Code

Climate Zone	90.1-2007	2006 IECC	2009 IECC	*Total*
2	13	0	0	***13***
3	38	0	0	***38***
4	4	0	4	***8***
5	0	3	11	***14***
6	3	0	31	***34***
7	1	0	4	***5***
8	0	0	6	***6***
Total	***59***	***3***	***56***	***118***

While the purpose of the pilot studies was to gain insights into the effectiveness and applicability of the DOE protocols and tools, the states themselves had additional goals. Several of the state studies used the project to:

- Increase knowledge of the construction data in their state (e.g., analysis of compliance rates by building use, building system, building size, compliance path);
- Understand the needs of local jurisdictions and what they consider to be the most common impediments to compliance;
- Identify the weak spots in compliance: where they need to concentrate efforts and funnel resources to improve compliance in their state (e.g., training);
- Identify potential issues with the state energy code itself;
- Determine actual compliance rates for use as a benchmark against future studies.

In order to ensure potential evaluators had an understanding of how to perform proper plan reviews and site inspections, PNNL staff provided training on the procedures and technical support to third-party contractors, building officials, energy office staff, and others involved in each pilot study. Training sessions were held in Des Moines, Iowa; Salt Lake City, Utah; Madison, Wisconsin; and Atlanta, Georgia, and focused on how to use the residential and commercial checklists as well as interacting with jurisdictional staff, builders, and designers. The residential training included both classroom and field training to give evaluators on-site experience using the residential checklist. The commercial training was held in a classroom, and supplemented with video clips of construction site inspections.

3.1 Georgia

Georgia's goal for their pilot study was to improve compliance with the state commercial energy code through enhancement of code enforcement efforts statewide. Georgia adopted the 2009 IECC and ASHRAE 90.1-2007 in January 2011. Early in the pilot study, the Georgia Department of Community Affairs (DCA) established a Compliance Working Group composed of key stakeholders in the state, which was instrumental in helping DCA locate the sample

Georgia At-A-Glance

Cost: $100,000
Evaluated: The equivalent of 44 commercial buildings
Evaluators: Independent third party
Evaluated compliance to: 2009 IECC and ASHRAE 90.1-2007
Contractor: B&F Technical Code Services Inc. (Hoffman Estates, IL)

buildings used in the study. The majority of these buildings were built to comply with ASHRAE 90.1-2004, and thus evaluated against stricter code requirements than they were originally designed to meet. Georgia's statewide construction codes are enforced by local inspection departments.

3.1.1 Methodology

Using DOE procedures and tools, DCA conducted evaluations of 69 new commercial buildings. Georgia used the DOE procedures that describe collecting data from multiple buildings to comprise a single sample (see Section 6.2 of *Measuring State Energy Code Compliance*). Additionally, many of the buildings were entered into the Score + Store database as separate building evaluations. When scored separately as opposed to being scored as a single sample, the resulting compliance scores can vary slightly.

The study included the following steps:

4. **Form a working group.** DCA formed a working group comprised of key stakeholders to assist the development of the study.
5. **Initial self-assessment.** In order to gain a better understanding of current code administration and enforcement practices across Georgia, DCA conducted an online survey of local jurisdictions.
6. **Identify samples.** DCA used the State Sample Generator to create a sample of buildings in the allotted in different building sizes and climate zones. However, evaluators found that the projects generated using this method were not truly indicative of the actual building projects currently available for evaluation purposes, attributing the discrepancy to the current economic recession
7. **Train evaluators.** Evaluators attended an intensive two-day training session on the pilot study's procedures and resources, sponsored by SEEA.
8. **Solicit participation.** It is not clear from the final report how local jurisdictions were solicited.
9. **Conduct plan reviews and inspections.** Third-party evaluators used the commercial checklists to perform plan reviews and field inspections of the sample buildings. Due to time and logistical constraints, not all stages of construction (from foundation to final completion) could be inspected in the 44 sample buildings. Therefore, an additional 21 buildings (in the same size and climate zone categories) were evaluated to form "composite" samples to achieve the equivalent of 44 total building samples.
10. **Collect data and report.** Data was entered into the Score + Store database.

3.1.2 Findings and Recommendations

The process of conducting the pilot study with the guidance and resources provided by DOE seems to have added great value to code compliance efforts in Georgia. The experience appears to have influenced the state to take additional steps toward training, education, and further engagement in enhancing compliance. For most projects, the Georgia evaluators found that applied sealing and caulking efforts met air leakage requirements, mechanical systems were close to fully compliant, insulation was properly installed in walls and roofs, and digital zone controls and thermostats were correctly installed. The biggest challenge encountered was related to insufficient information on plans and specifications (e.g., insulation R-values, fenestration U-values, and SHGC values).

Commercial plan reviews in the Georgia Pilot Study averaged 85 minutes and onsite inspections averaged 50 minutes. The evaluators averaged two trips per building evaluated, typically combining the rough-in (framing) and insulation inspections. Foundation inspections did not typically apply in Georgia, with the exception of a few buildings with heated slabs.

The main barrier to building energy code compliance was determined to be a lack of education and proper training. Many local jurisdictions in Georgia do not enforce the energy code and some do not even have code inspection programs. Some of the jurisdictions that have elected to enforce the state energy code are not able to do so because they lack staff, time, or expertise to properly enforce the code. This situation has been exacerbated by the current economic recession, since many local governments have experienced serious revenue shortfalls that have forced them to cut building code agency staff and funding. As such, code officials were reluctant to participate in the study as they assumed that their performance would be critiqued by the state, however they were assured that the study was to just collect data for statistical purposes and not a critique of individuals.

The results of the survey and evaluations were used by the Compliance Working Group to establish state-specific methods to increase energy code compliance in commercial buildings. Georgia will continue to provide additional training opportunities and explore alternative approaches to evaluating, measuring, improving, and removing barriers to building energy code compliance.

The Georgia study adhered closely to the DOE procedures and utilized most of the DOE resources; the state energy office deemed these materials essential to the completion of the pilot study. Since the pilot study was completed, Georgia has invested significantly in education and training for building industry professionals and code officials. According to the final report, the state is moving forward on another study to evaluate the permitting and inspection process of local building departments in order to develop recommendations for streamlining these processes. In addition, the state is funding pilot studies for commercial renovations and residential new construction and renovations. The state intends to utilize the same DOE procedures and resources for these studies.

3.2 Iowa

In partnership with MEEA, the Iowa pilot study included evaluations of 50 new residential buildings for compliance with the 2009 IECC. The primary goal of the study was to determine the rate of energy code compliance in new Iowa homes, as well as the time required to conduct energy code inspections; to train code officials and builders on the study methodology; and to identify training needs.

Iowa At-A-Glance

Cost: $78,000
Evaluated: 50 new residential
Evaluators: Second and third party
Evaluated compliance to: 2009 IECC
Contractor: The Building Inspectors, Inc.

Iowa is a rural state, and most housing starts occur in the few larger cities where building codes are actively enforced. However, approximately 40% of the population lives in areas that do not have building code departments (mainly counties and small towns in the northwest and southeast parts of the state) to provide plan reviews or building inspections. In this study the sample buildings were selected from areas that have building code departments, so they do not represent a true random sample of all residential construction in Iowa, but do cover the vast majority of new construction in the state.

3.2.1 Methodology

The Iowa study team included third-party energy raters, state building inspectors, and city and county building inspectors. Evaluators were trained by and received ongoing support from the State Building Code Bureau with assistance from MEEA and DOE. Evaluators also utilized the PNNL recommended methodology and the DOE residential checklist. The study followed these steps:

1. **Identifying samples.** Initially, the random Sample Generator was used to locate cities and counties for participation in the study, and samples identified in larger cities were included in the study. Many of the samples in rural counties could not be used because either there were no housing starts available at the time of the study, or the short time frame did not allow for the necessary inspections during the phases of construction. Evaluators chose samples in areas as close as possible to the original counties identified.
2. **Communicating with local jurisdictions.** An informational flyer was sent from the State Building Code Bureau to all jurisdictions identified for the study. The State Building Code Bureau also presented the study to the Iowa Association of Building Officials, emphasizing that the study was not meant to penalize any participating jurisdictions. Building officials were generally helpful and interested in the results of the study; but some were resistant to any involvement by the state.
3. **Coordinate with local jurisdictions.** A significant amount of time was spent coordinating site evaluations with local building departments.
4. **Conduct plan reviews.** Evaluators met with local building departments, builders, subcontractors, and homeowners to obtain whatever documentation was available. For each home they sought: building plans; documentation of code compliance; and Manual J or D documentation.
5. **Conduct inspections.** The limited timing for the study restricted the ability to follow individual homes through all stages of construction for site inspection. In order to obtain 44 samples, a composite of 50 homes was used; the majority of which were derived by piecing together data from more than one home to form the equivalent of one sample. In this way, a sample size of 50 homes provided the equivalent of 44 samples. The contractor believes that the composite approach works well because the contractor and code inspector will not have identified a home as an "energy study" home, which could bias the results.

3.2.2 Conclusions/Recommendations

The Iowa study was conducted with intent to follow the DOE recommended procedures. It encountered difficulties in deriving samples, as the majority of jurisdictions were not interested in participating. Hurdles to ensuring compliance included a lack of funding for plan review and inspection staff, lack of understanding of the value of energy codes, and lack of documentation submitted by builders with plans. Jurisdictions that gathered documentation, such as RES*check* or REM/Rate analyses, were simply looking at the "bottom line" to see if they passed, rather than reviewing the details. Many building departments in the state are just getting started with energy code compliance verification, and most jurisdictions are not inspecting to the 2009 IECC. Problems in finding actual samples during visits to the local jurisdictions indicated the need for changes in their record-keeping processes. Only about 50% of the jurisdictions participating in the study had some form of plan review documentation, adding to the challenge of finding specific building samples.

Lack of documentation for HVAC load calculations was identified as a major deficiency in the Iowa study; calculations were only completed and submitted for 12 of the 50 homes surveyed. Many jurisdictions don't require HVAC load calculations for new homes when the plan is submitted. However, investor-owned utilities in Iowa are offering training to HVAC contractors on load calculations. Another deficiency identified in the study was the lack of construction drawings and energy code documentation available for residential buildings. Only 16 of the 50 homes surveyed provided plans and specifications that adequately demonstrated energy code compliance.

Due to the lack of documentation in the plans, evaluation times for residential plan reviews in the Iowa Pilot Study were typically 15 minutes or less. If complete documentation had been available at plan review, study implementers estimate the review would have taken 30-45 minutes. Site inspection times ranged from 15-45 minutes, depending on how much of the home was observable, and entering the data into Score + Score averaged one hour per home. Total compliance evaluation times ranged from 2.5-3 hours per home; if all documentation had been available or observable evaluators estimate that the total time spent on each home would increase by around one hour.

The findings identified in the Iowa study are expected to be shared with various stakeholders such as the Iowa League of Cities, Iowa Homebuilders Association, Iowa Association of Building Officials, and the Iowa Utilities Board. As a result, the impact of the study will go beyond its implementers and will help to raise awareness and educate influential individuals in Iowa.

3.3 Massachusetts

In partnership with NEEP, the Massachusetts Department of Energy Resources (DOER) evaluated two groups of new residential homes for compliance with the 2006 IECC: 50 ENERGY STAR®-qualified new homes, and 50 standard (non-ENERGY STAR) new homes, for a total of 100 samples.

Massachusetts At-A-Glance

Cost: $144,000
Evaluated: 100 new homes (post-construction)
Evaluators: Third-party HERS raters
Evaluated compliance to: 2006 IECC
Contractor: NMR Group, Inc.

In addition to a goal of measuring energy code compliance, the DOER wanted to draw comparisons between the checklist and performance approaches. All homes were evaluated using both: a HERS rating (utilizing REM/Rate software), and the PNNL compliance checklist for both groups of homes evaluated.

3.3.1 Methodology

The DOE procedures and tools were developed for evaluating buildings key stages of construction. The Massachusetts study, however, evaluated finished, occupied homes in an attempt to apply the DOE approach to post-construction buildings. While many energy code items were not expected to be verified visually with this approach, it can cut costs.

On-site visits were not necessary for the ENERGY STAR homes, as these homes were evaluated based on information previously collected by HERS raters during the initial certification process. For the standard, non-ENERGY-STAR new homes, evaluation used the following steps:

1. **Sample identification.** The Sample Generator was not used to derive samples for the study because the state wanted to include unique factors not accounted for by the program, such as communities that

had adopted the Massachusetts "Stretch Code"[14], as well as an apportionment of spec versus custom built homes. Instead, the sample of potential homes was derived from new residential service requests as provided by investor-owned Massachusetts electric utilities, filtered based on specific criteria.

2. **Verification of sample buildings.** Local building departments were contacted to verify that homes represented one- to four-unit buildings, were built to the 2006 IECC version of the energy code, and did not participate in the ENERGY STAR for New Homes Program.
3. **Participant solicitation.** Homeowners were sent a letter explaining the purpose of the study and offering an incentive of $150-$200 for their participation. The study requested two to four hours of their time, with later follow up calls made to secure homeowner participation.
4. **Field inspections.** Two HERS raters visited each home and completed a data collection form created for the study, in addition to the DOE compliance checklist (customized to the 2006 IECC). A single, onsite, post-construction evaluation was done for each non-ENERGY STAR home. The study did not include plan reviews.

For the purposes of this study, it is important to note that many homes in Massachusetts use RES*check* to demonstrate compliance with the energy code. However, without visiting the building department to verify RES*check* or similar documentation, evaluators had to assume a prescriptive approach was initially used to demonstrate compliance for all of the non-ENERGY STAR homes. Therefore, individual building components which may have complied under a performance approach might appear as non-compliant under a prescriptive approach.

3.3.2 Findings and Recommendations

Checklists for ENERGY STAR homes were completed by the same HERS raters who inspected the homes during construction as part of the ENERGY STAR certification process. Their familiarity with the homes made it relatively easy for them to fully complete the checklists using the performance compliance approach, and they did not revisit the homes during the pilot study.

Evaluators for the non-ENERGY STAR homes completed onsite audits and used the prescriptive compliance approach for their evaluations. Evaluators visited 50 occupied home sites to conduct a full HERS rating and to complete the 2006 IECC checklist. Due to the large amount of data required to complete a HERS rating, site visits typically lasted 3-4 hours, in addition to 4-12 hours of office time spent entering and analyzing the onsite data. The evaluators would then spend around 1 hour completing the DOE checklist based on data contained in the HERS report.

While compliance verification in the Massachusetts Pilot Study averaged 16-17 hours of staff time per home, the contractors provided the following estimates for the level of effort for only completing evaluations per DOE procedures:

- Conducting a post-occupancy inspection and collecting only the information needed to complete the checklists would take from 30 minutes to an hour depending on the complexity and size of the home.

[14] A voluntary, more stringent energy code which may be adopted by and enforced in jurisdictions across the state.

- Massachusetts did not enter data directly into the Score + Store tool, but instead used an Excel spreadsheet for collecting and scoring results. Entering the collected information into the Excel spreadsheet was estimated to take 30 minutes for each residential sample.

In summary, collecting the necessary information during an onsite visit and then completing the checklist would take 1 to 1-1/2 hours. These estimates do not include blower door and duct blaster tests, which would add an hour to the required time onsite, bringing the total to somewhere between 2 and 2-1/2 hours.

A "post-construction" evaluation can pose challenges for evaluators attempting to verify all code requirements. In the Massachusetts study, evaluators report they were unable to verify compliance with the code for slab insulation or insulation applied to the interior surface of crawl space walls at any of the 50 sites visited. Exterior foundation insulation was verifiable only at two sites, but even then evaluators were unable to verify the installation quality or depth. National Fenestration Rating Council (NFRC) labels containing U-factors and solar heat gain coefficient (SHGC) values are normally removed from windows and doors as soon as a home is occupied and therefore were unverifiable in these post-construction inspections.

To summarize, the following items were not observable (and therefore not recorded on the checklists) at any of the 50 non-ENERGY STAR sites:

- Slab insulation R-value
- Foundation and crawl space insulation R-value
- Installation quality and depth of foundation insulation.

Additionally, items that were not observable (and therefore not recorded on the checklists) at *most* of the non-ENERGY STAR sites included:

- Door, window, and skylight U-factors
- Manufacturer, make, and model of fenestration and doors
- Window and skylight SHGC values
- Mass wall insulation R-values
- Duct sealing
- Building cavities used as supply ducts
- IC-rated recessed lighting fixtures
- Fenestration and swinging-door air leakage.

Both the ENERGY STAR homes and the non-ENERGY STAR homes included several sample homes that did not comply with the mandatory duct insulation requirement.
In addition to the number of inspections completed for each home, the Massachusetts pilot study diverted from the DOE procedures as it only included evaluations of new residential homes. Since the Massachusetts study only included finished, occupied homes, the Sample Generator tool was not used to determine samples, and most items on the checklist were unobservable, insights from this study are largely non-applicable to analyzing the DOE methodology as a whole.

The Massachusetts final report suggested that evaluators did not input data consistently, which may lead to skewed results. However, the study reports compliance in a number of alternative formats, including: Overall building UA (RES*check*), the performance path (HERS), and Annual Energy Cost, with greatly varying results.

3.4 Montana

The Montana study intended to evaluate homes in jurisdictions where the code is adopted and administered and compare them to self-certifying areas. In partnership with NEEA, the Montana study included evaluations of 125 new homes: half from areas with local jurisdictional enforcement and half from areas where builders self-certify energy code compliance. In addition, at the request of NorthWestern Energy (NWE)-Montana's largest electric utility-the study was expanded to determine compliance within its service area. NEEA also contributed funding to the study to ensure a valid sample size within their region. In most homes inspected, including all builder self-certified homes, assessments were based on the prescriptive path.

3.4.1 Methodology

Montana's pilot study report focused on the challenges they experienced in creating a valid sample set and finding buildings to fulfill that sample. The Montana study also departed significantly from the DOE recommended methodology (with justifications for doing so), but as a result biases may have been introduced into the study. When evaluators asked building departments to provide only the permits that were filed *after the updated building code became effective*, they discovered that many projects were still being enforced under the old 2006 IECC and, were thus deemed ineligible for inclusion in the study. Of the projects deemed eligible, there was a near-unanimous refusal of participation by builders and homeowners. In addition, due to the difficulty of traveling to remote areas of the state, seven jurisdictions were removed from study and replaced with more accessible ones. Evaluators felt that the weighted values for the 63 items on the checklist were not relatively indicative of the true impact on energy consumption of each item, so they developed alternative methodologies for analyzing the data. Sampling and recruitment processes changed throughout the study to accommodate these challenges, and sometimes evaluators were unable to collect complete data. Just over half of relevant items on the checklist could be evaluated and verified as either compliant or non-compliant. Unlike in other pilot studies, Montana evaluators had difficulty in implementing the DOE procedures due to inconsistent interactions between the study implementers and the construction and enforcement communities, possibly resulting from Montana's system of builder self-certification. The study followed these steps:

Montana At-A-Glance

Cost: $96,000
Evaluated: 125 new homes
Evaluators: Third-party
Evaluated compliance to: 2009 IECC amended
Contractor: The Cadmus Group, Inc. (for study implementation) and the National Center for Appropriate Technology (for site visits)

1. **Identifying samples.** The State Sample Generator derives samples based on data from the US Census Bureau, which relies on data provided by local code jurisdictions. Since more than half of new homes in Montana are in areas where builders self-certify compliance, study implementers relied on housing start data from the Montana Building Industry Association and the Montana Department of Labor and Industry to supplement the results from the Sample Generator.

2. **On-site inspections conducted.** Organizing on-site inspections proved difficult, as many building departments in Montana do not maintain permit information and most counties had not permitted as many new construction projects as expected. For homes that were inspected, third-party evaluators used a modified form of the DOE checklist depending on what areas of the home were viewable and how importantly they weighted the items.
3. **Data collection and reporting**. The study analysts modified the weighted values used in the DOE scoring methodology in the following manner: 1) since the distribution of site visits did not match the sampling plan, analysts developed a weighting mechanism to eliminate outliers and refine data to match the geographic distribution of housing starts in the state; and 2) since most site visits could only verify half or less of the applicable items on the checklist, they developed a weighting mechanism to count more heavily the compliance results for those sites having a greater amount of available data.

3.4.2 Findings and Recommendations

Initial feedback from this study indicates that it is rare to find information on plans about HVAC, domestic hot water, lighting, or building air leakage tightness techniques and/or design standards. Almost all houses in larger jurisdictions use RES*check*, but discrepancies are commonly found between the R-values and component areas on the RES*check* reports and those on the plans. In smaller jurisdictions, plan review seldom includes a verification of compliance with respect to energy features. When performing site inspections, code inspectors tend to only look for insulation R-values of the major building assemblies. Compliance with code requirements related to air leakage limitations is unusual in smaller jurisdictions and non-jurisdictional homes.

More than half of the residential construction in Montana occurs in areas without a local permitting authority. Since the Sample Generator is based on residential permit data, an alternative method of sample generation based on identifying new housing starts was needed for this pilot study. For site visits in self-certifying areas with no building department oversight, the consultant used state electrical permit data available from the Montana Department of Labor and Industry. The consultant then used aggregate Residential New Construction data obtained from the Montana Building Industry Association and the U.S. Census Bureau to create samples of the first two populations. Those samples were expanded to allow valid, independent code compliance verification for homes within NWE's service territory, still keeping the split between homes under jurisdictional control and those where the builder can self-certify.

Forming a Compliance Working Group would have been particularly helpful in Montana, as significant participation by builders and code officials could yield inroads to local jurisdictions and open doors for evaluators. Forming a Compliance Working Group between individuals would provide the opportunity to identify and overcome challenges together, and improve future compliance efforts. In addition, implementing a self-assessment/study can be a better starting point for states with a strong self-certification system in place, so long as the program implementer can rely heavily on an active group of code officials and leading builders.

3.5 Utah

Utah was chosen to evaluate residential buildings against the 2006 IECC and commercial buildings against the 2009 IECC. Utah's pilot study was performed in two phases. The focus of Phase 1 was for the state and local jurisdictions to gain experience conducting an evaluation of this type, and derive an initial assessment of energy code compliance. Phase 1 introduced stakeholders to the state's responsibilities resulting from the Recovery Act, and familiarized them with the process of a third-party evaluation. Phase 1 was a success in forging positive relationships with the participating jurisdictions, which were eager to understand the areas for improvements.

Utah's Department of Facility Construction Management engaged Colorado Code Consulting, LLC, a third-party evaluator, to conduct plan reviews and at least one onsite evaluation for each of the 27 buildings across all Utah climate zones. Phase 1 evaluations were conducted with local enforcement staff and were treated as educational opportunities; if infractions were observed, they were corrected prior to entering data into the Score + Store tool. Concurrently with Phase 1 of their study, Utah developed a Utah Energy Code Compliance Roadmap to illustrate the best path forward for increasing energy code compliance in the state.

For the Phase 2 study, 42 new residential buildings were evaluated across 22 jurisdictions, based on a random sample of homes generated by the State Sample Generator. To save time, each code inspector attempted to complete a 4-way inspection ,which looks at rough framing, rough plumbing, rough heating, ventilation, and air-conditioning (HVAC), and rough electrical.

3.5.1 Methodology

Utah At-A-Glance

Cost: $89,000
Evaluated: Phase 1: 27 residential and commercial buildings; Phase 2: 42 new residential
Evaluators: Third party
Contractors: Phase 1: Colorado Code Consulting, LLC. Phase 2: Navigant Consulting, Inc. (and four third-party firms)
Evaluated compliance to: residential to the 2006 IECC; commercial to the 2009 IECC

3.5.1.1 Utah Phase 1 Overview

In addition to Utah's Department of Facility Construction Management, ten jurisdictions agreed to participate in the Phase 1 pilot study. A total of 27 buildings were evaluated through plan review and field inspection during Phase 1, and data for the following buildings were entered into Score + Store: 15 new residential homes, 1 new low-rise residential building, 1 residential remodel, 9 new commercial buildings, and 1 commercial renovation. Residential buildings were evaluated against the 2006 IECC, and commercial buildings were evaluated against the 2009 IECC.

In keeping with the educational nature of phase 1, the evaluators felt it was important to allow builders to correct the non-compliant issues before proceeding. However, since this correction may distort the final compliance rates, the approach was not used during Phase 2.

3.5.1.2 Utah Phase 2 Overview

For Phase 2 of the study, a random sample of 42 new residential homes were evaluated in 22 jurisdictions in order to determine statewide compliance with the current edition of the Utah 2006 IECC. The evaluation followed these steps:

1. **Identify Samples.** For Phase 2, the Sample Generator provided a random sample of new residential sites. If there was a lack of available projects in some of the counties identified, evaluators replaced them with projects from a nearby county, which may have skewed the results.
2. **Train evaluators.** Four in-state third-party energy rating firms were trained on data collection methods to ensure that all elements contained in the checklists were properly checked.
3. **Communicate with local jurisdictions.** Using a specific script to describe the study, evaluators contacted the jurisdictions selected for the study, informing them of the statewide assessment.
4. **Survey local jurisdictions.** Local building departments selected for the study were asked to complete a jurisdictional survey prior to the site visit.
5. **Conduct plan review and inspections.** Project evaluators visited the building departments with jurisdiction over the sample buildings. For each home, evaluators reviewed plans, completed residential field inspection checklists, and conducted as close to a 4-way inspection as possible. In some cases not all aspects of the home could be observed, so the evaluators created composite evaluations to derive "equivalent single samples."
6. **Collect data and report.** Data was entered into the Score + Store tool and findings were prepared and presented to State of Utah energy officials.

3.5.2 Findings and Recommendations

Each residential plan review in the Utah pilot study took approximately one hour, and each residential inspection took another hour. Commercial plan reviews took 1-2 hours, and commercial inspections took about an hour. These times do not include driving or reporting times. It took approximately 45 minutes to enter each building into Score + Store.

The following onsite inspection challenges were identified for energy code compliance in the Utah study:

- Energy code provisions are the lowest priority on the list of building inspections, and building officials often miss violations.
- There are an insufficient number of International Code Council (ICC)-certified energy code inspectors and plan reviewers in the local building departments.
- Third-party inspectors are not always available for inspections for every stage of construction, so a true compliance evaluation may not be performed every time. Therefore it might be easier for individual jurisdictions to perform their own building plan reviews and inspections using the checklists than for a third party to do the inspections.
- Efforts to circumvent inspectors' determinations were observed.

- Building departments consistently misunderstood areas of the code that deal with reading and understanding software programs utilized in enforcing the code, so additional training was recommended in this area. For example, ACCA Manual J (the ASHRAE manual on heat load calculations) is required in most jurisdictions, but code officials were not looking at the actual calculated loads to determine if HVAC equipment was sized in accordance with the code.
- As in the other pilot studies, not all items could be inspected due to the timing of construction/inspection.

Conclusions reported by the study include:

- Building departments were generally supportive of energy code requirements and were trying to understand and comply with the code.
- There is a lack of consistency in carrying out the compliance verification policies and procedures in each jurisdiction. This may frustrate builders and could compromise energy code compliance.
- Energy code compliance inspections were a lower priority than other inspections relating to health or life safety.
- Consistent education and support for code officials and home builders are needed.
- A recognizable authority and resource for energy code questions is lacking. A single source is needed for code officials to obtain reliable information.

3.6 Wisconsin

The Wisconsin study was unique in that in all locations except certified municipalities, commercial building code compliance and enforcement are the responsibility of the state. For the pilot study, 17 of the 44 projects were located in certified municipalities, in which all the construction inspection is conducted by the city or county. Evaluation of the other 27 projects could be considered a second-party evaluation.

Wisconsin At-A-Glance
Cost: $143,000
Evaluators: Second party (Wisconsin Safety and Buildings Division staff)
Sample: 44 new commercial buildings
Contractor(s): None
Evaluated compliance to: 2009 IECC and ASHRAE 90.1-2007

Through a contract with MEEA, the State of Wisconsin Safety and Buildings Division evaluated new commercial buildings between October 1, 2010, and June 30, 2011. Using state staff as second-party evaluators, the study evaluated 44 commercial buildings (28 small, 10 medium, four large, and two extra-large) through on-site inspections during construction. At the time of the study, Wisconsin law required compliance with the 2006 IECC and ASHRAE 90.1-2004. The state has since formally adopted the 2009 IECC and ASHRAE 90.1-2007 and began enforcement on September 1, 2011. Wisconsin's pilot study success is attributed to the fact that no building plan is approved unless it is accompanied by a COM*check* or other similar calculation showing that the building, as designed, meets the code. For the pilot study projects, the reviewers ran their own COM*check* reports based on either the 2009 IECC or ASHRAE 90.1-2007 (depending on which one was originally used). Since the state has required COM*check* or comparable reports in one form or another since 1998, they believe they achieve a high compliance rate with most designers using reasonable and verifiable U-factors and R-values.

3.6.1 Methodology

Certain aspects of the study's execution deviated from the methodologies prescribed by DOE and thus are not optimal for comparison to other studies. The Wisconsin evaluators suggested that the checklist be rearranged to include one column for "Plan Review Value" and one column for "Field Verified Value" for each subject. They also suggested editing the checklist to more closely match the International Building Code and the Construction Specifications Institute Master Format; in no cases were the results dependent solely on the COM*check* reports. State inspectors attempted to make five separate inspections: after the footings and foundations (or basement walls) were poured; when the slab was partly poured; after the framing and insulation was in place; when the fenestration was installed and the interior finish material was being installed; and when lighting and mechanical equipment were in place and the building was almost ready for occupancy. Based on the size, a few projects combined several inspections into one, and in some cases several inspections were required to complete just one phase.

The study followed these steps:

1. **Sample Design:** New commercial buildings were identified for the study using a combination of the State Sample Generator and the Wisconsin Safety and Buildings Division commercial building "Regulated Objects" database.
2. **Soliciting participation:** Wisconsin's construction codes are uniform statewide and largely enforced statewide by staff and "delegated municipalities" (credentialed building, HVAC, and electric inspectors authorized by the state), so soliciting study participants was not difficult.
3. **On-site inspections conducted:** The state evaluators performed field inspections on the sample observations selected using the commercial checklists.
4. **Collect data and report:** Evaluators used Score + Store to secure and transmit the study's data.

3.6.2 Findings and Recommendations

While the enforcement infrastructure and culture in Wisconsin appears more advanced than other states, the state pilot study did not use independent third-party evaluators. The individuals conducting the study did appear to be seasoned and knowledgeable, yet second-party state staffers may be better suited for interim-year spot checks and evaluations rather than for the official compliance study. In addition, the report notes that the study's observed sample varied in the mix of building sizes and county locations from the Sample Generator, skewing toward small buildings (less than 25,000 square feet). The study also helped the state identify where additional training would be helpful. Additionally, it was suggested that the checklist should avoid the use of negative questions where a "yes" answer can be misconstrued. For example, an evaluator could logically check either "yes" or "no" for the following item, depending on how he read the following question: "Insulation intended to meet the roof insulation and requirements not installed on top of a suspended ceiling." The question should be reworded as follows: "Is roof envelope insulation installed on top of suspended ceiling tiles?"

Finally, the evaluators would like Score + Store to allow multiple R-values for walls, roofs, and fenestrations, along with different areas for each element, and then automatically calculate area-weighted averages for each assembly. One of the retail stores in the Wisconsin study had four different R-values for the walls around the building; a different convenience store had two different R-values for roof areas.

Wisconsin stated that both plan reviewers and field inspectors need training to spot potential problems with U-values and R-values in COM*check* and HVAC calculations.

3.7 Northwest Commercial Lighting Study

NEEA contracted with independent third-party lighting designers to develop and implement an evaluation of compliance with energy code lighting requirements in office and retail buildings in nine local building departments in Washington, Oregon, Idaho, and Montana. The study attempted to assess: (1) if sufficient data was included in the plans to determine whether the design met the applicable code; and if so (2) whether or not the buildings actually met the code via a visual inspection of those buildings. Ninety-one plans were reviewed and 29 buildings were visually inspected. The observations were evaluated against the lighting power density (LPD, measured in watts/sf) and lighting control requirements of the local energy code enforced in each of the nine municipalities (either the current or previous adopted version of each local code was allowed).

Northwest Lighting Study At-A-Glance

Cost: $70,000
Evaluators: Independent third party
Sample: 91 new commercial buildings (46 office, 45 retail) after completion
Contractor(s): Lighting Design Lab (Seattle, WA), lighting designers Stephanie Wood and David Butler
Evaluated compliance to: The codes in effect during the study period:

- Washington – 2009 Washington State Energy Code (WSEC)
- Oregon – 2011 Oregon Residential Specialty Code (ORSC)
- Idaho – 2009 IECC
- Montana – 2009 IECC

3.7.1 Methodology

A preliminary step narrowed the scope of the study from all commercial buildings identified by the Sample Generator to ensure that the results would be useful for identifying trends. First, the building types were limited to office and retail buildings, since both use large amounts of lighting and represent significant fractions of total commercial floor space in the region. Next, the population of buildings in the sample was narrowed by size and age of the buildings to ensure that the study represented a significant amount of square footage and that the lighting used would be representative of systems still in use by current construction practice; buildings were required to be 5,000 square feet or larger and to have been permitted under the current or the previous cycle energy code. The final step was to compare buildings from all parts of the region to see if any variations by location emerged from the data.

The lighting pilot study team assumed that obtaining commercial building plans with lighting designs from the local jurisdictions that met the project criteria would be relatively straightforward, but this was not the case. One team member estimated that he spent 75% of his time obtaining appropriate project records. Project permits are usually not searchable by building type or size, so researchers had to search files one-by-one to locate buildings that fit the necessary criteria. Multiple attempts were made to connect with the jurisdictions' records departments by phone, which was complicated because plans are sometimes kept at offsite locations. In many jurisdictions, it took weeks to obtain the requested plans. Hence, in-person visits were much more effective than phone or email requests.

3.7.2 Findings and Recommendations

The commercial lighting evaluation study determined that both lighting designers and local code officials lack proficiency in the Lighting Power Density (LPD) calculations and lighting control requirements of their local energy code. This feedback should be helpful for the states when considering training needs.

The pilot provides a good first attempt at conducting a study focused on one aspect of the energy code, rather than on the five phases of construction. A lighting study can be conducted post-construction, but still be useful in determining trends in compliance issues and identifying the training needs of local jurisdictions.

Since documents were either destroyed or incredibly difficult to acquire for many of the potential projects for this study, the randomness of the sample is highly questionable. There is likely a selection bias toward areas with more professionalized and streamlined plan review and enforcement processes.

It is unknown whether or not the study utilized a Working Group or utilized any other DOE resources. Perhaps having one standard format for reporting results would help analysts obtain the details for a similar study, in order to better understand how to improve the methodology in future studies.

The third-party evaluators discovered that the biggest barrier to the study's goal of understanding compliance with energy code lighting requirements was information acquisition. They estimated that 75 percent of the time was spent hunting for documents, which proved difficult across the jurisdictions because of administrative and data storage practices. While the study yielded some intriguing insights into lighting compliance in the region, such high staff time costs would likely make replicating this study infeasible.

3.8 Northwest Jurisdictional Survey

The NEEA jurisdictional survey focused on assessing jurisdictional practices and processes in Washington, Oregon, Idaho, and Montana. Several survey approaches were used to determine current residential and commercial compliance data collection, documentation, and storage practices and identify opportunities for improvement.

Northwest Jurisdictional Survey At-A-Glance

Cost: $25,000
Evaluators: State agencies in the four states
Sample: A sample of individual building observations was not involved
Contractor(s): None
Evaluated compliance to: No formal compliance evaluation was involved.

NEEA used the DOE jurisdictional survey to collect data regarding actual enforcement practices in jurisdictions, and coordinated with four state-specific entities to distribute the survey to local building departments: (1) Washington State University Energy Extension Program; (2) Oregon Building Codes Division; (3) Idaho Association of Building Officials (via a contractor); and (4) Montana Department of Environmental Quality. The NEEA report also identified opportunities for improvement in the region.

An attempt was made to select jurisdictions that were representative of each state as a whole (based on demographic characteristics such as number of permits issued per year, number of building department staff, and mix of buildings permitted). The success of these attempts varied considerably. One source of

variation was the motivation of the agency collecting the data. Washington saw this study as a way to establish or further relationships with select jurisdictions that could be leveraged to raise the priority of the energy code within their management and encourage building officials to attend energy code trainings. Alternatively, Idaho directed their contractor to simply complete the contractually required number of surveys. Oregon sent an abbreviated online survey to every jurisdiction in the state and followed up with in-person visits to a few jurisdictions that focused on providing feedback on plan reviews. Montana sent an email survey and also visited five jurisdictions with ICC staff members who were giving energy code trainings.

Table 3.5 shows the number of jurisdictions that participated in the surveys in each state and the data collection methods that were used.

Table 3.5. Jurisdictional Participation in Northwest Survey

State	Mail-in or Online Responses	Onsite Interviews	Field Inspections
Washington	0	6	1
Oregon	51	5	5
Idaho	0	15	0
Montana	11	5	0

3.8.1 Methodology

The NEEA study was exploratory and did not attempt to produce statistically valid results. Surveys were administered differently in each state: mail-in, on-line, and in-person. In some cases, surveys were supplemented by interviews, plan reviews, and construction site visits. Each state's approach varied considerably:

In **Idaho**, a contractor from the Idaho Association of Building Officials (IDABO) visited 15 jurisdictions to collect survey information. The survey helped the contractor identify major issues pertaining to energy code enforcement, education and training, and time or staff.

Montana's Department of Environmental Quality (DEQ) sent the survey via email to all 40 jurisdictions in the state. In addition, DEQ and ICC staff conducted energy code training at six jurisdictions, then followed-up with site visits in five of those jurisdictions to interview staff, review residential and commercial buildings plans, and/or conduct residential field inspections.

In **Oregon**, a shortened on-line survey went to every jurisdiction in the state. In addition, in-person interviews were conducted at five jurisdictions to get information on documentation practices and to test the data collection process to be used to measure statewide compliance for Recovery Act reporting.

The **Washington** survey was administered by the Washington State University Energy Extension Program (WSUEEP). The survey was conducted in-person by WSUEEP at seven building departments and was viewed as an opportunity to establish or further relationships with local jurisdictions.

3.8.2 Findings and Recommendations

This study reported that virtually all jurisdictions in the Northwest require energy code documentation with plan submittals. Idaho jurisdictions also specifically mentioned requiring HVAC load calculations. All respondents in Washington, Oregon, and Montana stated that commercial records are kept for seven years or more, while some Idaho jurisdictions keep residential records for less time (one to five years).

Based on survey responses, the main areas of residential non-compliance were envelope sealing (infiltration) and duct sealing, and the main areas of commercial non-compliance were envelope sealing, duct sealing, and lighting controls. When asked what information is typically missing that prevents determination of residential building energy code compliance, 57 responses referred to missing information on the building plans, and five noted a lack of accuracy on information that was supplied. When asked the same question regarding commercial building energy code compliance, 52 responses referred to missing information on the building plans, and five Oregon jurisdictions noted that COM*check* reports were missing.

4.0 Feedback on DOE Procedures and Resources

4.1 Overall Feedback on DOE Methodology

A primary objective of the pilot studies was to test the procedures and tools developed by DOE and to solicit input on their utility and recommended improvements. General observations and feedback on the methodology and resources are summarized below:

- Consistency is difficult to obtain across studies and among individual evaluators. Suggestions for improving consistency include additional guidance and instructions on DOE compliance checklists, evaluator training, and quality assurance of gathered data.
- The checklists developed by DOE were valuable tools for third-party evaluators, and could be valuable tools for state and local staff involved in code compliance during their normal course of code enforcement.
- Software tools, such as RES*check* and COM*check*, which are associated with trade-off and performance-based compliance approaches, demonstrated a strong correlation with higher compliance rates.
- The top barrier to compliance continues to be lack of training, followed by lack of resources and lack of compliance information on plan submissions. Documentation produced by software tools addresses this latter barrier, which might partially account for the correlation with higher compliance.
- Data sources for generating sample sets are not always accurate and, in some cases, are not available (e.g., residential renovations). Generating valid sample sets was further complicated by the economic climate and the fact that new housing starts are significantly lower than past data predicted.
- State compliance measurement studies are costly and require multiple visits to the building while under construction. Timing these onsite visits to observe all code requirements is difficult for third-party evaluators. Post-construction evaluations were implemented in one study in an effort to reduce costs, but many code requirements cannot be evaluated post-construction. The DOE procedures were designed to be used during building construction and did not work well as written in a post-construction situation.
- Access to buildings under construction is a major problem in some locations. Early engagement of state and local governmental agencies is important in securing their cooperation.

4.2 Compliance Checklists

Some of the items on the checklist are seen as impractical or not verifiable by third-party evaluators. Examples include the requirement for submittal of "as-built" drawings within 90 days of system acceptance, and "feeder and branch circuit load and sizing calculations provided that allow verification of voltage drop." Other items on the checklist are subjective, which requires evaluator comments rather than a simple yes or no answer. In many cases, the evaluator is required to provide an interpretation or judgment call, which could influence the outcome of the building rating or the overall state compliance rate. Summarized observations and suggested modifications to the DOE checklists based on feedback from pilot study evaluators include:

- Add “Not Observable” to the checklist and add additional guidance on when “Not Observable” and “Not Applicable” should be used.
- Provide definitions for the checklist items pertaining to insulation installed according to manufacturer specifications, as well as a graded approach for indicating quality of installation instead of pass or fail.
- Clarify where to find information needed to evaluate a given code requirement. Provide more detailed definitions of certain code requirements.
- Move some of the instructions closer to the items to which they apply.
- Simplify the commercial checklist, perhaps by developing a separate checklist for simple commercial buildings. (Note that DOE has considered creating a second commercial checklist that would be applicable to simple commercial buildings, as defined by the code.)
- Add a column to record “Value from Plans” in addition to the “Verified Value” to allow recording the required values found at plan review from U-factor multiplied by area (Total UA Alternative) and performance approaches. Additional ways for checklists to better support the various compliance approaches should also be considered.
- Where one code requirement is listed in multiple places, clarify that compliance should be indicated in only one of those locations. Examples include basement exterior vs. interior insulation; mass wall exterior vs. interior insulation; rough-in and post-construction duct tests; visual air sealing vs. a blower door test (2009 IECC or subsequent editions); and insulation installed on roof decks as opposed to under the roof deck.
- DOE expectations were that the evaluators would have a better understanding of the code than some actually did, as evidenced by the number of clarifications requested that pertained to the code itself rather than the DOE procedures. This observation applies more to the residential studies and checklists than to commercial. Clarification in the residential instructions and checklist text could improve understanding.
- Some code items can be verified by code officials, but are not verifiable by a third-party evaluator. These items should be reworded or removed from the DOE checklist (e.g., submission of as-built drawings within 90 days).

4.3 Score + Store

The Score + Store tool is an online version of the DOE checklists, so many of the checklist enhancements described in this section are also applicable to Score + Store. Additionally, the following enhancements specific to Score + Store are suggested:

- Allow states to generate custom checklists for use in specific studies.
- Allow users to export Word and/or Excel checklists from the tool.
- For each code requirement in Score + Store add links to training videos and other related content, some of which can come from deliverables of recently completed projects funded by the Recovery Act.

- Modify Score + Store to enable it to collect compliance documentation and photographs of construction (examples of both compliance and non-compliance).
- Modify Score + Store for collection of jurisdictional inspection data and results.
- Add validation checks to help ensure that data entry errors are found and rejected.
- Create alternative output formats and reports.
- Add functionality allowing states to better control access to the tool.
- Include the building ID or address to the main screen's checklist summary so the user can return more easily to a specific checklist for updates.
- Develop a user interface that functions over mobile networks (e.g., iPhone, iPad, or Android devices).

While none of the states implemented all of the DOE procedures and utilized each of the provided resources, all studies included at least one subset. The procedures and resources chosen may or may not have reflected each state's unique structure for oversight of energy code compliance. Certain aspects of the procedures worked well in some states, and failed in others.

4.4 Quality Assurance through DOE Procedures and Resources

Evaluation of buildings for energy code compliance involves several quality assurance (QA) issues that could impact the results. Many of these issues can be corrected if a knowledgeable person provides QA for processes used to determine state-wide compliance, thus ensuring consistency among evaluators and reported results. Additionally, DOE anticipates adding a QA section to the *Measuring State Energy Code Compliance* procedures document that highlights portions of the procedures most often misinterpreted, and will provide guidance in ensuring consistency.

Several examples from the state pilot study reports illustrate sources of confusion that could be addressed with a combination of improvements to the DOE materials, and with adequate QA oversight. Some of the major QA issues and suggested solutions are shown in Table 4.1.

Table 4.1. QA Issues and Possible Solutions

QA Issues	Possible Solutions
Some code requirements are subjective, and different evaluators might use different evaluation criteria. It is important to ensure that subjective requirements are evaluated identically by all evaluators using a consistent approach.	This issue could be resolved by better clarification of the code requirements and/or by allowing evaluators to rank the requirement as to degree of compliance. For example, quality of insulation installation could be graded on a scale rather than simply pass or fail. Examples and definitions could be included on how the scale should be interpreted.
Prescriptive values DO NOT APPLY if trade-off or performance approaches are documented at the jurisdiction.	Although an effort was made to clarify this in the checklist instructions, adding a column to the checklist for values from plan review will help.

QA Issues	Possible Solutions
The designation "Not Applicable" is only for items that do not apply to the building being evaluated. The designation "Not Observable" remains a controversial subject that needs to be addressed.	Very clear guidance should be provided on the checklists regarding when to use "Not Applicable" versus "Not Observable".
If a large percentage of checklist items are marked as "Not Observable", another building should be found to inspect some of those items using the multiple-building approach.	DOE may provide a lower bound for an acceptable number of checklist items marked "Not Observable", and/or a recommendation on the point at which a sample might be deemed to have too few observations to be considered valid.
Evaluators sometimes gathered partial data from several buildings and then entered multiple checklists into Score + Store. If a checklist has only plan review items, or does not include compliance evaluations in each stage of construction, then it probably is using the multiple-buildings approach and may need to be combined with another checklist to create a single sample.	If evaluators gather data from multiple buildings and combine them into a single sample building, they must ensure that the multiple checklists eventually get combined into one. Improved clarification will be provided both in the checklists and in the Score + Store tool.
Some evaluators may not thoroughly understand the energy code language and/or requirements, and may misinterpret some code requirements.	Additional guidance will be added to DOE checklists for code requirements that were identified as unclear to evaluators. These questions arose primarily in residential studies.
An evaluator may see an installation at a building site that doesn't comply with the code, along with a correction notice from the building inspector stating that the non-compliant installation must be corrected.	Procedures need to clarify whether the evaluator should mark the item as compliant (assuming it will be fixed) or non-compliant.
An evaluator reviews the inspection card in the building department that states that the non-compliant installation has been corrected and is now compliant. The evaluator doesn't actually view the corrected installation first-hand.	Procedures need to clarify if this item should be marked as compliant (with a note in the comment section stating that it has been corrected) or non-compliant (because the original installation that they saw in the field was non-compliant).
Some above-code programs or software approaches correlate to different paths by which code compliance can be determined. For example, COM*check* and RES*check* are mostly trade-off approaches. The checklists contain entries for software and code compliance approach used. In some cases, checklists stated that COM*check* or RES*check* were used, but they indicated a prescriptive approach. If the building is evaluated based on a prescriptive approach and yet trade-off documentation was submitted, the building could be incorrectly evaluated.	The compliance approach and software documentation submitted will be more closely linked and attempts will be made to clarify this in the tools. A validation might be added to the Score + Store tool flagging what appears to be an incorrect combination. From a QA perspective, if a trade-off or performance approach is indicated, an attempt should be made to collect a copy of the compliance documentation submitted to the building department.
If a prescriptive approach is indicated, one should verify that all checklist items marked as compliant have values that are actually at or better than code (where applicable).	Validation for this could be added to the Score + Store or Excel checklists used for collecting compliance data.

5.0 Evaluation of Alternative Compliance Evaluation Approaches

To date, several pilot studies have used procedures for measuring and tracking compliance that varied from the DOE recommendations described in *Measuring State Energy Code Compliance*. In all cases, the primary drivers for deviations from these procedures were cost and/or time considerations. In recognition that one size does not fit all, and in an effort to assist states in developing alternative annual measurement activities, DOE plans to develop additional procedures for the following alternative approaches:

- Post-construction evaluation
- Evaluation of a subset of compliance requirements
- Second-party evaluation
- Spot-check evaluation
- UA and performance compliance approaches.

DOE does not endorse the first three of these approaches as formal and complete code evaluations, as they do not encompass the entire code. However, DOE believes they can be useful approaches for meeting the goals of an annual measurement, for monitoring the current status of code compliance, for informing the state of critical issues that need to be addressed through training or policy changes, and for raising code awareness as part of the process.

5.1 Post-construction Evaluation and Evaluation of a Subset of Compliance Requirements

Post-construction evaluations are typically less costly, because onsite building evaluations would occur in a single visit rather than two to four visits during construction. This approach might also be more amenable for studies in rural areas, or areas not under jurisdictional control, since building owners could be contacted directly for the evaluation as opposed to going through a building department. The disadvantage to this approach, however, is that many of the code requirements are unverifiable at post-construction and, therefore, compliance for those items cannot be adequately determined. Approximately 58% of the residential checklist requirements and 23% of the commercial checklist requirements have been determined to be potentially difficult to evaluate post-construction. Additionally, self-selection of the most cooperative building owners and homeowners can create biased data.

Previous compliance evaluation studies have taken various approaches to address the problem of evaluating unverifiable code requirements. Some have assumed insulation levels based on stud depth, or that quality of insulation installation for hidden components would be the same as for insulation that could be inspected. The approach DOE anticipates suggesting will be to:

1. Rely heavily on testing procedures (blower door vs. visual inspection of air leakage, and possibly infrared for quality of insulation installation).
2. Choose to evaluate a subset of code requirements that can be visually inspected after construction instead of doing a complete code evaluation using the entire checklist.

The DOE scoring procedure assumes that each building is evaluated for the same set of code requirements. When a large majority of one code item is not included because it was not readily observed, the reported score can be biased and may not be valid for a complete 90% compliance study. A more appropriate approach might be to determine in advance which code items will be included, and ensure that those code requirements can be evaluated on a large majority of the buildings. For example, foundation insulation R-value, depth, and quality of installation are all code requirements that should be excluded from a post-construction study.

When using a post-construction evaluation, it should be determined in advance if the evaluation will include code requirements pertaining to plan review, and/or if the evaluators will be asked to pull plans from the building department as part of the evaluation. Plan reviews will typically be advantageous, as they will assist in verifying initial building compliance and determining more precisely what to look for during the inspection. However, it is important to note that even if a code requirement is verified as compliant during the plan review, it should be excluded from the generation of a compliance score if it is not visible during the post-construction inspection, as feedback from the pilot studies suggest that often times what is built does not exactly meet the plans.

Although not relevant to compliance with today's codes, which are confirmed when the certificate of occupancy is issued after final inspection, a post-construction evaluation can also identify the use or lack of use of controls or other building features. For instance, required dampers might be found wired open or lighting controls disengaged. This information is important to inform future code development and compliance initiatives, and may become more important as commissioning requirements are introduced into the code.

Since the post-construction guidelines will recommend a subset of code requirements, this same approach will be applicable to other studies where only a select number of code requirements are to be evaluated. For example, one pilot study in the Northwest focused only on the commercial lighting requirements. Other scenarios where a subset of code items might be evaluated include:

- The state has recently adopted a new code and wants to focus the study on just the new code requirements, such as duct blaster testing in the 2009 IECC.
- A previous evaluation showed that specific code requirements were the most often missed, and after subsequent training on those requirements, the state wants to re-assess compliance with those requirements.

DOE anticipates that scoring procedures for this approach would be identical to the existing approach defined in the guidelines, which assume the same basic set of requirements evaluated for each new building. When reporting state scores, results should be qualified as to the subset of code requirements included in the study.

5.2 Second-party Evaluation

As defined in Section 4.1 of *Measuring State Energy Code Compliance*, a third-party evaluator is one hired by the state or local agency to act on its behalf. A second-party evaluation could be done by building department staff within their own jurisdiction, and a first-party evaluation could be one where builders self-certify. These definitions are used in describing the approach proposed here.

The DOE procedures suggest using third-party evaluators. However, there are several advantages to using existing jurisdictional staff for evaluations in their own service area:

1. Building department staff are often already at the building sites. Travel to and from building sites is an expensive part of a third-party evaluation, and that additional cost could be largely eliminated.
2. Building department staff have authority to delay construction until an inspection is completed. A common problem with third-party evaluation, for example, is getting to the job site for a foundation inspection before backfill, or evaluating glazing before the labels are removed.
3. Since the approach is tied to the code officials' normal responsibilities, a potential exists to create larger sample sets more cost-effectively than with third-party evaluations. The volume of data collected could be substantially larger.
4. Onsite evaluations using the compliance checklists can be a great training aid for building inspectors and building owners/contractors.
5. Using second-party evaluators could be much more sustainable. Third-party evaluators are typically hired for a limited duration.

There are also several disadvantages to using building department staff to evaluate buildings in their own service area:

1. The job of jurisdictional staff is to ensure that any infraction they discover is fixed, and therefore all code infractions would tend to be fixed or not found. If an infraction is not fixed, there may be a reluctance to report it. Anything less than 100% compliance could reflect poorly on the jurisdictional staff, which may lead to a significant conflict of interest.
2. Many jurisdictions do not inspect energy code requirements, but even those that do typically will not inspect all items in the code let alone the DOE checklists.
3. This approach could not be used in locations where there are no building departments.

To address the disadvantages of a second-party evaluation, DOE anticipates suggesting that second-party evaluations focus on gathering data about common code infractions rather than data designed to determine a final compliance rate. In such an evaluation, the code official would report what infractions were found, and whether or not these were later fixed. Checklist data could also indicate whether or not the infraction was fixed, but that would not affect the scoring.

Under this scenario, the checklists would be modified to allow the code official to indicate what infractions are found, both in plan review and onsite inspections, and to later indicate if those infractions are fixed. The scoring would be based on the number of infractions caught, which might tend to make the scoring lower than with other approaches. Any reporting of that score would be qualified to clarify this point.

As with other approaches, jurisdictions with an interest in energy codes may be more cooperative than others, thus creating an inherent bias in the evaluation results. However, jurisdictions might be more cooperative if using their own staff instead of allowing a third-party evaluator access to their plans, processes, and building sites.

A second-party approach eliminates the difficulty of deciding how to score an infraction that is subsequently carded by the code official. This issue arose during the pilot study evaluations, and it was concluded that the infraction should be marked non-compliant unless the evaluator returned to the site to verify that the infraction was fixed. With second-party evaluations, this is a non-issue, as both the infraction and the subsequent fix are recorded.

While different from a third-party compliance measurement, a second-party approach recording infractions will inform the state of where the majority of code issues exist within the design and construction community. This approach will provide focused information and training for the jurisdictions, as well as the design and construction community, and can have a longer-term impact in raising code awareness and compliance.

5.3 Spot-check Evaluation

A spot-check evaluation is defined as an evaluation of buildings under construction to observe whatever code requirements are visible at the time of inspection. This approach will not guarantee an evaluation of the entire code for each building, but it can provide data on many code requirements. The main consideration in using a spot-check evaluation is that any attempt to provide an overall compliance rate would require an alternative approach for scoring and reporting results. DOE has not established this approach and would likely require a larger sample set, with metrics generated more like those proposed for renovations. Reporting of any scores may need to caveat the degree to which compliance with the entire code could be determined from the data.

5.4 Total-UA and Performance-based Compliance Approaches

Several state studies used software modeling in conjunction with the DOE checklist procedures to compare outcomes using the code's UA and performance approaches to the prescriptive approach and/or DOE procedures. An important consideration for states making these comparisons is the extent to which it wants to evaluate the entire code or just the code requirements that are part of the software approach. There are two benefits for incorporating modeling approaches into a compliance study:

1. A higher compliance rate may result if one assumes that some buildings submitted without documentation and which fail by a prescriptive evaluation might actually pass via a UA or performance approach. In this case, however, the building should lose some credit for not meeting the code requirement to provide documentation demonstrating compliance via those approaches. The lack of adequate compliance documentation for determining compliance has been repeatedly listed in the top three barriers to code compliance.
2. Performance modeling can be used to demonstrate the impact of non-compliant measures. The modeling approach, if combined with the mandatory checklist, might yield a better understanding of the actual performance of a building and provide additional insight into the impacts of the infractions. However, conclusions based on modeling can be misleading, especially in commercial buildings, where the impact of a single code requirement might be small in one building and large in another.

Several mandatory code requirements are not actually evaluated directly in the UA and performance analysis, although they are typically still considered code requirements. As an example, if RES*check* or COM*check* software is used for computing compliance based on the UA compliance approach, there are

several mandatory and prescriptive code requirements listed on the RES*check* and/or COM*check* report that are not part of the UA calculation. The signature line in the RES*check*/COM*check* reports specifically notes these mandatory requirements:

> *Compliance Statement: The proposed building design described here is consistent with the building plans, specifications, and other calculations submitted with the permit application. The proposed building has been designed to meet the 2009 IECC requirements in REScheck Version 4.4.0* ***and to comply with the mandatory requirements listed in the REScheck Inspection Checklist****.*

Even if the building is modeled using simulation software under the code's performance approach, there are mandatory code requirements that cannot be incorporated into the modeling software. For this reason, the results of a procedure such as that proposed by DOE are not directly comparable to results given by UA or performance software unless these additional requirements are incorporated. One of two approaches would need to be considered for the results to be compared:

1. A methodology could be used to generate an integrated score accounting for the code requirements that were not directly included in the software modeling result.
2. The comparison could be based on only a subset of code requirements, where the software results were compared only to the code requirements included as part of the software modeling.

In the latter case, and using RES*check* as an example, approximately 28% of the code requirements on the DOE checklist could be considered as part of a RES*check* UA compliance result. RES*check* does not include any concept of quality of insulation installation, duct insulation levels, or air leakage rates, to name a few of the non-covered requirements. Because the DOE checklist procedure encompasses a UA or performance approach, the results for a building that submitted a RES*check* or COM*check* report when permitted should be identical to the results of the DOE procedures if the additional mandatory requirements are considered. The results could potentially be different for a building that did not submit compliance via a UA approach, but was evaluated based on a UA approach, because that building would be rated under a prescriptive approach according to the DOE procedures.

While a performance approach may incorporate additional code requirements, the codes specifically list mandatory requirements that must also be met. For residential, these requirements include submission of documentation, a posted certificate, air leakage sealing requirements, mechanical controls, duct sealing, and mechanical pipe insulation. There have been fewer studies designed to demonstrate commercial building compliance using the performance approach based on simulation, because model development is extremely expensive for commercial buildings. The New York study used generic prototype models (as opposed to models representing each building's actual geometry) to evaluate impacts of various code requirements.

DOE anticipates evaluating ways that UA and performance modeling approaches might be used to determine overall compliance rates, in a manner that is comparable with their existing procedures. A building checklist covering the non-modeled requirements could be completed, much as it would for other approaches. The checklist would identify which checklist items were to be used as input to the modeling approach, and which were mandatory requirements to be evaluated on a pass/fail basis. The software tool could be used to produce a compliance percentage, and the mandatory checklist items could be scored as usual (the points passed divided by the points available), but based only on those checklist items that were not modeled in the software. The two scores (modeling and mandatory checklist) could then be combined.

6.0 Conclusion

The DOE procedures were developed for measuring and reporting an estimate of a state-wide rate of compliance with the adopted energy code. Many of the states' final reports provide more detailed statements related to compliance, such as identifying the most common code infractions. Care should be taken in interpreting these results to ensure an understanding of what is being reported. For example, the slab insulation rates for one study were reported as very low, but only 14 out of 44 buildings were constructed with slab foundations, a small sample size to work with.

It is important to acknowledge that the studies occurred during a period of time not favorable for evaluating new construction, as the housing market was still suffering from the economic downturn, and construction starts were low in most parts of the country. In many states the study was conducted during a time of transition to the 2009 IECC; some had not yet finalized adoption of the updated energy codes, and others had so recently updated them that they were not yet fully implemented in all jurisdictions. Study implementers enacted creative solutions to overcome such challenges, which may have biased the final compliance score derived in each state.

The cost of evaluating a statistically valid sample and conducting a study in all four building populations may be prohibitive for states without financial support, and is made even more difficult given current economic conditions. Beyond costs, the ability to measure compliance in renovations will further be challenged by the lack of adequate data needed to generate a representative sample of buildings for evaluation. Finally, the format of the energy code and the subjectivity of its provisions can introduce bias and make consistent measurements difficult to obtain. This last challenge can be partially addressed by using the feedback received from pilot study participants to improve DOE procedures and tools. The compliance pilot studies varied in their rigor, and should not be interpreted to represent compliance rates nationally. As an example, not all studies for new residential construction included multi-family dwellings. Several sources of potential bias were identified in these initial studies:

- Jurisdictions are often non-responsive and/or non-cooperative with respect to facilitating building entry for inspection and/or access to plans and specifications to the point that a purely random sample set may have to be altered. Assuming that the most cooperative jurisdictions are more active in enforcing code compliance, one might assume that the samples taken from the non-responsive jurisdictions are more likely to yield a lower compliance rate.
- For post-construction studies, there is also a self-selection bias introduced in gaining access to the building. The building owners willing to allow an onsite evaluation of their home or commercial building are probably those more interested in energy savings and willing to tolerate the inconvenience.
- Even the states selected for the pilot studies and other states that have implemented their own represent a bias favoring higher compliance rates. Many of the states responding to the DOE opportunity have a history of active involvement in energy code advancement.

One general finding was that the documentation needed for determining code compliance was sometimes unavailable from the building department. Another was that the use of a trade-off or performance approach, and the corresponding software products typically used for those approaches, appears to be correlated with higher compliance. While the use of these approaches does not guarantee

compliance of the final building, it does provide documentation of compliance and implies some level of understanding of code requirements on behalf of the submitter.

Only a handful of code compliance evaluations were done for renovations, and no results were reported due to the small number of samples evaluated in those building populations. Residential renovations, in particular, will be very difficult to evaluate because many renovations are completed without pulling a permit, and accurate data sources for sampling and locating samples are not available. The New York study states that the number of renovations requiring a permit each year exceeds the number of new residential buildings constructed, but that only 6% of all residential permits listed in the Dodge residential permit data set were for renovations. In the commercial data set, commercial renovations make up 50% of the listings.

It is also important to acknowledge that a state's structure of oversight of energy code compliance can impact the ability of evaluators to carry out the study. Some states have a strong culture of home-rule; others an environment where builders self-certify compliance; still others have an organized system rooted in state-level code enforcement. For example, in Montana, where two-thirds of builders self-certify compliance, evaluators had great difficulty identifying and gaining access to buildings for the study. This enforcement structure and the difficulties encountered contrast to the experience of evaluators in Wisconsin, where construction codes are uniform statewide and largely already enforced by state staff (and municipalities authorized by the state to enforce). In Wisconsin, soliciting study participants was not an issue.

The pilot study project was an initial attempt to assess the DOE procedures and resources for evaluating energy code compliance rates in states. However, in order to stay within the timeframe desired by DOE, several participants were allowed the flexibility to create individual programs for measuring a state's progress toward 90 percent compliance using various modifications of the DOE recommended methodologies. As a result, the scores determined by the pilot studies cannot be interpreted to represent compliance rates at national, state, or local levels. Within the state studies, results varied considerably, depending on which analysis methodology was used to report the final results. In addition, deviations from the DOE procedures make comparison of results between states impossible and make it difficult to identify trends nationally.

While the Compliance Pilot Studies did not generate consistent energy code compliance rates nationwide, they did have a positive impact on future compliance activities. During the completion of these studies, states increased dialogue with local jurisdictions, educated and heightened the awareness about energy codes to building departments, and helped identify and execute training needs. The studies provided a platform for increasing knowledge about energy code compliance activities across the state on the local level. A greater understanding at this level can help inform policy-makers as they consider ways to improve the status and procedures of energy code compliance in their states.

Appendix A

Opportunity Notice

Appendix A Opportunity Notice

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BUILDING TECHNOLOGIES PROGRAM

90% Compliance Pilot Studies

You are invited to submit a Statement of Interest

The Department of Energy's Building Energy Codes Program (BECP) is announcing an opportunity for states to participate and collaborate in Energy Code Compliance Evaluation Pilot Studies. Late last year, state governors sent letters of assurance regarding energy codes to the Secretary of Energy. A number of states are following up on these letters by beginning to develop plans to measure compliance with their codes (based on the 2009 International Energy Conservation Code [2009 IECC] for residential buildings and the ANSI/ ASHRAE/IESNA Standard 90.1–2007 [ASHRAE 90.1-2007] for commercial buildings, or equivalent codes). They are also developing plans to achieve 90% compliance with these target codes within eight years, and to conduct an annual measurement of the rate of compliance. In order to assist states with these efforts, BECP is providing many forms of support, including proposed methodologies and tools that states may use to measure energy code compliance.

"Over the next year, BECP and the five national energy efficiency partnerships (EEPs) will be funding five to six statewide energy code compliance evaluation pilot studies..."

BECP has developed a detailed approach that states may use to measure building energy code compliance. This approach—a free benefit to states—will benefit from the on-the-ground testing afforded by pilot studies in participating states.

Over the next year, BECP and the five national energy efficiency partnerships (EEPs) will be funding five to six statewide energy code compliance evaluation pilot studies designed to measure code compliance based on the methodologies and tools BECP has developed. The pilot studies are intended to help states in their compliance efforts, while at the same time providing valuable insight into the effectiveness of these tools and suggestions for their improvement.

The pilot studies will be implemented over a 10-month period, with final reports from the studies being due to BECP in April 2011. For the studies, BECP is seeking states that are willing to:

- implement the studies in this time frame
- collaborate and communicate with BECP and their EEP in the design, development, and deployment of the pilot study
- work with a broad group of stakeholders in the state.

BECP will be working with the five EEPs to identify states that respond to this notice and meet the criteria for selection. As such, responses indicating interest in this opportunity should be sent to the appropriate EEP with a copy to BECP, as instructed on page 2 of this notice. States that are not directly associated with one of these five organizations may also apply, and should send a statement of interest directly to BECP.

Please continue reading to find pilot study details and how your state can respond.

continued >

BUILDING TECHNOLOGIES PROGRAM

Benefits to States

The pilot studies are not assumed to be full state evaluations. States may choose to evaluate a single building population (such as new commercial construction only), or a smaller sample than is recommended for a full evaluation. These smaller studies may provide participating states and jurisdictions with the following:

- comprehensive energy code training and identification of additional training needs
- technical assistance in implementing a code compliance evaluation
- initial feedback on compliance rates in the state.

Materials Available

BECP has developed the following tools which will be used during the pilot studies:

- a complete suite of training materials on the 2009 IECC and ASHRAE 90.1 – 2007
- guidance on manning and certifying a workforce for code compliance evaluations
- methodologies for conducting a compliance evaluation and for measuring the results, including:
  - » development of statistically valid evaluation samples
  - » evaluation checklists to be used for the onsite evaluations
  - » derivation of overall state metrics based on the onsite evaluations.

These materials are available at no cost. Additional online tools will be made available during the study period.

How to Respond

At this time, states are encouraged to submit a short statement of interest demonstrating an understanding of the goals and objectives of the pilot study and the state's ability to meet the expectations of the study. It is understood that this notice does not provide full details, such as detailed selection criteria, funding amount, and detailed scope. Responding positively with this initial statement of interest in no way obligates a state to participate. More formal proposals for participation in the pilot studies will be developed in collaboration with the EEPs during April 2010, with final selection occurring in late April. The EEPs will contact states with more details. Additional information, including detailed selection criteria, is available online at: http://www.energycodes.gov/news/arra/pilot_studies.stm. Statements of interest must be returned to the appropriate EEP with a copy to BECP no later than April 9th, 2010. States not affiliated with an EEP should submit their letters of interest directly to BECP. Submissions should be e-mailed to the following contacts, as appropriate:

Building Energy Codes Program: rosemarie.bartlett@pnl.gov

Energy Efficiency Partnerships:

Midwest Energy Efficiency Alliance (MEEA)	ielnecave@mwalliance.org
Northeast Energy Efficiency Partnerships (NEEP)	dvigneau@neep.org
Northwest Energy Efficiency Alliance (NEEA)	dcohan@nwalliance.org
Southeast Energy Efficiency Alliance (SEEA)	ben@seaalliance.org
Southwest Energy Efficiency Project (SWEEP)	jmeyers@swenergy.org

Pilot Study Objectives

BECP hopes to gain information from the studies that can aid in the refinement of these tools and materials, including:

- lessons learned and feedback on BECP methodologies and tools
- data from the evaluation checklist
- information on the logistics of evaluating large commercial buildings
- an increased understanding of the time required to complete a single building evaluation
- identification of additional tools and materials that would further assist the states in energy code enforcement and compliance.

Expectations of States

Participating states will be expected to:

- use the BECP methodologies, checklists, and materials for evaluating compliance and/or training efforts
- provide resulting evaluation data to BECP for analysis
- provide reports summarizing lessons learned and containing suggested improvements to the methodologies and materials developed by BECP.

If further questions remain, please do not hesitate to contact BECP's Rose Bartlett at rosemarie.bartlett@pnl.gov.

Building Energy Codes
U.S. Department of Energy

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

EERE Information Center
1-877-EERE-INF (1-877-337-3463)
www.eere.energy.gov/informationcenter

PNNL-SA-71704

Appendix B

Selection Criteria for Pilot Studies

Appendix B

Selection Criteria for Pilot Studies

The following material describing the pilot study opportunity was provided to the states in, addition to Appendix A of this report, to describe the selection criteria for states wishing to participate in the Compliance Pilot Study Program.

The Building Energy Codes Program (BECP) has developed materials, procedures and tools for state and local governments and their agents to use for measuring and reporting energy code compliance rates. DOE and the five Energy Efficiency Partnerships1 (EEPs)[15] will be funding five to six statewide energy code compliance evaluation pilot studies designed to measure code compliance based on these methodologies and tools. The following criteria will be used in the final selection of states to participate in these studies. All state proposals, developed under collaboration with the EEPs or independently in the case of states not aligned with an EEP, will be evaluated based on the degree to which their proposals demonstrate an effective test of the DOE materials and to adhere to the following criteria and conditions.

B.1 Selection Criteria

Project Plan. The state proposals should include a project plan with clearly defined goals aligned with the DOE pilot study objectives, which were identified in the initial Opportunity Notice sent to states, elaborated on in the Statement of Work provided to the EEPs, and included in the list of selection criteria (this document). The plan will describe how the pilot study will be designed and conducted, including identification of the state's goals for the pilot study and the milestones established to meet those goals. The plan should further identify how the activities will benefit the state in improving energy code training, enforcement, and compliance. The plan should identify how the state intends to use the DOE-developed training and code compliance evaluation materials and tools.

Reporting. The state, directly or through a designated representative of their project team, will report the progress of the study on a monthly basis to DOE. The state proposal will identify report and data deliverables that include the following components:

- A summarization of lessons learned in using the DOE materials and tools.
- Evaluation times for individual buildings from any of the four sample populations, including the number of trips required to the building site(s) for each sample.
- Identification of where the DOE materials are not practical and suggested improvements to them.
- Where procedures deviate from the DOE guidelines, the report should include reasons why.
- Feedback from the evaluators on where they felt adequately trained and prepared, and where they recommend additional training and/or instructions.

[15] EEPs include the Northeast Energy Efficiency Partnerships (NEEP), the Southeast Energy Efficiency Alliance (SEEA), the Midwest Energy Efficiency Alliance (MEEA), the Southwest Energy Efficiency Project (SWEEP), and the Northwest Energy Efficiency Alliance (NEEA). Since the writing of this "Selections Criteria for State Energy Code Compliance Pilot Studies" the term "EEP" has changed to "Regional Energy Efficiency Organization" (REEO).

- Feedback on pulling the building sample sets, including suggested changes in the jurisdictional record keeping processes (e.g. what information was needed but not readily available).
- The evaluation checklists and/or data collected from evaluation checklists will be provided back to DOE for analysis at the end of the study.

Project Team. Due to the short timeframe in which the states will be selected and asked to develop proposals for the pilot studies, it is doubtful a full project team can be identified and their services officially secured prior to developing the state proposal. However, states should identify potential project teams that the states would consider qualified to plan, conduct and implement a pilot study and which are able to represent state and local entities critical to code implementation and enforcement.

Project Schedule. The proposal will include a statement committing to the completion of the project by March 2011, and submission of a final report by April 2011. The deliverable due date for the final report is set by Recovery Act requirements and stipulated by the funding mechanism associated with the state pilot studies.

Collaboration. The state's proposal should demonstrate a willingness to collaborate and communicate with DOE staff (and others as directed by DOE), and the EEPs in the design, development, and deployment of the pilot study plan. The state will allow DOE/EEP staff to participate and act in an advisory capacity, and will coordinate with DOE/EEPs at key milestones in the study.

End User Participation. The state should demonstrate that a pilot study can be successful implemented in the state by identifying stakeholders that the state and/or the project team plans to involve in the project and the degree to which they will be involved. Organizations such as chapters of the International Code Council, State AIA Chapter, ASHRAE Chapters, Chapters of the Associated General Contractors, and/or Homebuilders Associations are examples of such stakeholders.

Project Cost Share. While not a requirement for state participation, a state's commitment of staff time, resources or funding toward the successful completion of the pilot study is encouraged.

Varying State Scenarios. DOE is interested in pilot testing the code compliance evaluation materials in states with varying code adoption and enforcement policies, some of which are listed at the end of this document. DOE will attempt to select states from these varying categories. Additionally, it is hoped that the studies will vary in their approaches and in the sample populations evaluated. Several example pilots are described below along with the varying information that could be collected from these different studies. The state's proposal should include mention of the state classification and what additional information could be gleaned from the project.

B.2 State Code Adoption and Enforcement Scenarios

B.2.1 State Adoption/Enforcement Style

1. Mandatory: Code is adopted by state and locals are required to adopt and enforce it without modification. Example: Virginia.

2. Modified Mandatory: State adopts a mandatory code. Locals can adopt and make amendments that do not lessen the stringency. Locals can also choose not to adopt or enforcement. Examples include South Carolina and Maryland.
3. Voluntary: State has a voluntary code and there is no clear responsibility of who adopts and enforces it.

B.2.2 State Code Options

1. Target Codes: State has adopted the 2009 International Energy Conservation Code (2009 IECC) for residential buildings, and either the ANSI/ASHRAE/IESNA Standard 90.1–2007 (90.1-2007) or 2009 IECC Chapter 5 for commercial buildings.
2. Earlier Code: State has adopted IECC and/or 90.1 codes that are earlier than the target codes. Codes older than the 2006 IECC or 90.1-2004 are not considered viable for the study.
3. Modified Code: The code is based on the target codes but with modifications. There are three sub-categories
    a. Modifies target codes and resulting code is deemed to meet or exceed the target codes.
    b. Modified target codes and resulting code does not meet or exceed the target codes.
    c. Modified earlier codes.
4. State Developed Code: The state has its own codes which are not based on the national codes. Example is California.

B.2.3 Example State Pilots

The pilot studies could be used to gain insight into a variety of compliance evaluation factors. The following list contains suggestions for evaluation pilot studies that could provide some of these insights. This list is not exhaustive - there are many other beneficial activities that could be pursued and would be considered equally valid in selecting states for this activity.

1. Some pilot studies could use 3rd party consultants to perform the evaluations and others could use building jurisdictional staff (e.g. the self-assessment approach mentioned in DOE materials).
2. While most states will probably want to evaluate only Tier 1 items on the commercial code checklists, DOE is interested in at least one pilot using the full code checklists, which would provide estimates of the level of effort for each approach. Alternatively, a small set of the evaluations within one or more pilots could use the full checklist. Either approach could help identify the additional effort required to evaluate all checklist items vs. just Tier 1 items.
3. Pilot studies may choose smaller sample sets than required for a formal evaluation. Alternatively, the pilot study could evaluate a statistically valid sample set of only one of the four sample populations defined in the DOE methodologies (new residential construction, new commercial construction, residential renovations, or commercial renovations). For example a pilot study could evaluate new residential buildings only or evaluate commercial building renovations only. Of particular interest will be information on the logistics associated with evaluating large commercial buildings.

4. Alternative training techniques could be used in the pilot studies, including pilots where the evaluators must watch a webcast on how to use the checklists vs. pilots where the evaluators only use the instructions that accompany the checklists.
5. It is hoped that both jurisdictions with electronic permitting systems and jurisdictions without such systems will be included.
6. While measurement will be based on the checklists, DOE would like to support an approach that allowed compliance software to be used. Some pilots may wish to have the gathered data input into software products, such as REScheck, COMcheck, or HERS rating software in order to compare prescriptive results against trade-off, performance, and/or above-code measures.
7. Pilots may include corrective training activities. If a small number of buildings are evaluated and the same, repeated code infractions become apparent, there is an opportunity to attempt various training approaches in the jurisdictions to evaluate which approaches are most successful.

Appendix C

State Survey Results

Appendix C

State Survey Results

Additional insights were afforded by the jurisdictional surveys implemented as part of the Georgia and Utah pilot studies. Jurisdictional survey data from Georgia and Utah has been aggregated in Table C.1and Table C.2. Table C.1 contains averages of the state responses and Table C.2 contains aggregate total responses. The Georgia jurisdictions submitted 103 responses, and the Utah jurisdictions submitted 27 responses.

Table C.1. Jurisdictional Survey Data for Georgia and Utah (Averages)

Survey Question	Georgia Responses (103 Total)	Utah Responses (27 Total)	Combined Responses (130 Total)
During the previous calendar year, how many residential building permits were issued by your agency?	67 avg (6,870 total)	298 avg (8,039 total)	183 avg (14,909 total)
During the previous calendar year, how many commercial building permits were issued by your agency?	182 avg (18,701 total)	450 avg (12,160 total)	316 avg (30,861 total)
What methods are used as a basis for documenting residential energy code compliance?			
Prescriptive	40%	24%	32%
Trade-off	20%	61%	41%
Performance	8%	15%	12%
What methods are used as a basis for documenting commercial energy code compliance?			
Prescriptive	32%	23%	28%
Trade-off	26%	57%	42%
Performance	9%	16%	13%
How many hours are devoted to the average residential plan review for energy codes?	1.7 hrs	1.1 hrs	1.4 hrs
How many hours are devoted to the average commercial plan review for energy codes?	1.8 hrs	1.9 hrs	1.9 hrs
How many hours are devoted to the average residential field inspection for energy codes?	2.1 hrs	1.1 hrs	1.6 hrs
How many hours are devoted to the average commercial field inspection for energy codes?	2.0 hrs	3.0 hrs	2.5 hrs

Table C.2. Jurisdictional Survey Data for Georgia and Utah (Aggregate Totals)

Survey Question	Georgia Responses (103 Total)	Utah Responses (27 Total)	Combined Responses (130 Total)
How is your agency funded?			
Permitting Revenue	49	14	63
Jurisdictional Budget	82	22	104
State Funded	0	0	0
Other	7	0	7
Who conducts plan reviews for energy code compliance?			
In-house staff	72	24	96
Third-party entities	13	3	16
Other jurisdictions or government agencies	4	0	4
Not done	21	1	22
Other	5	0	5
Who conducts field inspections for energy code compliance?			
In-house staff	85	25	110
Third-party entities	15	5	20
Other jurisdictions or government agencies	5	0	5
Not done	9	2	11
Other	3	0	3
What level of education and training does your agency staff receive specifically for residential energy codes?			
Professional certification and annual training	18	12	30
Periodic formal training	40	12	52
On-the-job training, but seldom formal training	25	3	28
Training not provided	17	0	17
No answer	3	0	3
What level of education and training does your agency staff receive specifically for commercial energy codes?			
Professional certification and annual training	14	12	26
Periodic formal training	37	10	47
On-the-job training, but seldom formal training	21	3	24
Training not provided	18	0	18
No answer	13	2	15
How would you prefer to receive training?			
Webinar/Online	43	10	53
Classroom	88	23	111
In the field	37	12	49
Other	4	0	4
What format does your agency use to maintain permitting data?			
Paper	77	20	97
Digital	60	14	74

Survey Question	Georgia Responses (103 Total)	Utah Responses (27 Total)	Combined Responses (130 Total)
Other	4	27	31
How many years does your agency maintain permitting data?			
1-2 years	0	2	2
3-5 years	18	0	18
6-7 years	17	5	22
More than 7 years	63	20	83
No answer	5	0	5
What limitations impede your ability to enforce the residential energy code?			
Time or staff	48	12	60
Money	41	9	50
Code books	9	1	10
Education or training	56	16	72
Data provided with plans	42	15	57
Building access	0	0	0
Equipment	24	6	30
Not applicable	14	3	17
Other	4	3	7
What limitations impede your ability to enforce the commercial energy code?			
Time or staff	52	11	63
Money	40	9	49
Code books	8	2	10
Education or training	57	15	72
Data provided with plans	42	13	55
Building access	0	1	1
Equipment	23	7	30
Not applicable	13	3	16
Other	4	3	7
In your jurisdiction, what plan review and/or inspection items do you generally find do not comply with the residential building code?			
Envelope insulation levels	20	8	28
Envelope insulation installation	33	13	46
Envelope sealing (infiltration)	54	16	70
Fenestration	11	10	21
Duct insulation	12	10	22
Duct sealing	42	8	50
Piping insulation	28	3	31
Lighting fixtures	31	2	33
Other	3	15	18

Survey Question	Georgia Responses (103 Total)	Utah Responses (27 Total)	Combined Responses (130 Total)
In your jurisdiction, what plan review and/or inspection items do you generally find do not comply with the commercial building code?			
Envelope insulation levels	17	6	23
Envelope insulation installation	28	10	38
Envelope sealing (infiltration)	46	15	61
Fenestration	13	16	29
Duct insulation	14	6	20
Duct sealing	37	11	48
Piping insulation	23	7	30
Lighting fixtures	30	14	44
Lighting controls	30	16	46
HVAC system controls	21	12	33
Other	6	1	7
Does the energy plan review and inspection cover all aspects of the energy code?			
Yes	71	20	91
No	14	5	19
No answer	18	2	20
What information is available to your staff during field inspection?			
Approved plans	68	25	93
Energy code compliance checklists	39	15	54
Published energy codes and/or standards	60	18	78
Other	4	2	6
Do you accept software compliance reports submitted with permit applications in lieu of a plan review?			
Yes	38	9	47
No	33	15	48
Not applicable	24	2	26
No answer	8	1	9
What information is typically missing from residential plans, specifications, and/or actual construction that prevents you from determining compliance?			
Fenestration and/or glazing details	6	4	10
HVAC load calculations	5	1	6
Energy compliance documentation	5	7	12
Envelope insulation levels	4	1	5
Envelope sealing	3	0	3
Lighting and lighting control specs	3	1	4
Roof details	2	0	2
Duct insulation/sealing	1	1	2
Door details	1	0	1
Piping details	1	1	2
Approved plans	0	1	1

Survey Question	Georgia Responses (103 Total)	Utah Responses (27 Total)	Combined Responses (130 Total)
Wrong assumptions	0	1	1
Nothing or no/unclear information provided	20	2	22
What information is typically missing from commercial plans, specifications, and/or actual construction that prevents you from determining compliance?			
Energy compliance documentation	10	3	13
Insulation details	8	2	10
Inadequate plans	6	2	8
Fenestration details	6	1	7
HVAC details	4	2	6
Manual J calculations	0	5	5
Door details	3	0	3
Envelope sealing	3	0	3
Lighting details	2	0	2
Duct sealing/insulation	2	3	5
Incorrect data/calculations/assumptions	2	2	4
Footing size	1	0	1
Floor and ceiling joist sizes	1	0	1
Piping details	1	1	2
Nothing or no/unclear information provided	12	4	16
What software and/or other information technologies do you use to facilitate plan reviews, inspection processes, record-keeping, and communication with permitees?			
RES*check*	7	5	12
COM*check*	7	4	11
EnerGov Solutions	5	0	5
MS Office	3	3	6
Blue Prince	2	0	2
MUNIS	1	0	1
Innovative Technologies Outfitters	1	0	1
Black Bear	1	0	1
Selectron IVR	1	0	1
Code Coach	1	0	1
Permits Plus from Accela	1	1	2
Twin 32	1	1	2
Right Soft for checking Manual J calculations	0	1	1
EDEN database software	0	2	2
Citizen Serve for inspection results	0	1	1
1-Quest	0	1	1
In-house permitting software (Kelly)	1	0	1
None or no information provided	80	18	98

Further insights can be gleaned by including data from the Northwest Jurisdictional Survey Study. Table 3.5 shows how many jurisdictions participated from the four Northwest states and the data collection methods used. Figure C.1, Figure C.2, and Figure C.3contain combined jurisdictional survey results for Georgia, Utah, Washington, Oregon, Idaho, and Montana. Figure C.1 identifies the key impediments to enforcing both the residential and commercial energy codes. Figure C.2 and Figure C.3 show the most commonly found non-compliant residential and commercial energy code requirements, respectively.

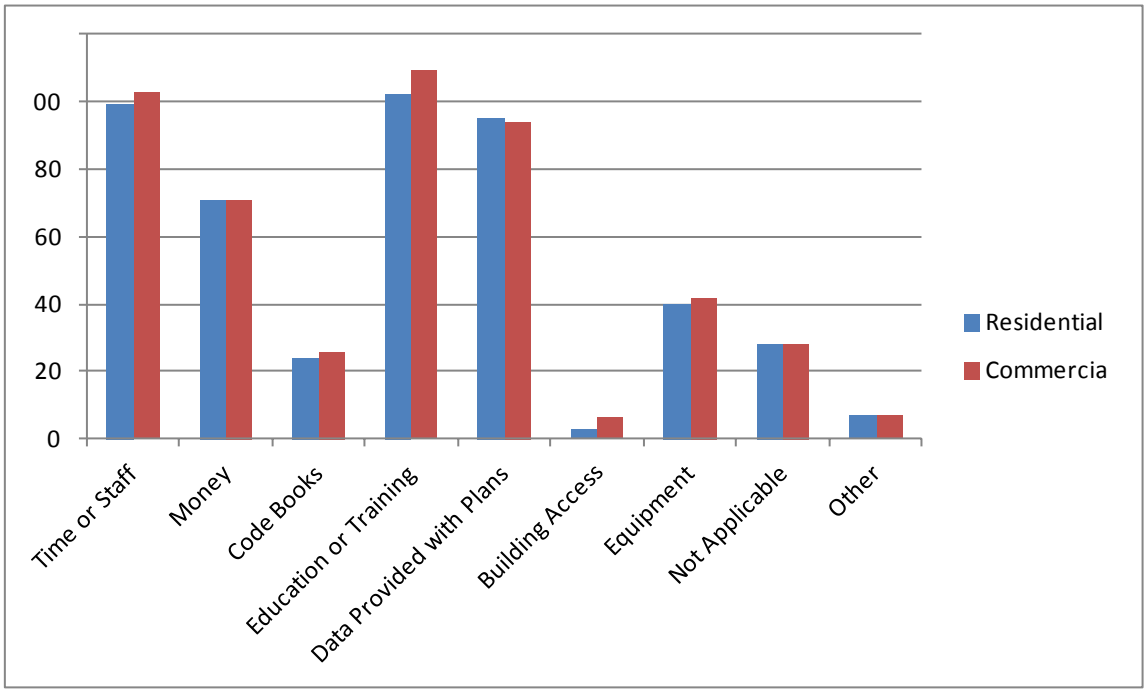

Figure C.1. Impediments to Enforcing the Energy Code

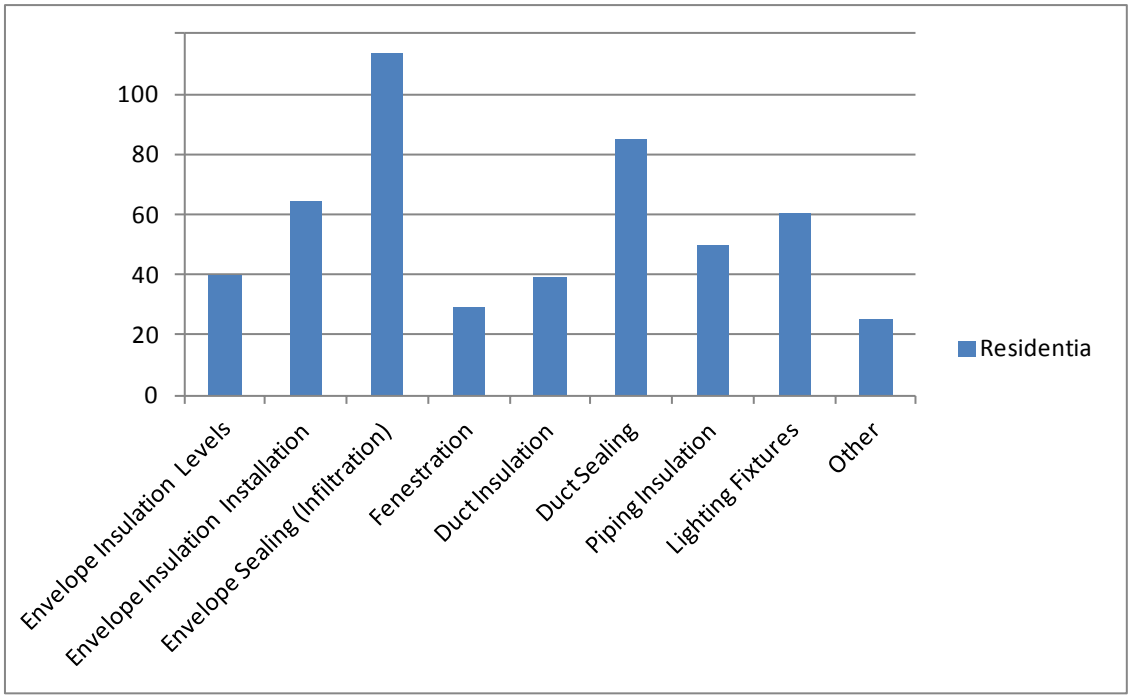

Figure C.2. Most Commonly Found Non-Compliant Residential Energy Code Requirements

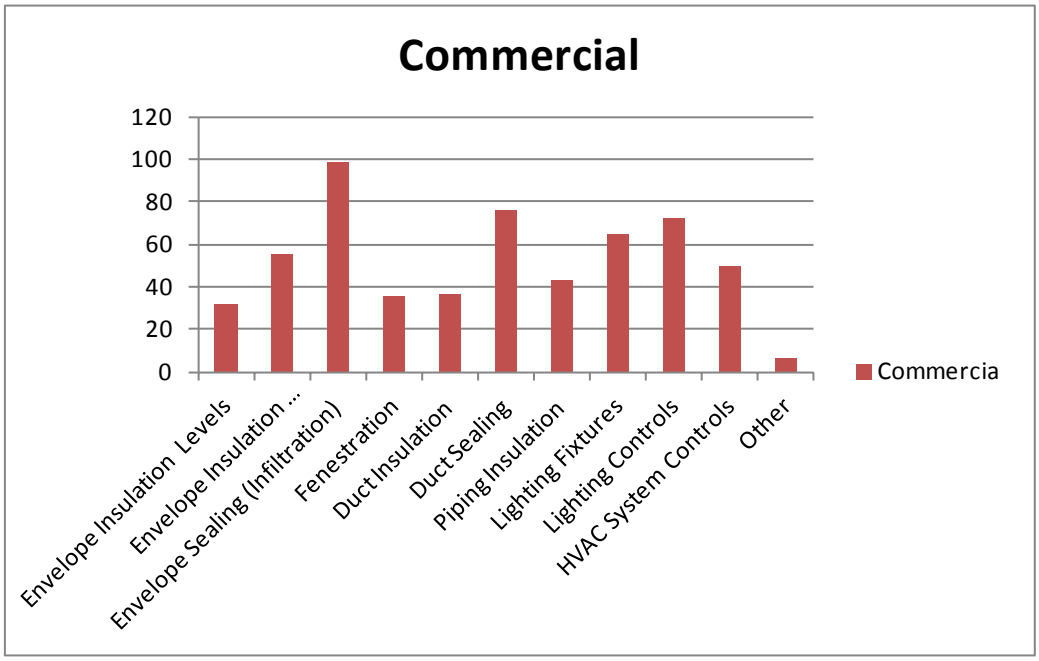

Figure C.3. Most Commonly Found Non-Compliant Commercial Energy Code Requirements

Appendix D

Observations from Other State Studies

Appendix D

Observations from Other State Studies

D.1 New York

In 2010, the New York State Energy Research and Development Authority (NYSERDA) conducted an assessment of the rate and nature of New York's compliance with the 2007 New York State Energy Conservation Construction Code for residential buildings, and ASHRAE 90.1-2004 or 90.1-2007 for commercial buildings (depending on the code in effect when the building permit was issued). Their study involved a comprehensive, state-wide assessment of code compliance for both new commercial and new residential construction, using DOE procedures and tools as well as other methods for determining compliance, including Trade-Off and Annual Energy Cost calculations. The study also included surveys and interviews of builders and contractors, designers, engineers, code officials, and homeowners. Energy code compliance for new residential buildings (including multi-family buildings) was estimated at 67% based on 44 samples, and 83% based on 26 new commercial buildings. As part of the study, New York also evaluated 26 new commercial buildings. The New York report represents these values at a computed 95% upper confidence level (73% and 85% respectively). All other state scores included in this document are reported as raw scores (without the confidence level included).

The New York study was similar to the Massachusetts study in that it evaluated residential homes post-construction. However, unlike the Massachusetts study, the New York building departments were involved, plans were pulled, and plan review was included as part of the study. Another difference was that the New York study eliminated ENERGY STAR homes from the sample set. (The percentage of ENERGY STAR homes in New York State in 2010 was 23%.) The New York study team made a strong effort to select buildings to be evaluated from a completely random sample set, but lack of cooperation from various building departments from which samples were drawn made this goal impossible. The level of effort to access non-cooperative jurisdictions far exceeded the team's original estimates, and failure to gain access in all cases introduced potential bias to the study results. Efforts to recruit buildings in order to make the study more statistically valid included offering small monetary incentives, which included $100 in the residential sector and $150 in the commercial sector. Where access to jurisdictions was an issue, the New York study team used other sources to identify candidate buildings, including cross-referencing tax rolls, property sales, and Google searches. Even these measures were not deemed enough to overcome the self-selection bias that was introduced in gaining access to an already constructed building. An introductory letter from NYSERDA was very helpful in recruiting commercial buildings for evaluation. Additionally, an email from the New York Department of State, the agency responsible for promulgation of the state building code, to local code officials helped to gain their cooperation. This type of written introductory communication to building owners and code officials was considered an essential step in recruitment of local government to assist with securing candidate buildings.

In addition to deriving a compliance result using DOE procedures, New York performed trade-off (UA) calculations for both residential and commercial buildings (using RES*check* and COM*check* respectively), and also conducted an annual energy performance simulation assessment of the buildings using REM/Rate for residential, and eQuest for commercial. For simulating commercial buildings, a standard set of building models of varying sizes was used, as opposed to developing models based on

each building's geometry and characteristics. These models were also used to help determine the energy impacts associated with certain non-compliant energy code requirements. It should be noted that the trade-off and simulated performance approaches did not take into account all code requirements, but instead only looked at the requirements that could be addressed in the software. See the "Total-UA and Performance-based Compliance Approaches" section of this document for a discussion of the use of trade-off and performance software in more detail.

In the commercial sector, the New York study found lower compliance rates for smaller buildings compared to larger buildings. However, the sample size was small (26 buildings) and this result was not supported by the combined data from the Georgia and Wisconsin pilot studies, both of which evaluated commercial buildings. DOE procedures recommend a larger sample size for New York than 44 small, medium, and large buildings. The Sample Generator tool indicates that New York should also evaluate seven X-large (250,000 ft^2 - 400,000 ft^2) and seven XX-large (>400,000 ft^2) buildings based on previous years' construction.

D.1.1 Time to Evaluate

Residential home inspections were done in 2-3 hours. Homes with duct systems required two technicians to complete the inspection in the time allotted due to the need to conduct a leakage test of the duct system (i.e., blower door and duct blaster tests).

D.1.2 Survey Results

New York received a total of 179 surveys from local code officials, which were designed to determine the extent to which plans were reviewed and buildings inspected for energy code compliance. The findings from these surveys included:

- Code officials evaluated the installed insulation levels and quality of insulation installation in the building envelope, but did not consistently check for compliance with additional code requirements.
- Inspections averaged 100 minutes on each residential building, and 200 minutes on each commercial building. However, these averages are skewed upward by a few respondents who reported very long times.
- Code officials cite lack of contractor knowledge as a major impediment to compliance.
- New requirements, such as duct sealing and HVAC loads calculations, are seldom implemented.

Builders surveyed reported that they felt plans were reviewed often by local compliance code officials, but actual inspections for compliance with the energy code requirements were less frequent. About 44% of the surveyed builders reported using the HERS performance path, and about 44% reported using RES*check*.

Findings on a separate survey addressing residential renovations indicated that a majority of homeowners and/or their contractors do not file a permit for renovations. In no instances did a code official comment on any energy-related component of the renovation.

The survey directed at architects was completed by 69 respondents. The findings from these surveys highlighted the need for improved commissioning practices and requirements, and education of building owners.

D.1.3 Case Studies

The New York study included case studies of eight of the evaluated commercial buildings. The case studies included interviews with code officials, architects, engineers, and contractors associated with the construction of these eight buildings. Some conclusions drawn from these studies include:

- Contractors indicated that they built what was on the plans. However, some contractors faced with budget pressures make changes that alter planned energy code elements, and such changes are seldom questioned by code officials or architects.
- Most code officials rely on others to document and verify energy code requirements are satisfied.
- There was an awareness to look for COM*check* reports (which the state requires), but COM*check* reports were only found for about one third of the buildings sampled. When COM*check* documentation was submitted, not much was done beyond ensuring "Pass" was on the report. When inspections did occur, they were generally for insulation only.
- Architects felt that there should be a codes "hotline" or other source for code interpretations. They also felt that continued free access to tools such as COM*check* and RES*check* was critical, as is local training.
- Both architects and engineers are required to put their seal on commercial building plans and are often cognizant of energy code requirements; however, neither group is responsible for verifying that the as-built system matches the plans unless the building owner retains them to oversee construction.

D.2 Illinois

Since August 2009, the Illinois Energy Conservation Code for Commercial Buildings has been the 2009 IECC (ASHRAE 90.1-2007). In January 2010, Public Act 096-0778 became effective, officially establishing the 2009 IECC as the Illinois Energy Conservation Code for Residential Buildings as well.

Illinois conducted plan reviews and field inspections to measure the baseline compliance rate for new residential and commercial buildings in the state against the 2009 IECC. The DOE Sample Generator was used to guide selection of a random sample of new residential and new commercial buildings located within 35 Illinois jurisdictions, based on permits representing 2008-2009 construction starts. Using DOE-developed procedures and tools, the state evaluated a sample of 44 new residential buildings, one residential renovation, and 10 new commercial buildings. Time constraints precluded multiple construction site visits, so compliance verification depended partially on permit documents, which provide traceable legal records of construction progress. The evaluators felt that the high levels of documentation they observed reflected the willingness of the code officials and builders to comply with the building energy codes. The state compliance metrics derived from the study and reflected in Score + Store were 87.2% for new residential construction and 98.2% for new commercial construction. Note that the commercial sample size is too small to yield a statistically valid compliance score.

Of the 44 new residential buildings that were evaluated, 47% used the prescriptive approach for measuring compliance, 36% used the UA trade-off approach (RES*check*), and 18% used the performance approach (REM/Rate). The most common code infractions for new residential construction were: 1) heating and cooling system sizes/types/capacities observed in the field did not match submitted HVAC load calculations, 2) HVAC load calculations were not submitted at all, and 3) air leakage labels were not attached to most fenestration and doors.

Of the 10 new commercial buildings that were evaluated, 70% used the prescriptive approach for measuring compliance and 30% used the UA trade-off approach (COM*check*). The most common code infractions for new commercial construction were: 1) heating and cooling system sizes/types/capacities observed in the field did not match submitted HVAC load calculations, 2) slab-edge insulation R-values were not appropriate, and 3) slab-edge insulation was not installed in accordance with the code requirements or the manufacturer's instructions. The Illinois evaluators noted that the COM*check* compliance reports they reviewed contained omissions or discrepancies that were not found by the code officials, which highlights the need for additional training on the use of COM*check*.

The Illinois evaluators stated that building department staff in the 35 jurisdictions that they worked with were generally cooperative, knowledgeable, and helpful. Once they understood the purpose and scope of the compliance assessment study, they were enthusiastic about the opportunity to talk with experts about building energy code compliance. Access to the jurisdictions was enabled by team members who were familiar with and known to the Illinois code enforcement community.

D.2.1 Time to Evaluate

Illinois code specialists spent an average of 60 minutes on plan reviews and an average of 135 minutes on field inspections.

D.2.2 Survey Results

Illinois used a customized version of the DOE-developed jurisdictional survey to gather information from building code officials, plan reviewers, and field inspectors.

D.3 Maine

Efficiency Maine, an independent quasi-state agency that promotes efficient and cost-effective use of energy, conducted a baseline study on behalf of the Maine State Planning Office to measure the current energy performance of small and medium-sized commercial buildings constructed during the past five years. The study provides information on baseline construction practices for commercial buildings throughout Maine. However, since the study was done post-construction and did not use DOE procedures and tools, the reported results are not directly comparable to other studies described in this report.

Efficiency Maine initially conducted stakeholder meetings to develop attributes for the baseline study. It researched the protocols for building baseline benchmarking and developed a process and metrics for implementing the study. The study resulted in a baseline against which the energy performance of future structures built in accordance with the Maine Uniform Building and Energy Code can be compared.

The primary activities of the study included sample design and site selection, recruitment, building plan and specification review, site visits, data collection, and building owner/operator interviews. Data analysis involved code compliance and energy usage intensity comparisons. A total of 74 commercial buildings of varying use types were evaluated as part of the study.

The Maine study evaluated existing commercial buildings, so there were issues in visually inspecting many code items. The study report describes the procedure used to determine compliance with some of the envelope requirements that are more difficult to inspect post-construction. The procedures included interviewing the building owner for details that could not be verified, and then making a judgment based on what could be inspected and the results of the interview.

Conclusions from the study indicate that standard construction is highly variable in Maine and, on average, considerably below energy code levels adopted by the state at the time of the study. The DOE results reported in Section 11 of this report indicate little variability in compliance rates across building use types. The Maine report, however, indicates that schools and grocery stores demonstrated the highest compliance rates. The higher rates for schools might be attributed to the High-Performance Schools Construction Program that has been operating in Maine for many years. Interviews with grocery store owners indicated that regional grocery chains have made a concerted effort to build efficient stores, and their chains include other states with mandatory codes.

Appendix E

National-level Analysis of Pilot Study Data

Appendix E

National-level Analysis of Pilot Study Data

The pilot studies provided a valuable structure to identify potential national trends with respect to building energy code compliance. This section highlights some of the trends, discusses data-driven conclusions about compliance, and presents detailed results on specific code requirements. Some of the unique results observed during the pilot studies are also highlighted.

Compliance data was collected in the Score + Store[16] online tool for residential and/or commercial buildings throughout the states of Wisconsin, Georgia, Utah, Virginia, Illinois, Iowa, and Massachusetts. All buildings evaluated as part of the pilot studies were new construction, except for the recently occupied residences evaluated as part of the Massachusetts study.[17] A total of 145 new commercial buildings and 256 residential buildings were entered into Score + Store. However, some of these buildings were partially completed or did not evaluate a sufficient number of checklist items to be considered valid. Any residential or commercial building that had fewer than 10 checklist items evaluated was removed from the building data used to inform the national analysis.

Most of the states included in this section had difficulties implementing a sampling plan as part of their pilot study as recommended in the DOE procedure, and thus biases may have been introduced. Additionally, much of this national evaluation is based on a small number of self-selected states. As such, many of the observations and conclusions are preliminary and will necessitate further data to be substantiated.

E.1 Overall Building Compliance

Figure E.1 and Figure E.2 show individual building compliance scores and study averages. The DOE checklists are used to generate individual building scores based on the number of compliant code requirements that are reported. For new residential construction, the study average is derived by averaging the individual building scores. For new commercial construction, weighting by building size is recommended in the DOE procedures. However, the study averages shown in Figure E.2 are simple averages of the commercial building scores, and may not match exactly what was reported as the study score for that state.

A total of six states are represented in Figure E.1, with one state completing two studies. This figure shows the distribution of residential compliance scores and the average for each study (vertical black line). The histograms show the wide range of individual building scores and study averages. Individual building compliance scores ranged from 20% to 100%. The study averages ranged from 62% to 94%; however, it should be noted that Studies A and D consisted of very few residential buildings.

[16] https://energycode.pnl.gov/ScoreStore

[17] A small number of additions and renovations were also evaluated, but were not included in the data analysis presented in this section. A New York study is discussed in Appendix B of this report, but the data from New York was not received in time to be included in this section.

Five different studies included new commercial buildings, however two used a small sample size; Figure E.2 depicts the four studies that had at least five commercial buildings. All study averages were above 80% and almost all of the commercial building compliance scores were 50% or higher.
The data used to create Figure E.1 and Figure E.2 was leveraged to create the national study evaluations shown in subsequent analysis in this section. In some cases, subsets of this complete data were used for reasons specific to, and explained in, specific sections.

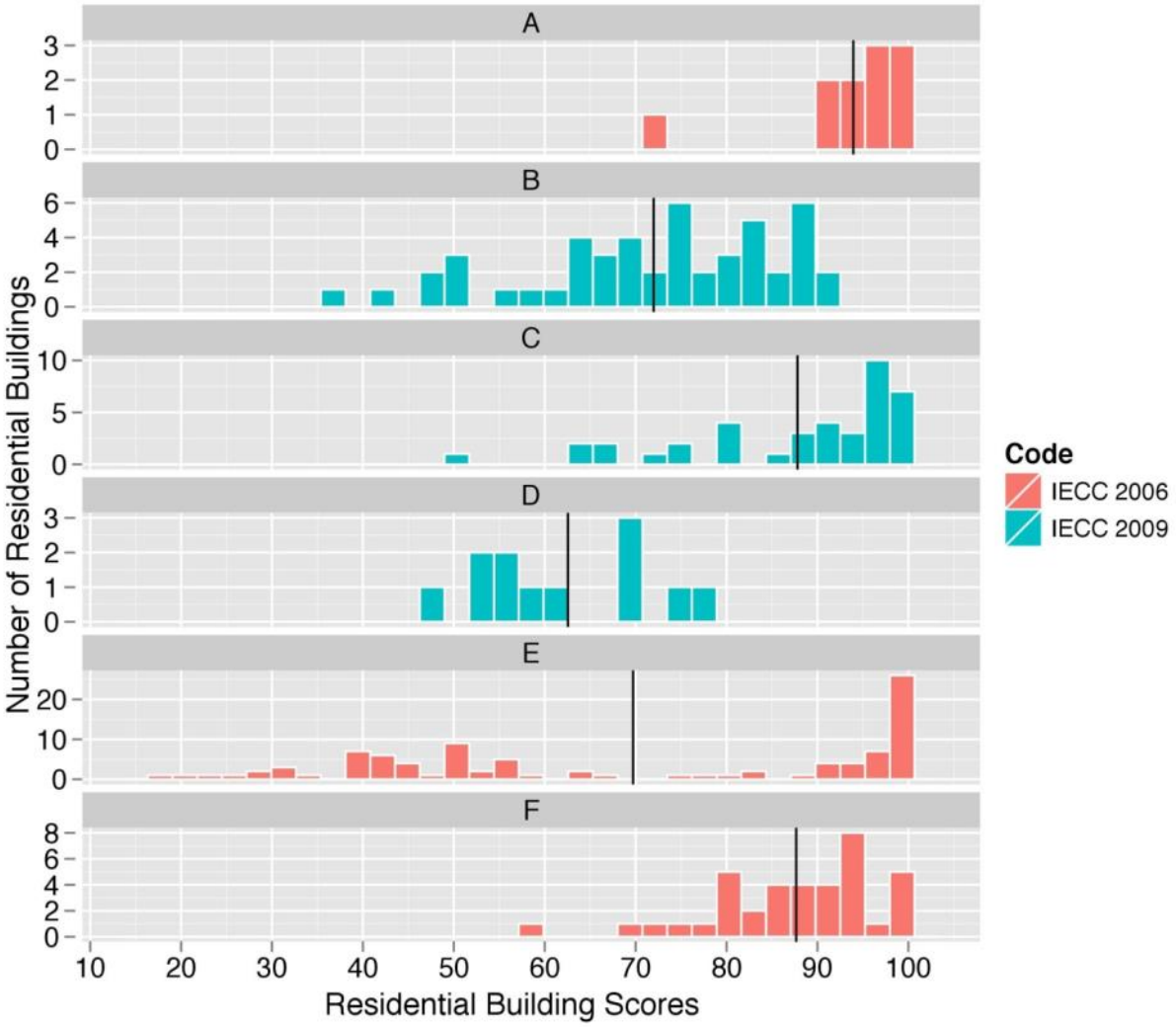

Figure E.1. Compliance Scores for Residential Buildings Grouped by State Study

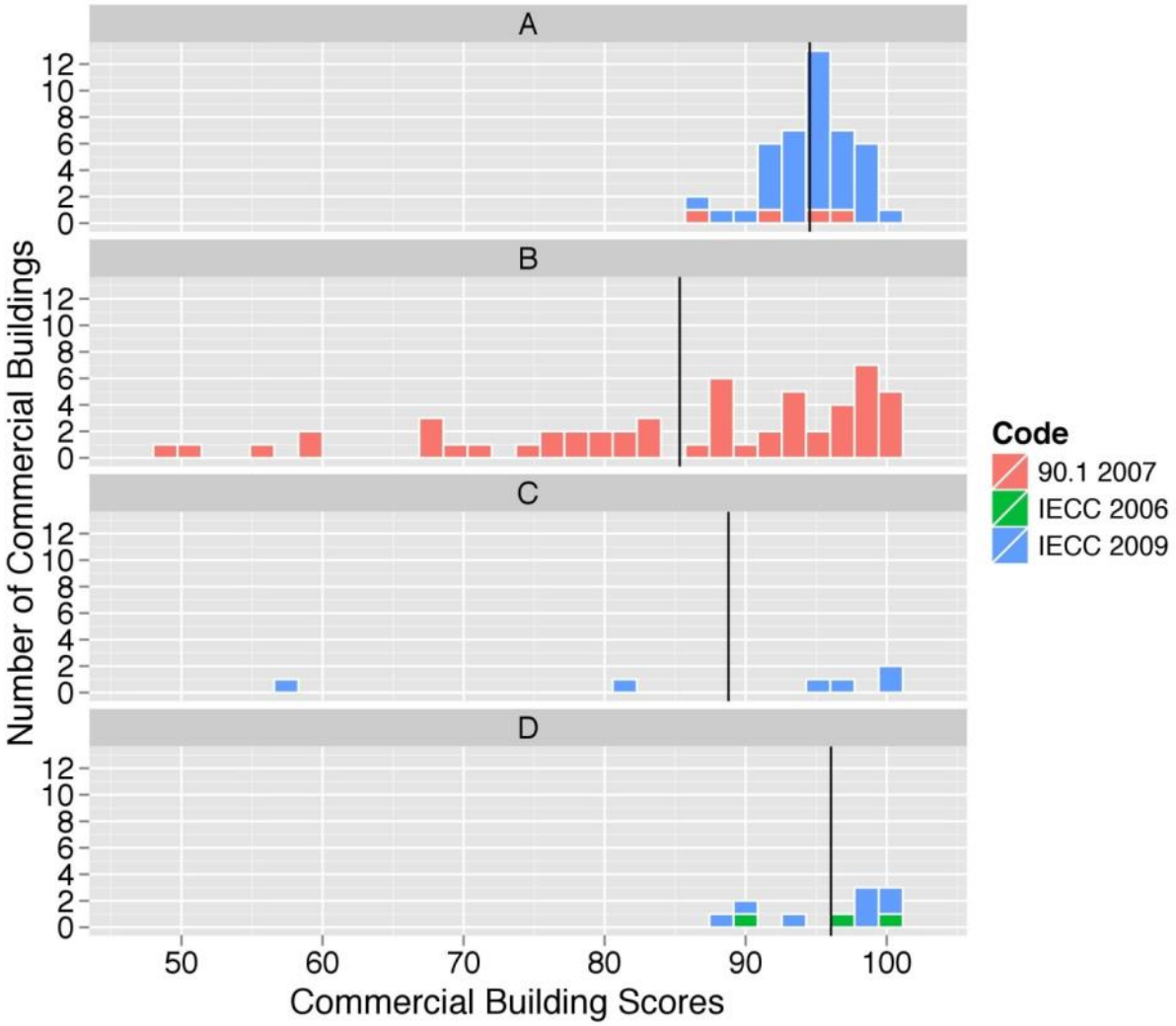

Figure E.2. Compliance Scores for New Commercial Buildings Grouped by State Study

E.2 Compliance by Building Size

DOE procedures recommend that commercial buildings of different sizes be evaluated as a part of a state's study. This guidance was driven by the concern that state-wide compliance rates for new commercial construction had the potential to be affected by building size. Figure E.3 supports an outcome that size does not affect a commercial building's compliance score when comparing small, medium, and large buildings.[18] Additional observations are needed for the X-large and XX-large buildings to more conclusively determine how compliance rates are affected by building size.

While building size was not controlled in the residential studies, the reported square footage of each building was used in Figure E.4 to separate the buildings into general size groups. Figure E.4 also indicates that building size does not significantly affect a building's compliance score. However,

[18] The New York study found lower compliance rates for small buildings (see Appendix D). However, New York's sample size was small (26 buildings) and did not include any X-large or XX-large buildings.

additional observations for buildings over 5,000 ft^2 could improve the statistical significance of an improved compliance score for these larger dwellings. Additionally, not all of the residential studies included multi-family buildings, and as a result this building type may be under-represented in these analyses.

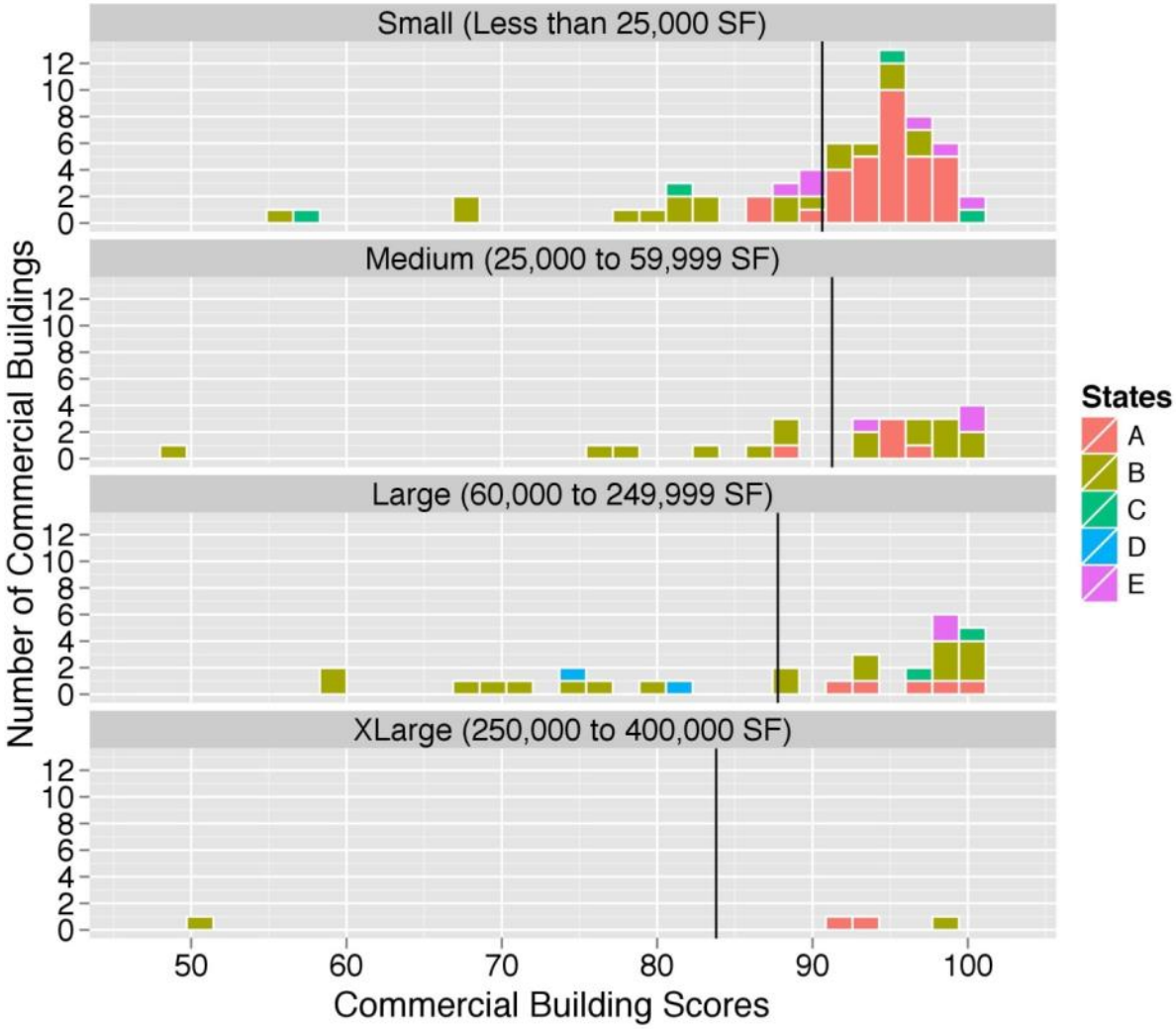

Figure E.3. Compliance Scores for New Commercial Buildings Grouped by Building Size

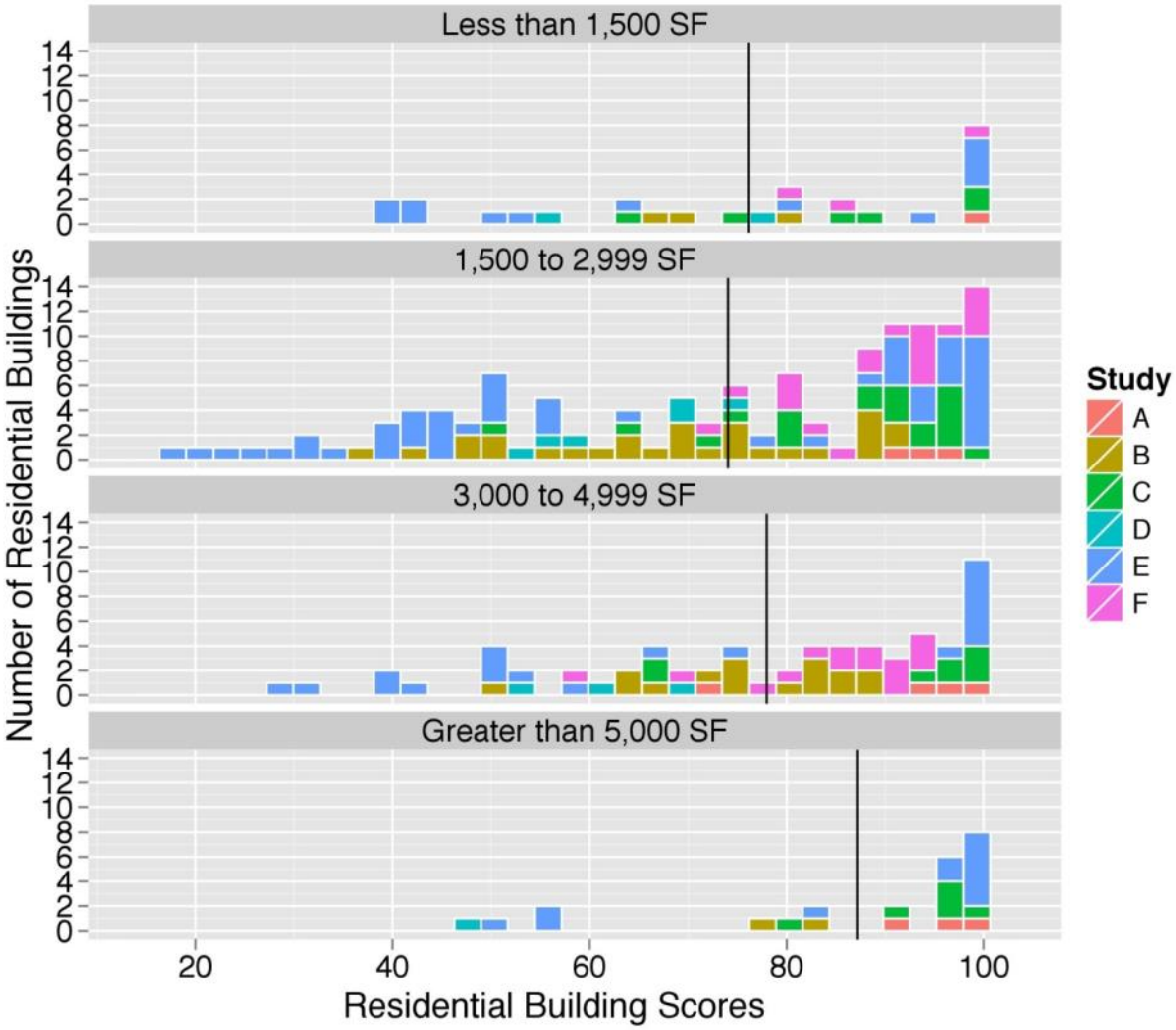

Figure E.4. Compliance Scores for Residential Buildings Grouped by Building Size

E.3 Compliance by Building Use Type

Figure E.5 shows nine groupings of the compliance data for new commercial buildings based on building use, and an unidentified grouping to cover buildings for which a use was not indicated. Compliance scores for each of the new commercial buildings are shown along the y-axis. The white box-and-whisker plots show the larger distributional structure of each building use grouping. The rectangle shows the region where the middle 50% of the compliance scores are located. The black line in the middle of the box shows the median compliance score for each building use grouping. The black lines that extend up and down from each box (whiskers) show the remaining part of the range for expected building scores. Any points that are shown beyond the whiskers would be considered extreme. The points overlaid on the box-and-whisker plots show each building's compliance score. These points are color-coded to indicate the performance approach used for that building (prescriptive, trade-off, or performance). The points are also displayed as different shapes to indicate the number of building use

types identified for the building. Where multiple building use types were indicated for a single building, that building is included in each applicable box-and-whisker plot.

This image highlights that building use has little to no effect on compliance. It is therefore reasonable to conclude that a compliance rate found for one building use is likely to be representative of the compliance rate that would be found for other uses. Regardless, DOE recommends that a variety of commercial building use types be sampled in assessing the rate of compliance, but it may not be a necessary factor to control in the sampling design.

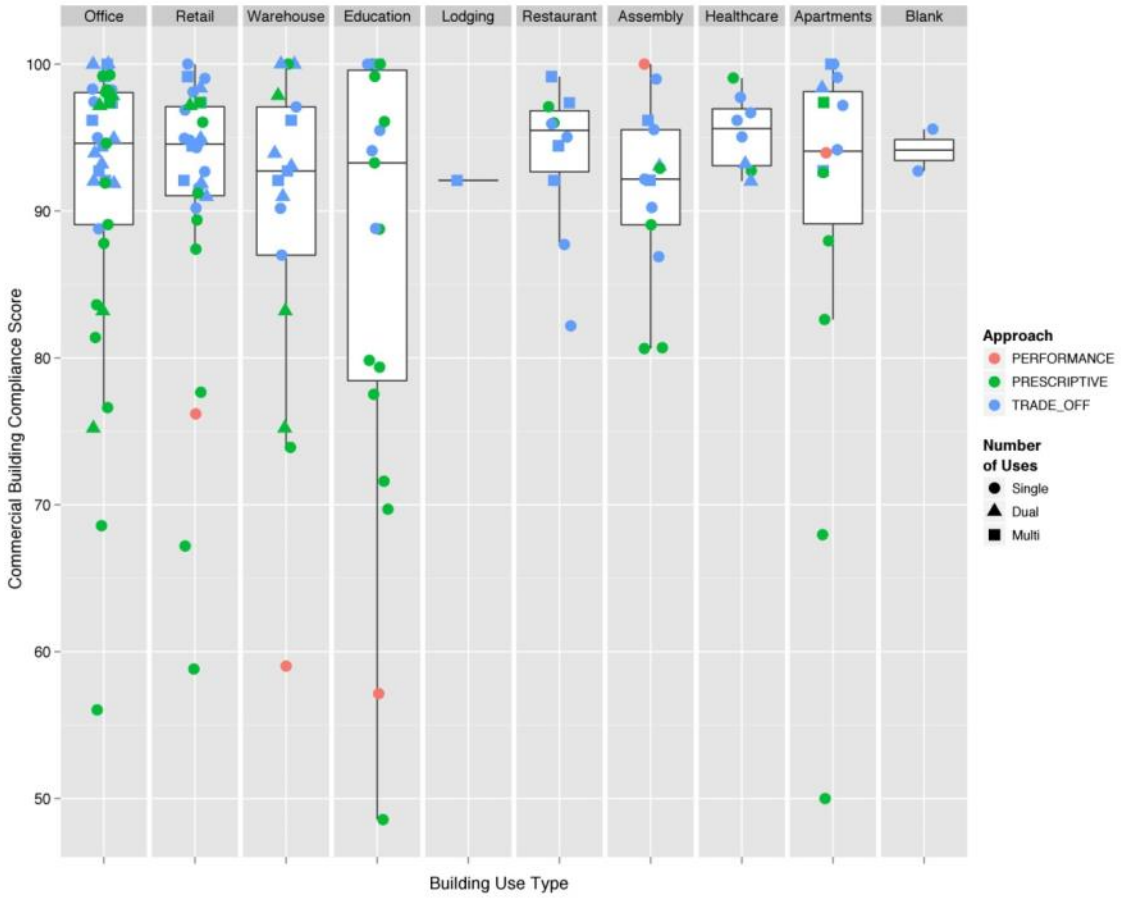

Figure E.5. Compliance Scores for New Commercial Buildings Grouped by Building Use Type (Points represent individual buildings.)

E.4 Compliance by Code Compliance Approach

The approach by which compliance was documented (prescriptive, trade-off, and performance) was tracked for each building. This post-study analysis grouped buildings based on their specified compliance approach for both new residential and commercial buildings. In both cases, buildings demonstrating compliance by the prescriptive approach had lower individual building compliance scores, and lower overall state compliance averages, than buildings complying by other compliance approaches. However, performance-based compliance for commercial buildings is complex, not often used, and there were not many buildings in this sample set. Figure E.6 and Figure E.7 show the residential and commercial

building compliance scores grouped by compliance approach. Figure E.8 and Figure E.9 show residential and commercial building compliance scores grouped by software products used to demonstrate compliance. Compliance approach and software used in demonstrating compliance are closely correlated, but not identical (for example, RES*check* supports both the trade-off and performance approach). As expected, the results of both groupings are similar.

The Massachusetts data was omitted from the residential plots (Figure E.6 and Figure E.8). The onsite data collected for 50 Massachusetts homes did not include a visit to the building department, and a prescriptive approach was assumed for all 50 homes. Since RES*check* is a popular tool for demonstrating compliance in the state, many of those homes may have submitted RES*check* documentation and used either a trade-off or performance approach.

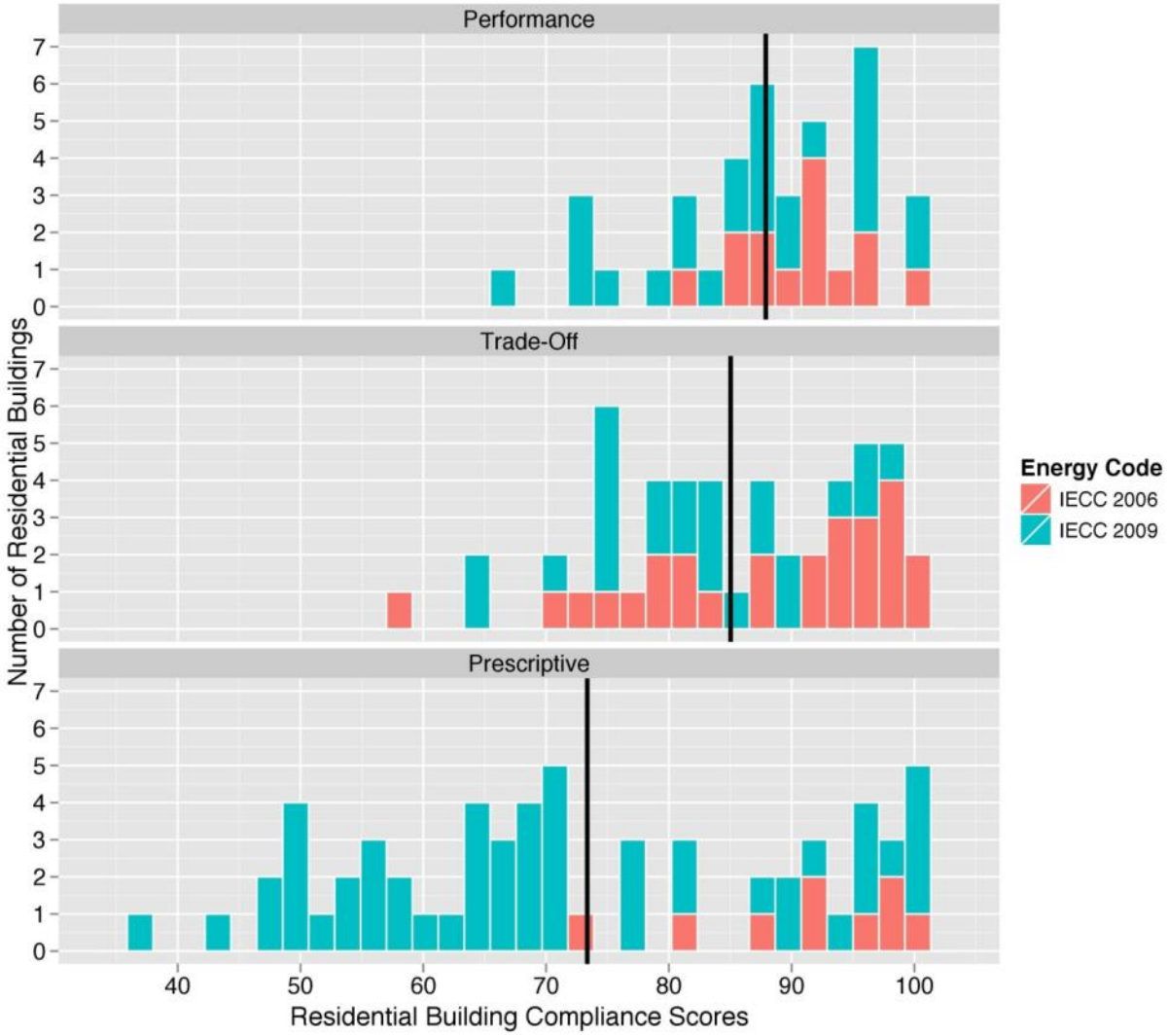

Figure E.6. Compliance Scores for New Residential Buildings Grouped by Compliance Approach

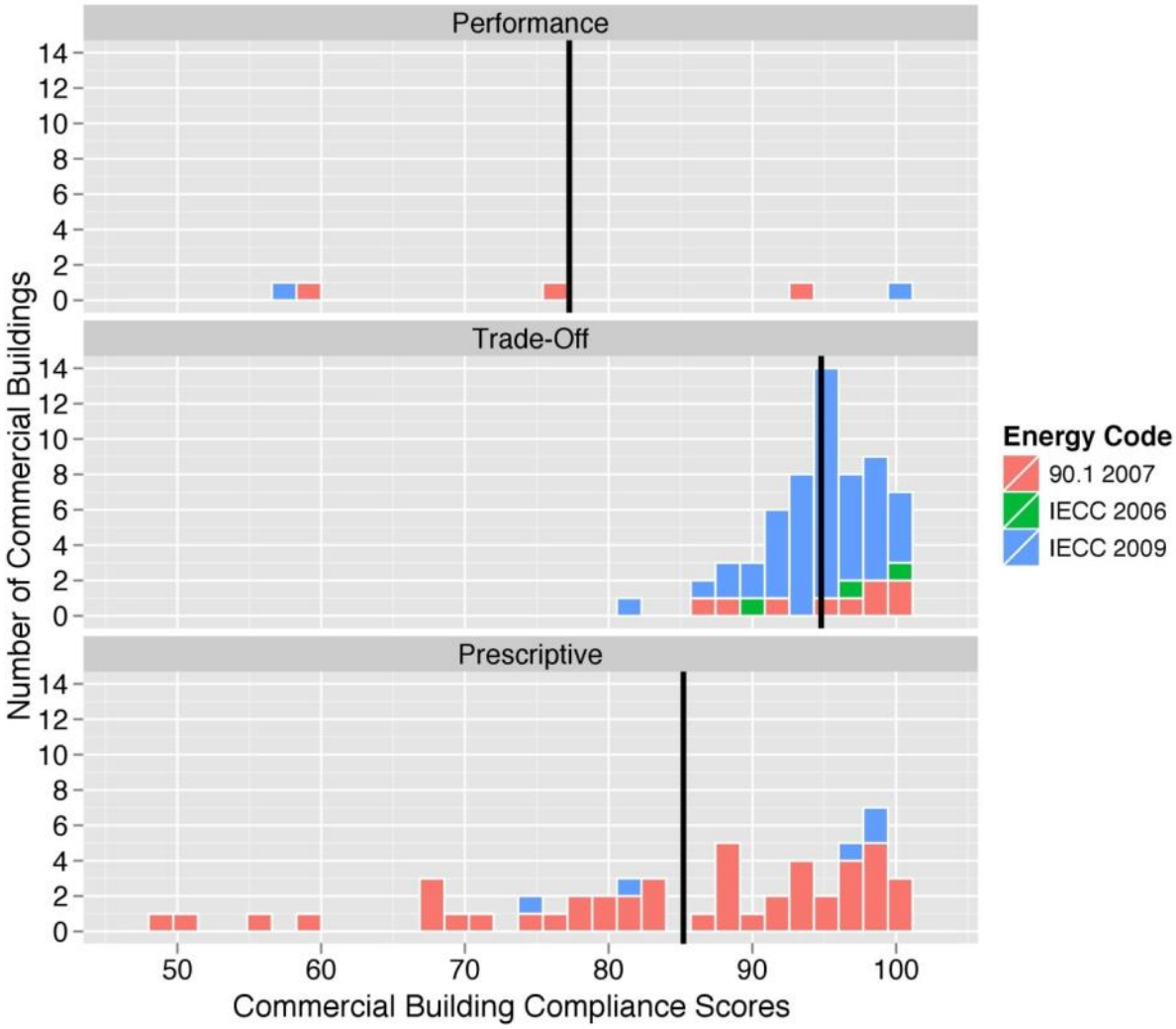

Figure E.7. Compliance Scores for New Commercial Buildings Grouped by Compliance Approach

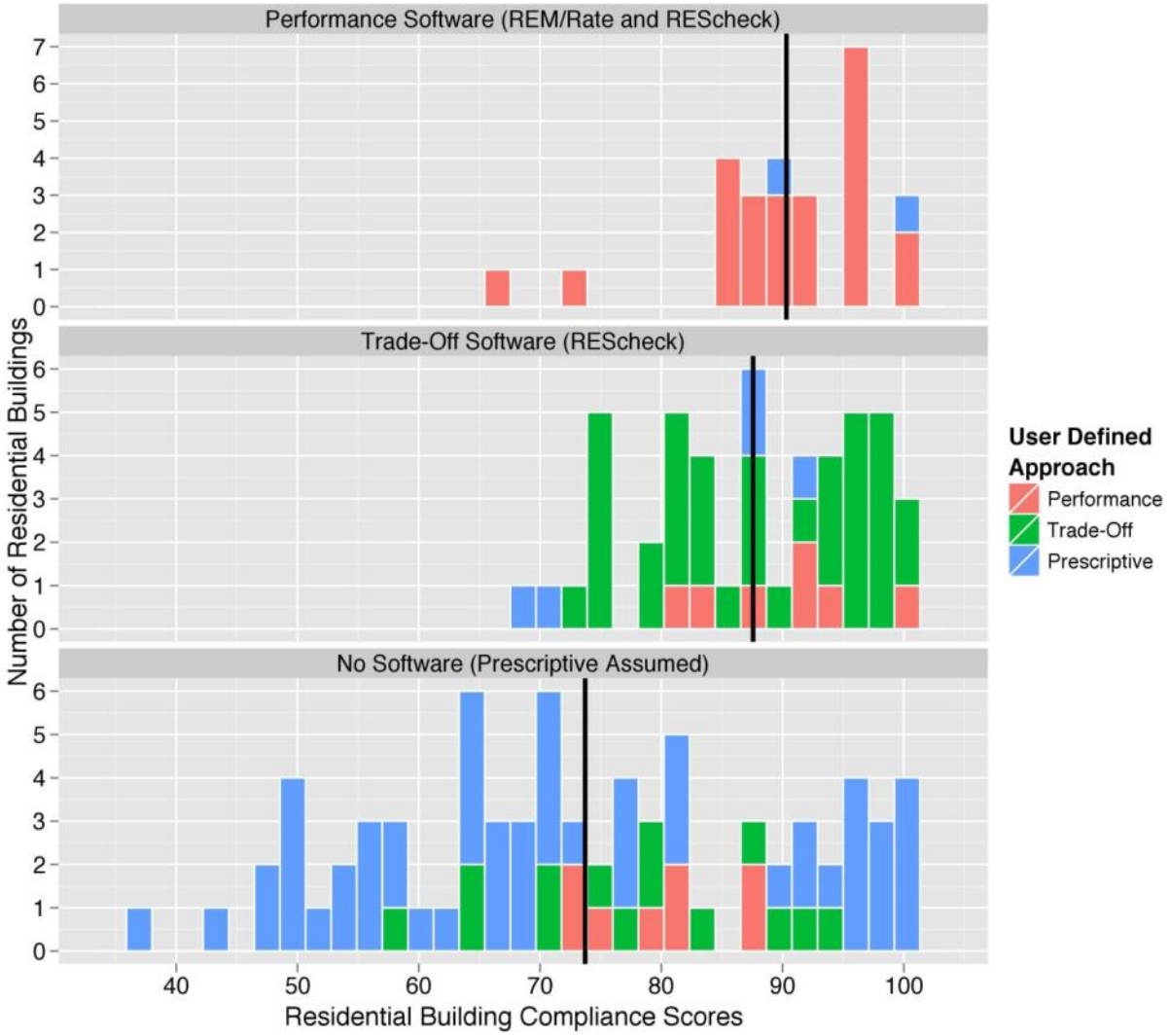

Figure E.8. Compliance Scores for New Residential Buildings Grouped by Software Product

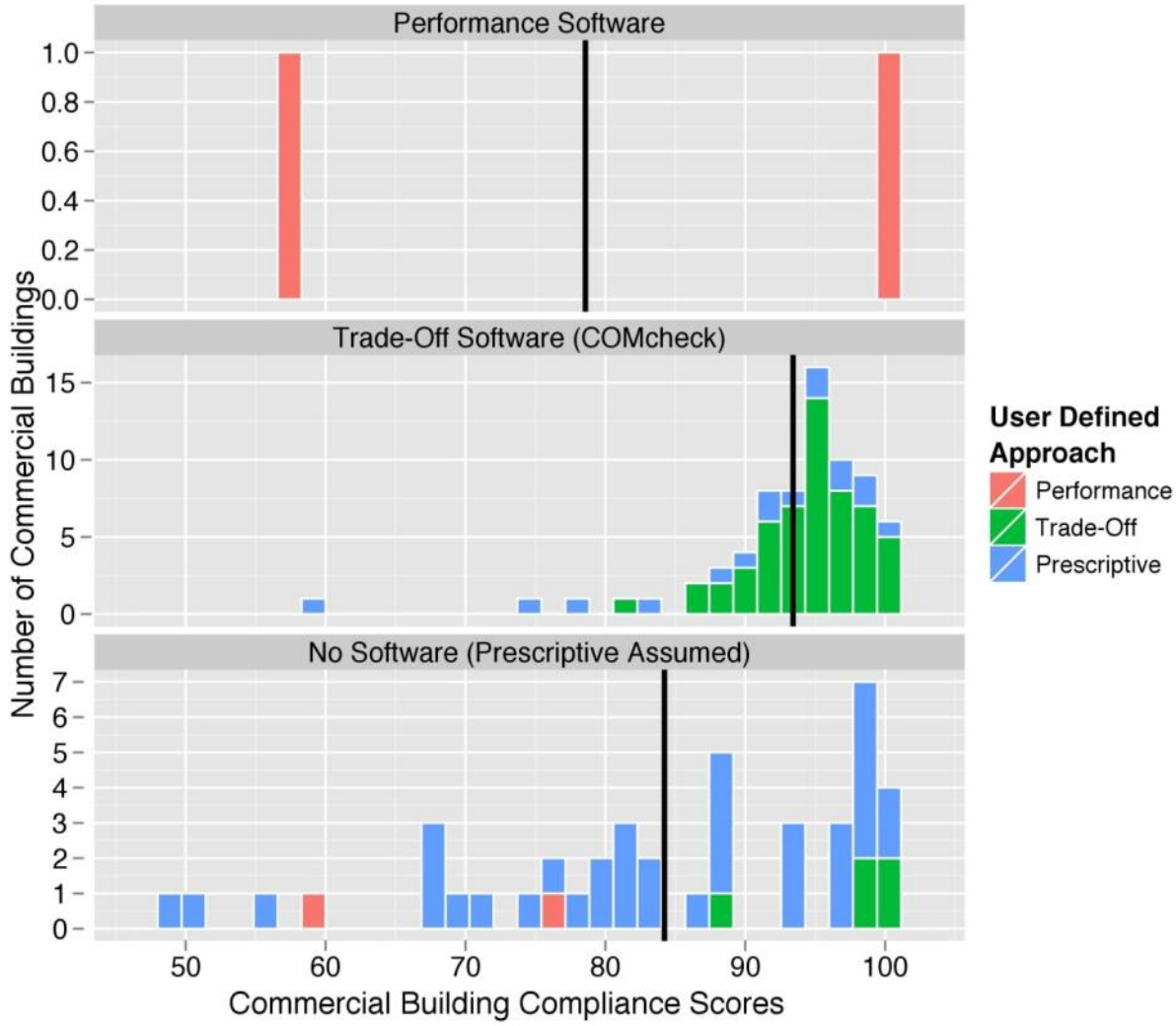

Figure E.9. Compliance Scores for New Commercial Buildings Grouped by Software Product

E.5 Compliance by Building Ownership

Commercial building ownership does not appear to have a significant effect on the rate of compliance. However, the histograms in Figure E.10 highlight that there were only a few buildings evaluated in many of the groups (State, Local Government, and National Account). This makes it difficult to identify any significant differences if they do exist.

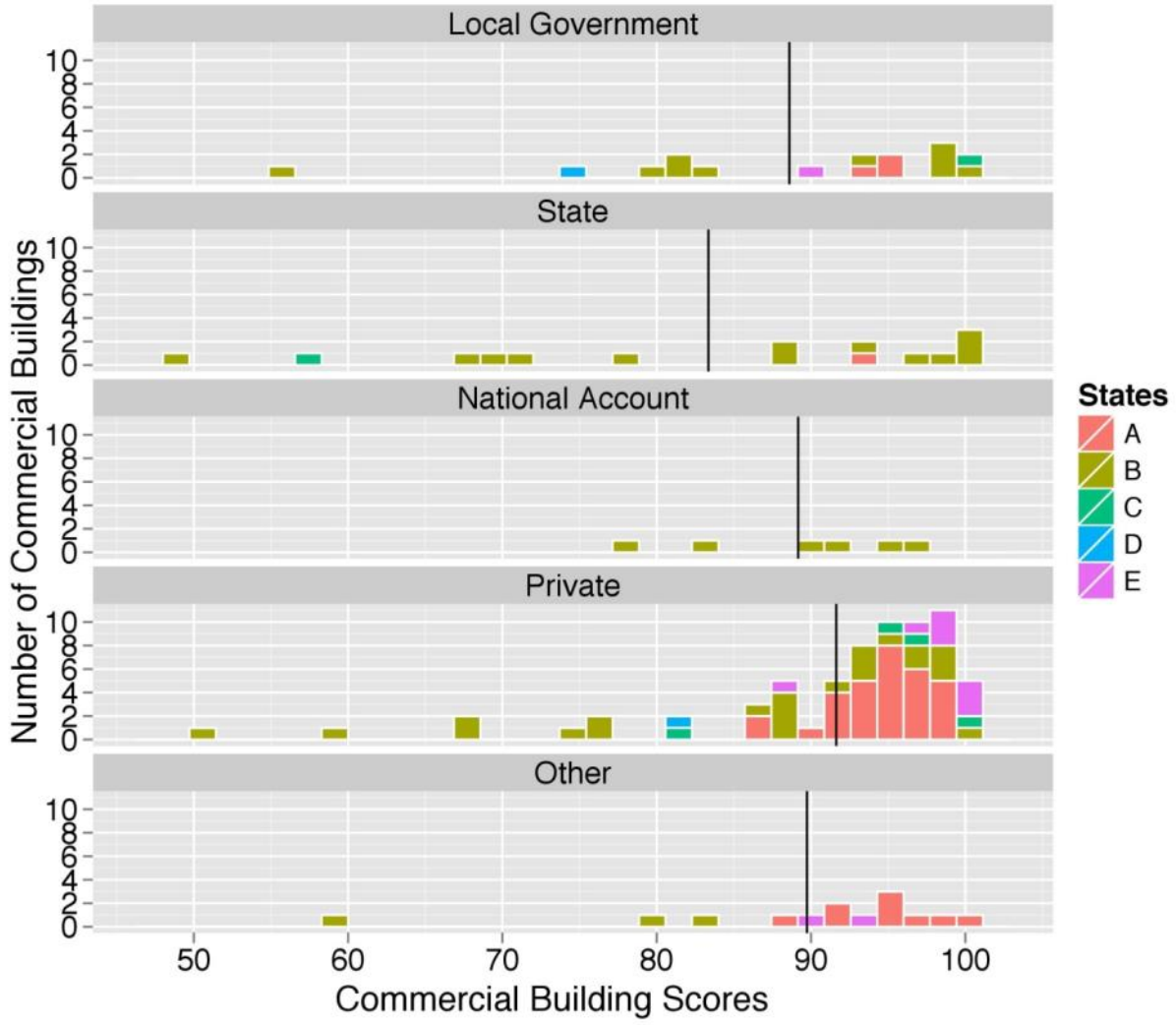

Figure E.10. Compliance Scores for New Commercial Buildings Grouped by Ownership

E.6 Building Compliance across Subsets of Code Requirements

Several subsets of code requirements were evaluated to determine their impact on the rate of code compliance based on the subset rather than all code requirements:

- **Tier 1 Code Requirements** – DOE checklists group code requirements into three tiers based on estimations of how impactful they are, with Tier 1 being the most significant. This scenario compares compliance rates if all code requirements are evaluated, as opposed to only Tier 1 requirements.
- **Energy-Related Code Requirements** – Code requirements related to documentation and administration do not have a direct impact on the final energy use of the building. This scenario compares compliance rates if all code requirements are evaluated, as opposed to compliance rates if the documentation, labeling, and administrative requirements are removed.
- **Code Requirements Visible Post-Construction** – A large number of code requirements may not be observable if a single visit is made to the building after it is constructed and an occupancy permit

issued. This scenario compares compliance rates if all code requirements are evaluated, as opposed to compliance rates if only the code requirements observable post-construction are considered.

Building compliance scores using these subsets were derived using the data from the three state studies that evaluated all residential code requirements and the two states that evaluated all commercial code requirements. Massachusetts was removed from this analysis as it was a post-construction study and not all code requirements were evaluated. This analysis was used to better understand effects associated with evaluating a smaller set of code requirements.

All code requirements included on the DOE checklists are labeled with a checklist identification number (ID). This ID has two letters that identify the construction stage from the DOE checklist and a number to identify the specific code requirement. The checklist groupings are:

- PR - Plan Review
- FO - Foundation
- FR - Framing/Rough-In
- PL - Plumbing (commercial only)
- ME - Mechanical (commercial only)
- EL - Electrical/Lighting (commercial only)
- IN - Insulation
- FI - Final Inspection.

Table E.1 lists the code requirements, by checklist ID that were removed from the full set of requirements to form the three subsets.

Table E.1. Code Requirements (by Checklist ID) Removed from Complete Checklists to Create Subset Checklists for Tier 1, Energy-Related, and Post-Construction Evaluations

Checklist Subset	Code Requirements Removed from Complete Checklists		
	Tier 1	**Energy-Related**	**Post-Construction**
Commercial	EL1, EL2, EL3, EL5, EL9, FI11, FI12, FI13, FI14, FI15, FI16, FI17, FI19, FI2, FI20, FI21, FI3, FI4, FI5, FI6, FI7, FI8, FO1, FO2, FO3, FO4, FO5, FO9, FR1, FR12, FR14, FR2, FR3, FR4, FR5, FR6, FR7, FR8, FR9, IN10, IN11, IN12, IN13, IN14, IN15, IN16, IN17, IN4, IN5, IN8, IN9	FI16, FI17, FI7, FI8, FR12, FR13, FR3, FR7, ME1, ME2, PR1, PR2, PR3, PR4, PR5	FO1, FO10, FO2, FO3, FO4, FO5, FO6, FO7, FR1, FR10, FR11, FR12, FR13, FR14, FR2, FR3, FR8, FR9, IN1, IN10, IN12, IN14, IN4, IN6, IN7, ME2, ME33, ME35
Residential	ME1, ME10, ME11, ME13, ME18, ME19, ME2, ME20, ME21, ME22, ME23, ME24, ME25, ME26, ME27, ME28, ME29, ME3, ME31, ME32, ME34, ME36, ME37, ME38, ME4, ME41, ME42, ME5, ME7, ME8, ME9, PL1, PL2, PL4, PR6, PR7	PR1, PR2, FR4, FR7, FR22, IN13, FI7	FO1, FO2, FO3, FO4, FO5, FO6, FR1, FR2, FR3, FR4, FR5, FR6, FR7, FR8, FR9, FR10, FR11, FR12, FR15, FR16, FR18, FR22, IN3, IN5, IN6, IN7, IN8, IN9, IN10, IN13, FR12, FR15, FR16, FR18, FR22, IN3, IN5, IN6, IN7, IN8, IN9, IN10, IN13"

Figure E.11 and Figure E.12 show histograms of building compliance scores when all code requirements are included, and the respective compliance scores when only a subset of code requirements are included. The solid black line represents the average of the building scores and the dashed lines identify the 95% upper confidence level on the mean.

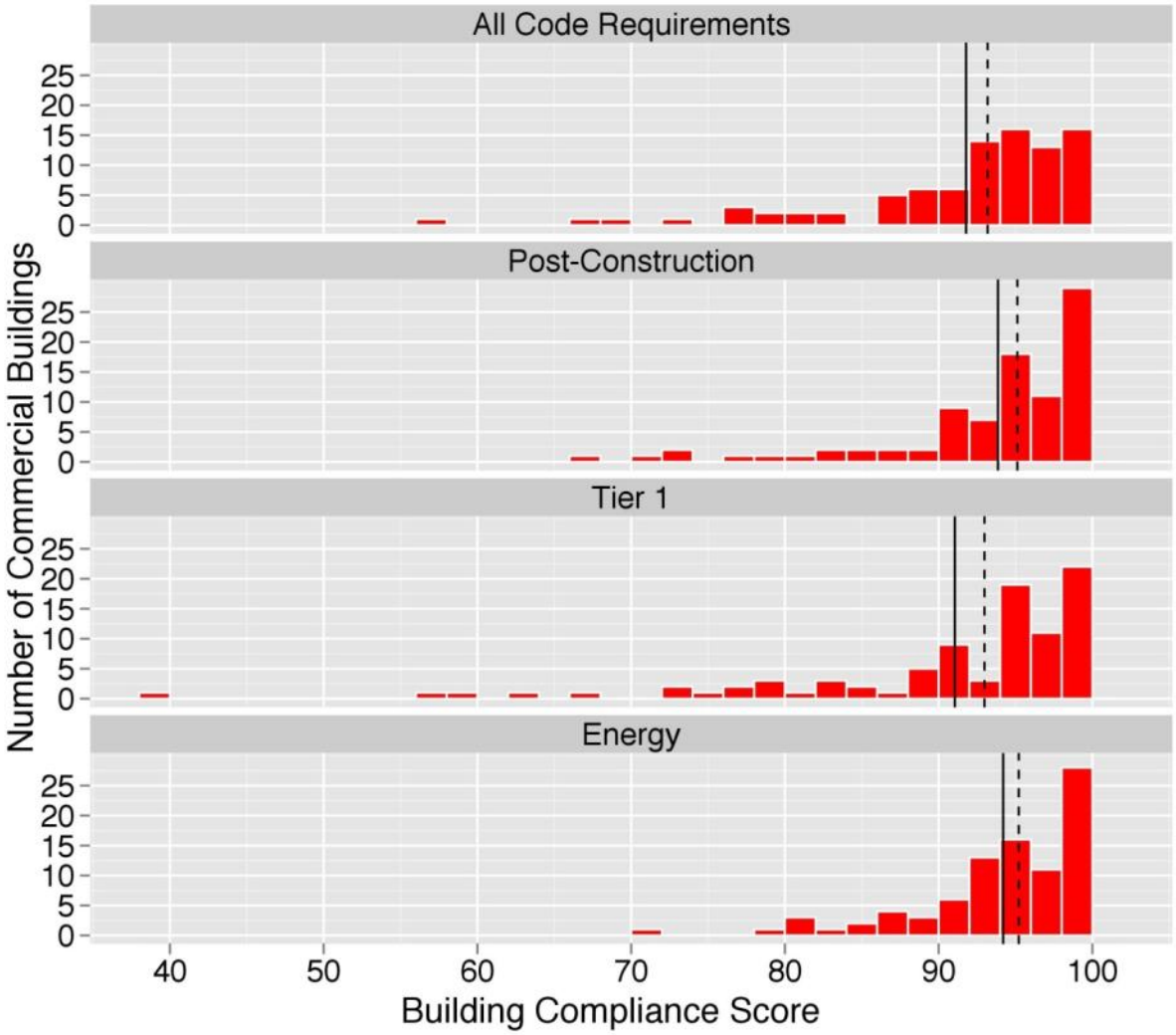

Figure E.11. Compliance Scores for New Commercial Buildings Grouped by Subset Scores for Post-Occupancy, Tier 1, and Energy-Related Code Requirements

Figure E.12. Compliance Scores for New Residential Buildings Grouped by Subset Scores for Post-Occupancy, Tier 1, and Energy-Related Code Requirements

Figure E.13 and Figure E.14 show differences from complete checklist compliance scores for new commercial and residential buildings. Each point is the difference between the building score (represented as a percentage) based on all code requirements and the respective building score based on a subset of code requirements.

If there were no difference, on average, between the building score evaluated against all code requirements and the building score based on a subset of building requirements, the points would be displayed randomly about zero (the dashed line). The solid line shows the average trend of the difference building scores.

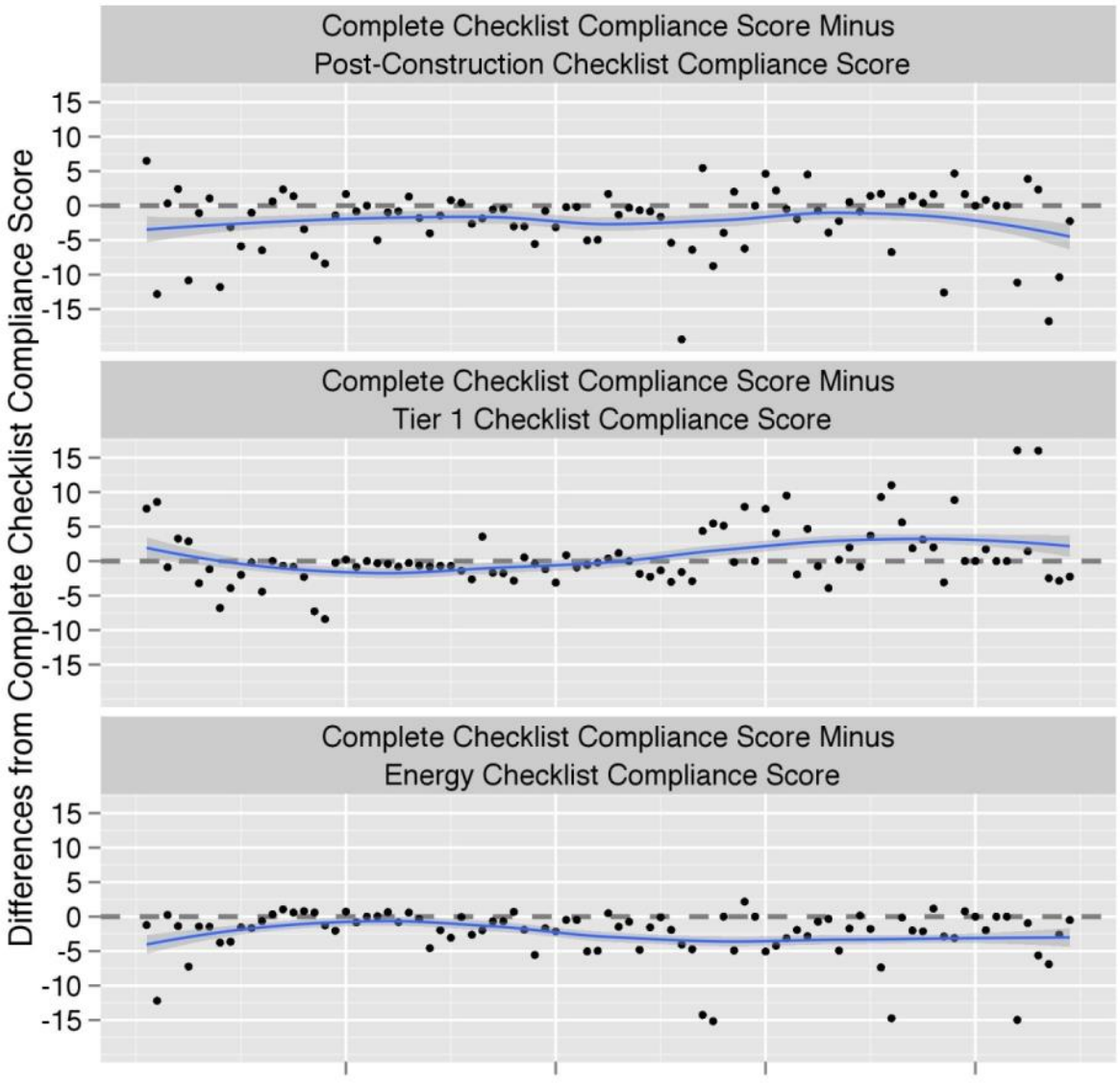

Figure E.13. Differences from Complete Checklist Compliance Scores for Commercial Buildings. Compliance Scores are Represented as Percentages.

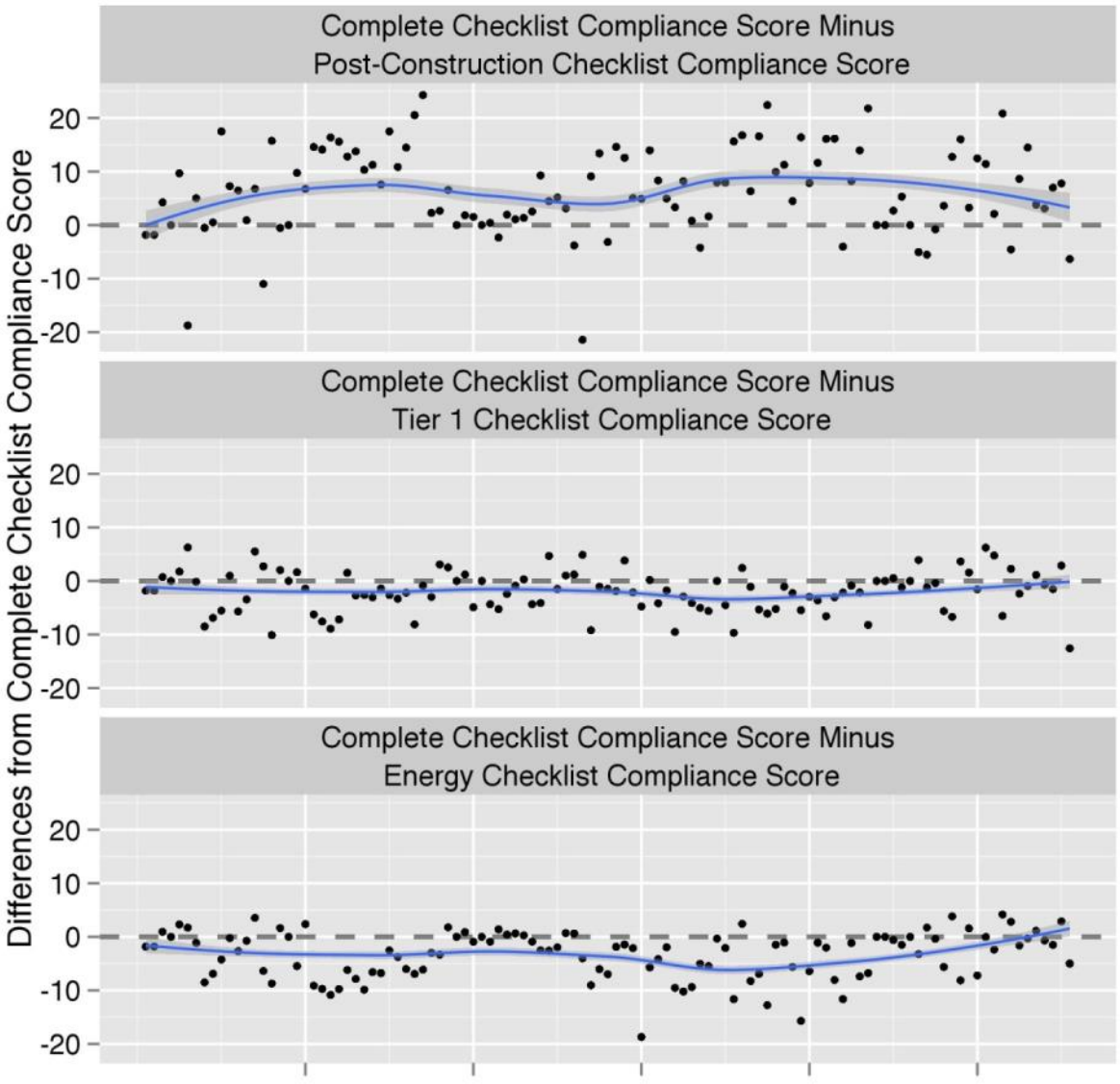

Figure E.14. Differences from Complete Checklist Compliance Scores for Residential Buildings. Compliance Scores are Represented as Percentages.

E.6.1 Commercial Compliance Based on Checklist Subsets

Figure E.11 demonstrates that slight increases in compliance scores occur when a post-construction or energy-related checklist is used to evaluate buildings. However, a checklist that includes only Tier 1 code requirements may reduce the expected compliance rate. The limited number of code requirements used to score each building for the Tier 1 checklist increases the variability in building scores for a state study. Figure E.13 highlights that the matched pair difference from the complete checklist changes a building's compliance score by less than 2.5 percentage points on average. However, some building scores changed by as much as 15 percentage points.

E.6.2 Residential Compliance Based on Checklist Subsets

Figure E.12 indicates that post-construction studies increase the variability in building scores and can reduce the average compliance score by 5 percentage points. The other two checklist subsets (Tier 1 and energy-related) do not appear to affect the expected compliance score for a building. Figure E.14 also highlights the larger effect on a building's compliance score when using the post-construction checklist. The Tier 1 and energy-related checklist differences stay close to zero and don't exhibit as much variability as the post-construction differences.

E.7 Compliance with Individual Code Requirements

In this section, compliance of specific code requirements is evaluated to identify any influential trends. All evaluated buildings discussed and shown in previous sections were to evaluate individual code requirements. However, a few code requirements were not included from the Massachusetts study, because they related to plan review and were difficult to evaluate in a post-construction study that did not include a visit to the corresponding building department.

The following sections document the least and most compliant code requirements, as well as requirements most often marked as “Not Applicable” and “Not Observable.” Note that some code requirements are somewhat subjective, and feedback from the pilot studies indicates that there was confusion about how to score them. In this section, the terms “compliant” and “non-compliant” are used to refer to code requirements that were marked as satisfying or not satisfying the code according to the evaluator checklists. See Table E.1 for an explanation of the checklist ID used in the following plots.

In the following plots, the point identifies the proportion estimate (the number of times the code requirement passed divided by the number of times the code requirements was evaluated). The line identifies the 95% confidence bound on this estimate, using the Clopper-Pearson (also called the "exact" method) interval. The width of the interval is related to the number of buildings used to estimate the proportion. Thus, requirements having wide intervals are code items with fewer observations. For example, F09 in Figure E.15 was established using 7 buildings, while FI7 was estimated using 88 buildings. Code compliance proportion estimates based on too few buildings result in an interval that ranges from 0 to 1, and intervals of that range are not included in any plots.

The most and least compliant code requirements reported in this section may not always align with the most and least compliant state-specific code requirements reported in the Score + Store reports. At the time of this study, those reports display the top three most and least compliant code requirements based on total counts, as opposed to proportion estimates. Reporting by total counts fails to identify important code requirements, such as non-compliant basement insulation levels in studies where only a portion of the homes have basements.

E.7.1 Least Compliant Code Requirements

Figure E.15 displays the code requirements that could be reliably estimated as the least compliant over all of the observed residential buildings in the state studies (compliant less than 90% of the time). Table E.2 provides the code requirement text associated with each checklist ID shown in Figure E.15.

The high-efficacy lighting code requirement (FI6) was the worst performing Tier 1 item. The remaining five most non-compliant code requirements were related to lack of labeling or documentation.

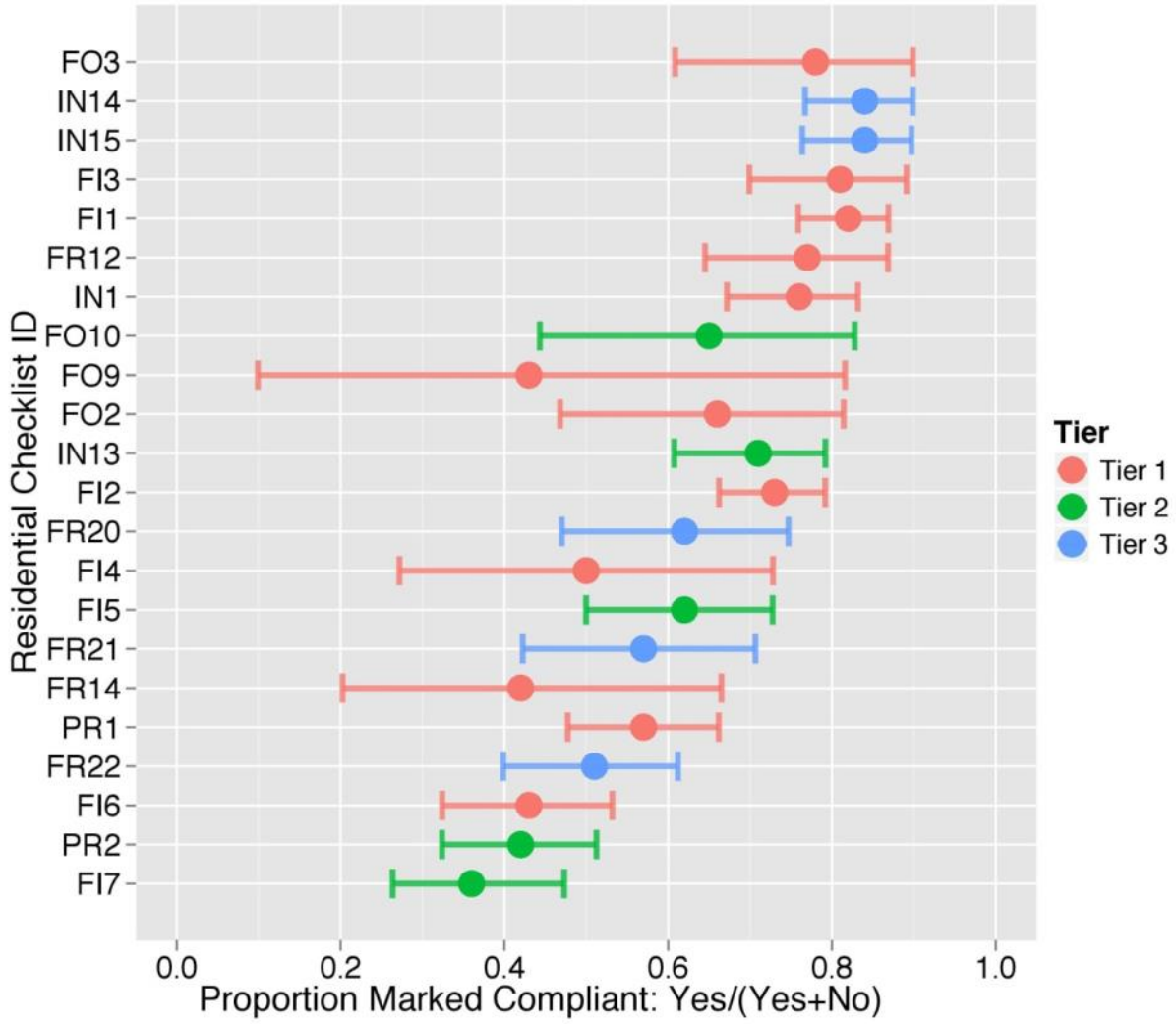

Figure E.15. Least Compliant Residential Code Requirements

Table E.2. Least Compliant Residential Checklist Requirements (least compliant listed first)

Checklist ID	Checklist Text
FI7	Certificate posted.
PR2	HVAC loads calculations Heating system size(s): Cooling system size(s):
FI6	Lighting - 50% of lamps are high efficacy.
FR22	Fenestration and doors labeled for air leakage.
PR1	Construction drawings and documentation available. Documentation sufficiently demonstrates energy code compliance.
FR14	Duct tightness via rough-in test.
FR21	Swinging door air leakage.
FI5	Heating and cooling equipment type and capacity as per plans.
FI4	Duct tightness via post-construction test.
FR20	Glazed fenestration air leakage.
FI2	Ceiling insulation installed per manufacturer's instructions. Blown insulation marked every 300 sq ft.
IN13	All installed insulation labeled or installed R-value provided.
FO2	Slab edge insulation installed per manufacturer's instructions.
FO9	Crawl space continuous vapor retarder installed with joints overlapped by 6" and sealed, and extending at least 6" up the stem wall.
FO10	Exposed foundation insulation protection.
IN1	Floor insulation R-value.
FR12	Duct insulation.
FI1	Ceiling insulation R-value.
FI3	Attic access hatch and door insulation.
IN15	Air sealing of all envelope joints and seams via visual inspection: dropped ceilings, knee walls, assemblies separating garage, tubs and showers, common walls between units, rim joist junctions.
IN14	Air sealing of all openings and penetrations via visual inspection: site-built fenestration, window/door openings, utility penetrations attic access openings.
FO3	Slab edge insulation depth/length.

Figure E.16 displays the commercial code requirements that could be reliably estimated as the least compliant over all of the observed commercial buildings in the state studies (complied less than 90% of the time). Table E.3 provides the code requirement text associated with each checklist ID shown in the figure.

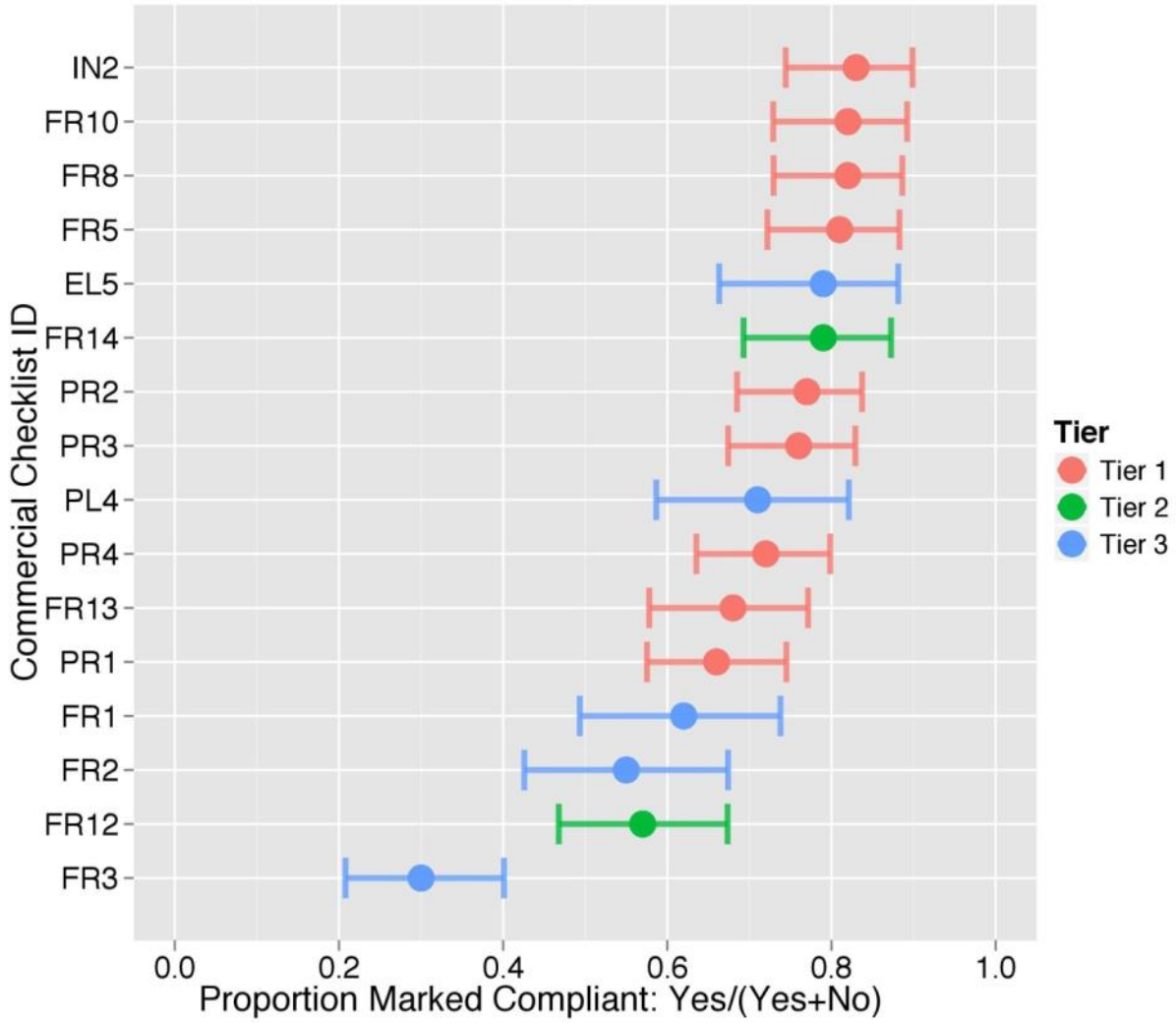

Figure E.16. Least Compliant Commercial Code Requirements

Table E.3. Least Compliant Commercial Code Requirements (least compliant first)

Checklist ID	Checklist Text
FR3	Fenestration and doors labeled for air leakage.
FR12	Fenestration products rated in accordance with NFRC.
FR2	Doors meet maximum air leakage requirements.
FR1	Fenestration meets maximum air leakage requirements.
PR1	Plans and/or specifications provide all information with which compliance can be determined for the building envelope and delineate and document where exceptions to the standard are claimed.
FR13	Fenestration products are certified as to performance labels or certificates provided.
PR4	Plans, specifications, and/or calculations provide all information with which compliance can be determined for the lighting and electrical systems and equipment and delineate and document where exceptions to the standard are claimed. Information provided should include interior and exterior lighting power calculations, wattage of bulbs and ballasts, transformers and control devices.
PL4	Heat traps Installed on non-circulating storage water tanks.
PR3	Plans, specifications, and/or calculations provide all information with which compliance can be determined for the service water heating systems and equipment and delineate and document where exceptions to the standard are claimed.
PR2	Plans, specifications, and/or calculations provide all information with which compliance can be determined for the mechanical systems and equipment and delineate and document where exceptions to the standard are claimed.
FR14	U-factor of opaque doors associated with the building thermal envelope meets requirements.
EL5	Ballasted one- and three-lamp fixtures with >30 W/lamp have two lamp tandem wired ballasts when >2 fixtures in same space on same control.
FR5	Roof insulation R-value.
FR8	Vertical fenestration U-Factor.
FR10	Vertical fenestration SHGC value.
IN2	Roof insulation R-value.

E.7.2 Most Compliant Code Requirements

Figure E.17 displays the residential code requirements that could be reliably estimated as the most compliant over all of the observed residential buildings in the state studies (compliant more than 50% of the time). Table E.4 provides the checklist text associated with the top 14 checklist IDs shown in the figure.

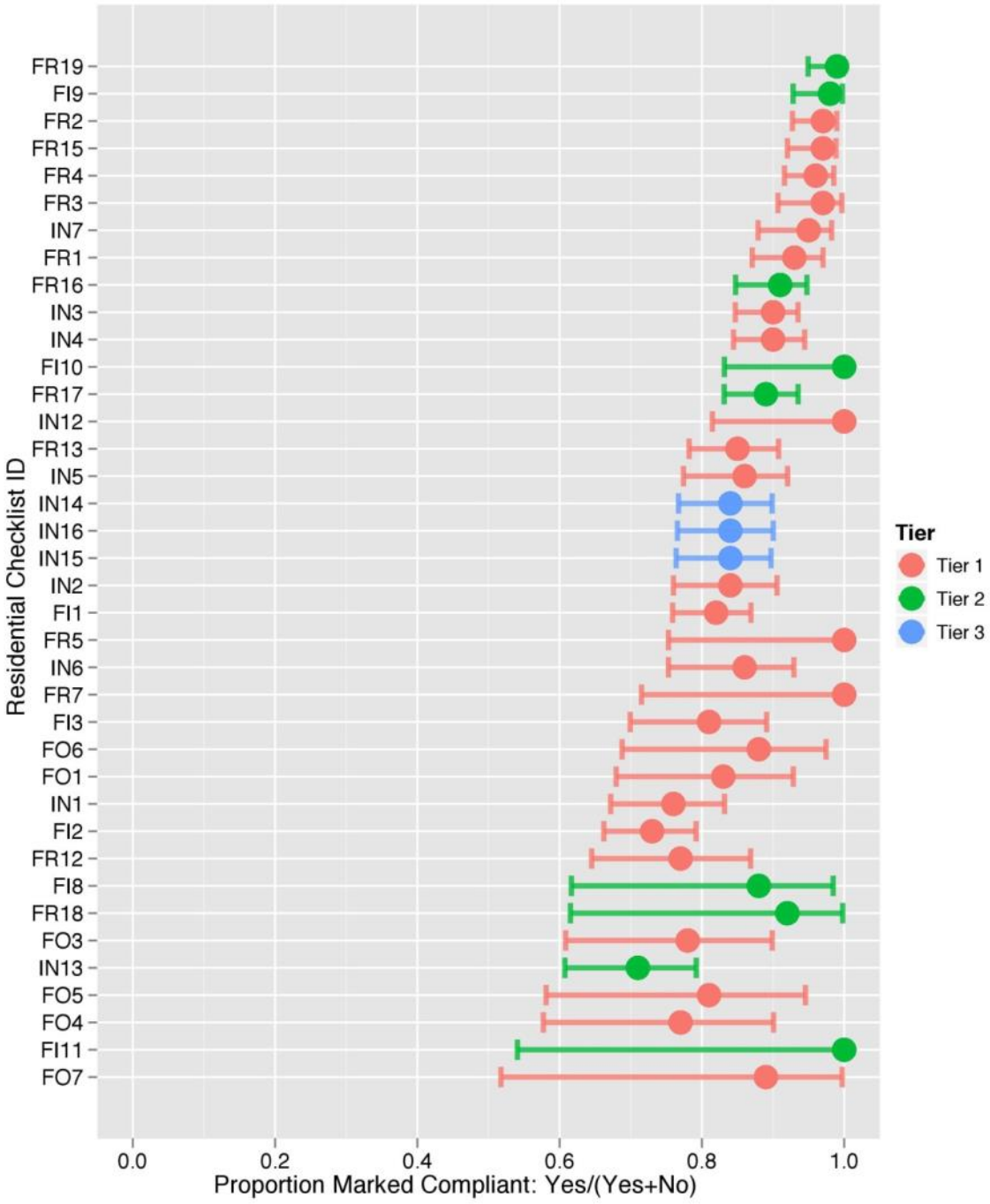

Figure E.17. Most Compliant Residential Code Requirements

Table E.4. Most Compliant Residential Code Requirements (most compliant first)

Checklist ID	Checklist Text
FR19	Dampers installed on all outdoor intake and exhaust openings.
FI9	Programmable thermostats installed on forced air furnaces.
FR2	Glazing U-factor (area-weighted average). Up to 15 sq. ft. of glazed fenestration, including skylights, may be exempted from U-factor and SHGC requirements under the prescriptive approach.
FR15	Building cavities NOT used for supply ducts.
FR4	Glazing labeled for U-factor (or default values used).
FR3	Glazing SHGC value, including sunrooms (area-weighted average). Up to 15 sq. ft. of glazed fenestration, including skylights, may be exempted from U-factor and SHGC requirements under the prescriptive approach.
IN7	Basement wall interior insulation depth.
FR1	Door U-factor. One side-hinged door up to 24 sq. ft. can be exempted from the prescriptive door U-factor requirements.
FR16	IC-rated recessed lighting fixtures meet infiltration criteria.
IN3	Wall insulation R-value.
IN4	Wall insulation installed per manufacturer's instructions.
FI10	Heat pump thermostat installed on heat pumps.
FR17	HVAC piping insulation.
IN12	Air sealing complies with sealing requirements via blower door test.

Figure E.18 displays the commercial code requirements that could be reliably estimated as the most compliant over all the observed commercial buildings in the state studies (complied more than 50% of the time). Table E.5 provides the checklist text associated with the top 14 checklist IDs shown in the figure.

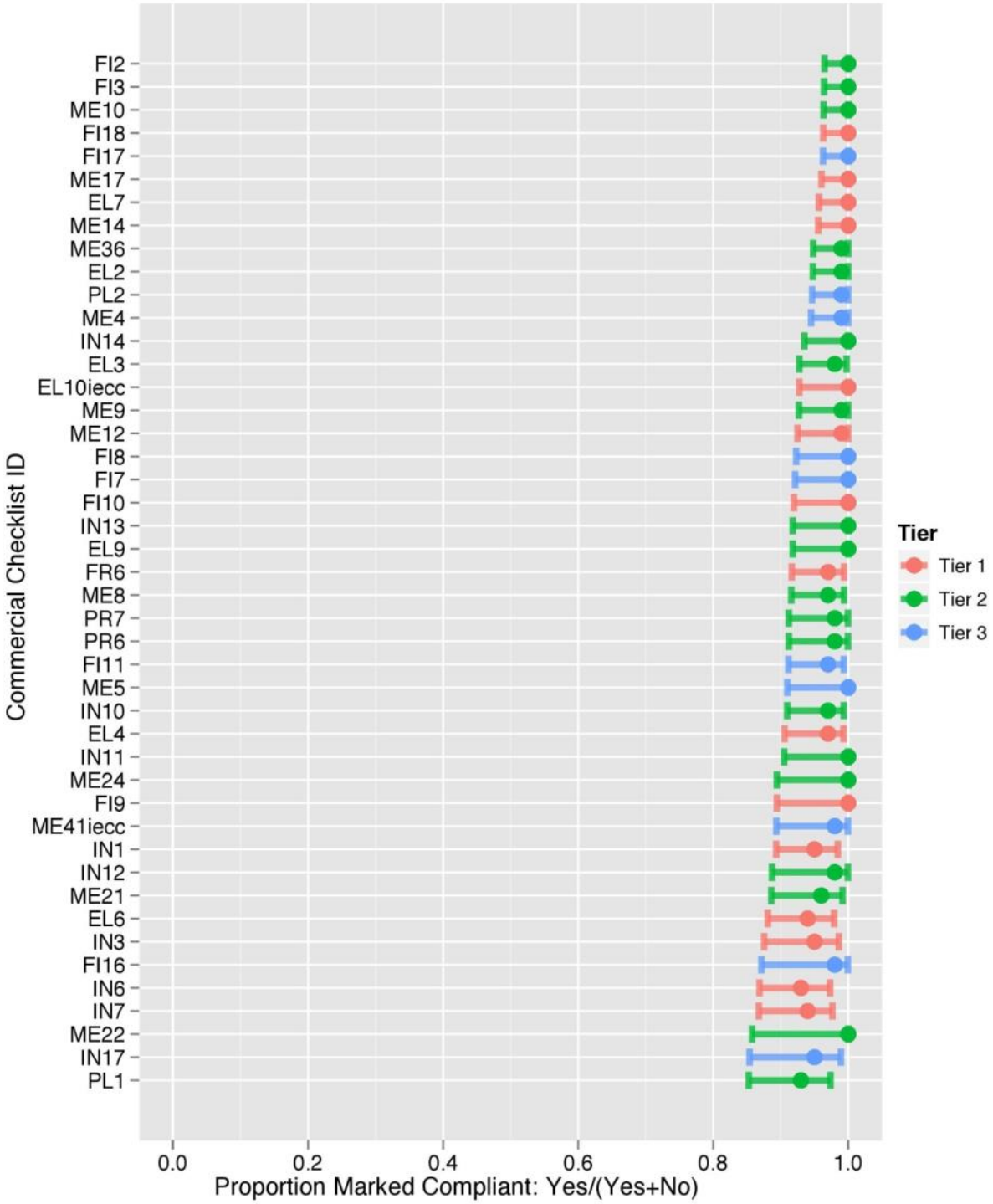

Figure E.18. Most Compliant Commercial Code Requirements

Table E.5. Most Compliant Commercial Code Requirements (most compliant first)

Checklist ID	Checklist Text
FI2	Heating and cooling to each zone is controlled by a thermostat control.
FI3	Temperature controls have the following features: dead band controls, setpoint overlap restrictions, off-hour controls, automatic shutdown, setback controls.
ME10	Ducts and plenums sealed based on static pressure and location.
FI18	Installed lamps and fixtures are consistent with what is shown on the approved lighting plans.
FI17	Furnished O&M instructions for systems and equipment to the building owner or designated representative.
ME17	Zone controls can limit simultaneous heating and cooling and sequence heating and cooling to each zone.
EL7	Exterior grounds lighting over 100 W provides >60 lm/W unless on motion sensor or fixture is exempt from scope of code or from external LPD.
ME14	Means provided to relieve excess outside air.
ME36	Service water heating equipment meets efficiency requirements.
EL2	Independent lighting control installed per approved lighting plans and all manual control readily accessible and visible to occupants.
PL2	Temperature controls installed on service water heating systems <=110 ^{o}F for intended use serving dwelling units and <=90 ^{o}F serving other occupancies.
ME4	Outdoor air and exhaust systems have motorized dampers that automatically shut when not in use and meet maximum leakage rates. Check gravity dampers where allowed.
IN14	Exterior insulation is protected from damage with a protective material.
EL3	Automatic lighting controls for exterior lighting installed.

E.7.3 Code Requirements Most Often Marked "Not Applicable"

Figure E.19 and Table E.6 highlight the residential code requirements that were most often marked "Not Applicable" (NA). Those checklist items with the highest percentage (near 100%) were the items related to sunrooms, pools, and skylights. Figure E.20 and Table E.7 show the commercial code requirements that were most often marked NA.

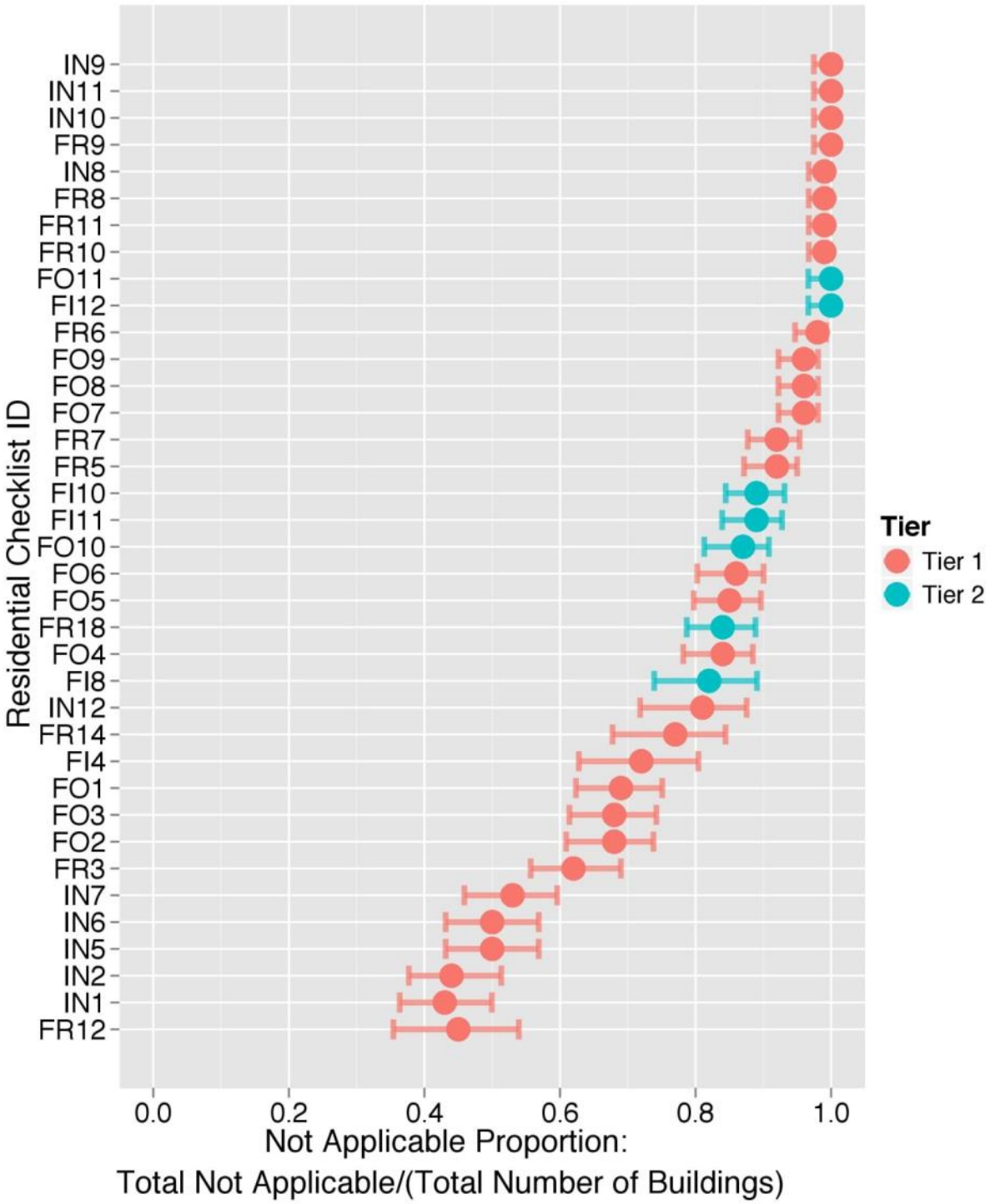

Figure E.19. Residential Code Requirements Most Often Marked "Not Applicable"

Table E.6. Residential Code Requirements Most Often Marked "Not Applicable"

Checklist ID	Checklist Text
FR9	Sunroom skylight U-factor.
IN10	Sunroom ceiling insulation R-value.
IN11	Sunroom ceiling insulation installed per manufacturer's instructions.
IN9	Sunroom wall insulation installed per manufacturer's instructions.
FR10	Mass wall exterior insulation R-value.
FR11	Mass wall exterior insulation installed per manufacturer's instructions.
FR8	Sunroom glazing U-factor.
IN8	Sunroom wall insulation R-value.
FI12	Pool heaters, covers, and automatic or accessible manual controls.
FO11	Snow melt controls.
FR6	Skylight SHGC value. Up to 15 ft^2 of glazed fenestration, including skylights, may be exempted from U-factor and SHGC requirements under the prescriptive approach.
FO7	Crawl space wall insulation R-value.
FO8	Crawl space wall insulation installed per manufacturer's instructions.
FO9	Crawl space continuous vapor retarder installed with joints overlapped by 6" and sealed, and extending at least 6" up the stem wall.

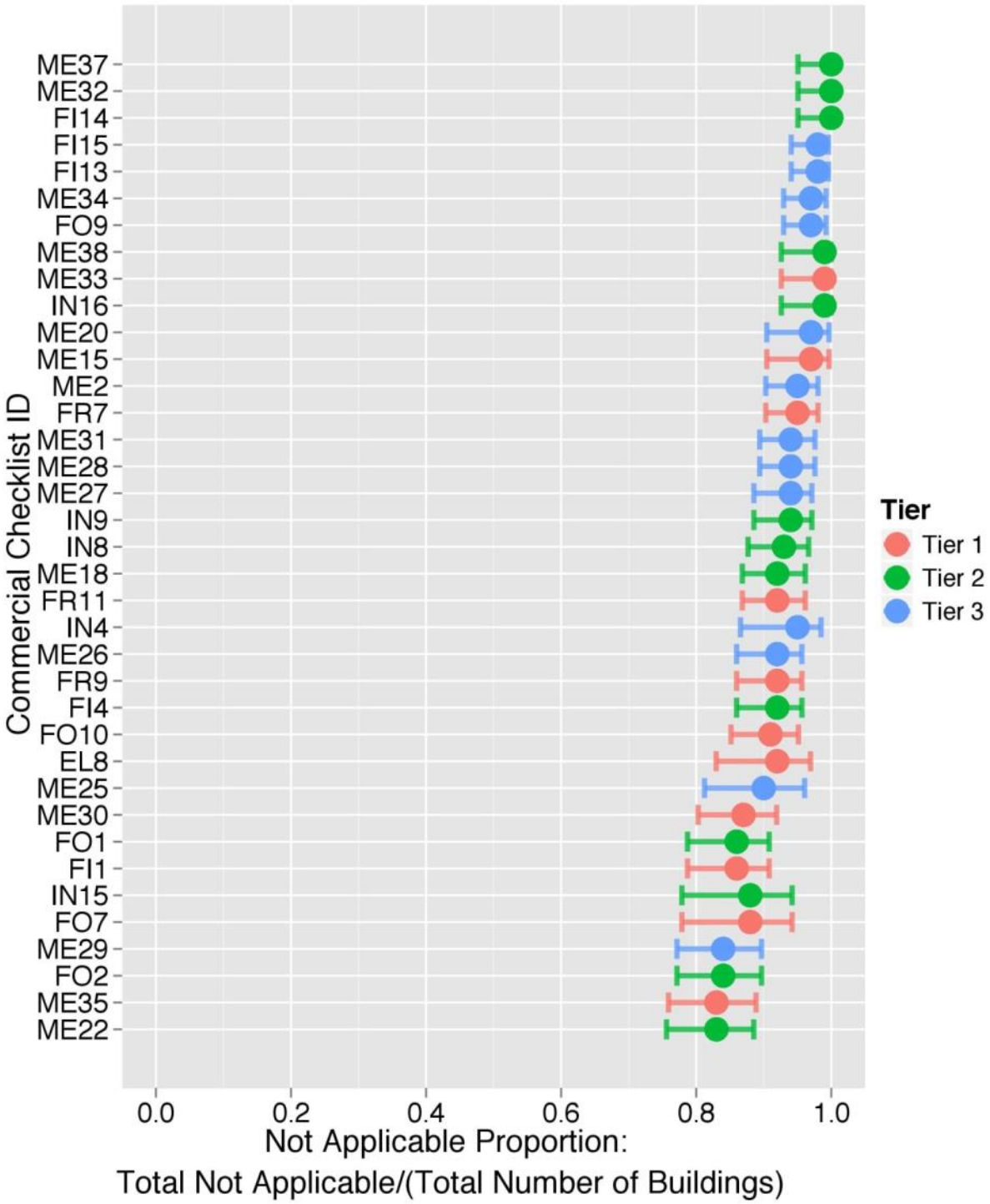

Figure E.20. Commercial Code Requirements Most Often Marked "Not Applicable"

Table E.7. Commercial Code Requirements Most Often Marked "Not Applicable"

Checklist ID	Checklist Text
FI14	Pool covers are provided for heated pools and pools heated to > 90°F have a cover >=R-12.
ME32	Kitchen hoods >5K cfm have make up air.
ME37	Combined space and water heating system not allowed unless standby loss less than calculated maximum. AHJ has approved or combined connected load <150 Kbtu/h.
FI13	Pool heaters are equipped with on/off switch and no continuous burning pilot light.
FI15	Time switches are installed on all pool heaters and pumps.
FO9	Freeze protection and snow/ice melting system sensors for future connection to controls.
ME34	Unenclosed spaces that are heated use only radiant heat.
IN16	Foundation vents do not interfere with insulation.
ME33	Fume hoods exhaust systems >=15,000 cfm have VAV hood exhaust and supply systems, direct make-up air or heat recovery.
ME38	Service water heating equipment used for space heating complies with the service water heating equipment requirements.
ME15	Water economizers provided where required, meet the requirements for design capacity, maximum pressure drop and integrated economizer control and heating system impact.
ME20	Water economizer specified on hydronic cooling and humidification systems designed to maintain inside humidity at > 35°F dewpoint if an economizer is required.
FR7	Performance compliance approach submitted for vertical fenestration area >40% or skylight area > 3%.
ME2	PTAC and PTHP with sleeves 16 in by 42 in labeled for replacement only.

E.7.4 Code Requirements Most Often Marked "Not Observable"

Figure E.21 and Table E.8 identify the code requirements that were most often marked "Not Observable" for new residential construction. Figure E.22 and Table E.9 show the code requirements most often marked "Not Observable" for new commercial construction. The listed code requirements for both residential and commercial buildings are ones that would generally be expected to be difficult to observe during or after construction. Interestingly, the results from comparing Least Compliant Code Requirements to these "Not Observable" items results in a fair amount of overlap for both commercial and residential (e.g., many of these same code requirements also show up in previous tables listing least compliant residential and commercial code requirements). Those code requirements showing up on both lists are marked red in Table E.8 and Table E.9.

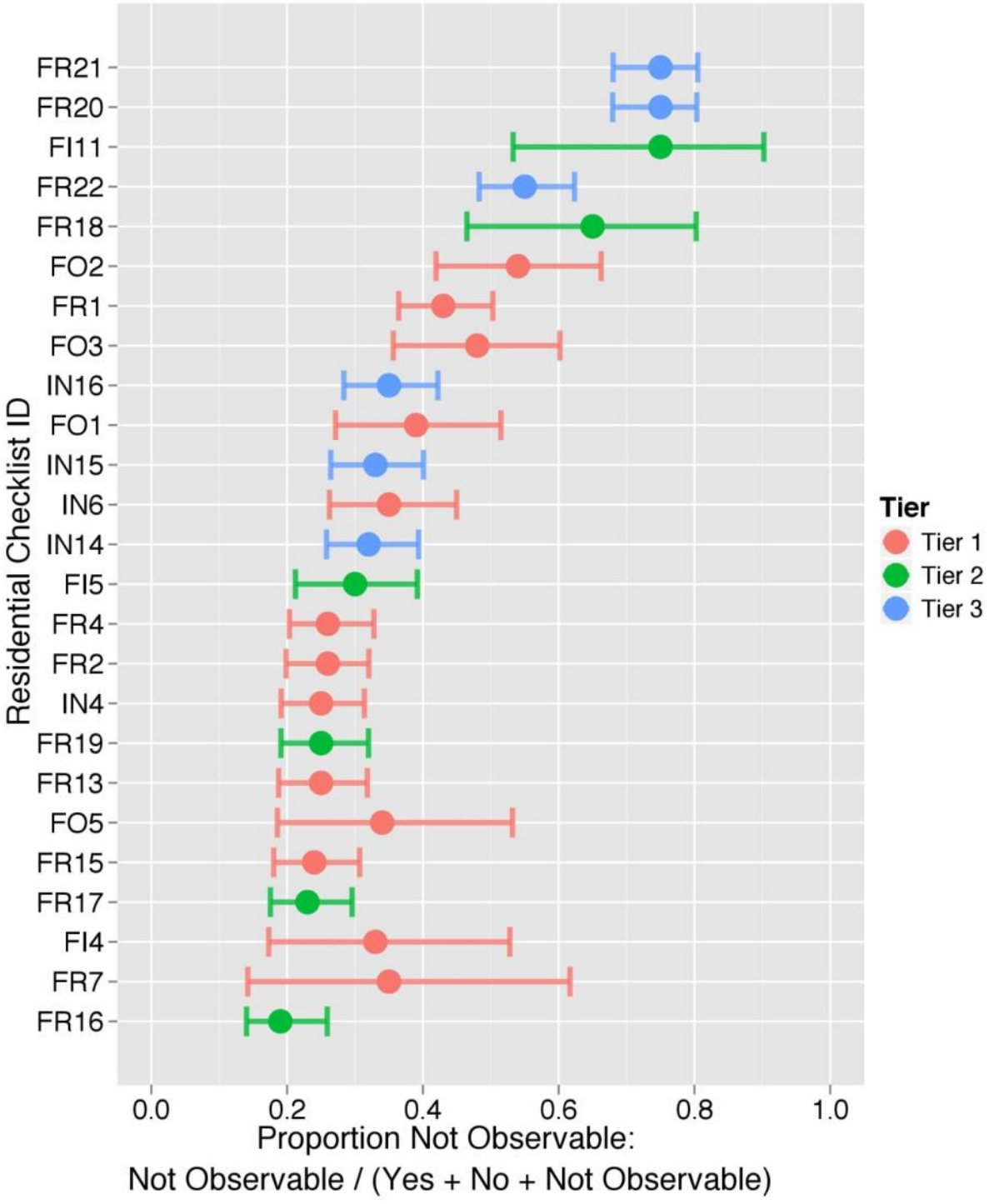

Figure E.21. Residential Code Requirements Most Often Marked "Not Observable"

Table E.8. Residential Code Requirements Most Often Marked "Not Observable" Requirements marked in red are also included among the least compliant.

Checklist ID	Description
FR21	**Swinging door air leakage.**
FR20	**Glazed fenestration air leakage.**
FI11	Circulating service hot water systems have automatic or accessible manual controls.
FR22	**Fenestration and doors labeled for air leakage.**
FR18	Circulating hot-water piping insulation.
FO2	**Slab edge insulation installed per manufacturer's instructions.**
FR1	Door U-factor. One side-hinged door up to 24 sq ft can be exempted from the prescriptive door U-factor requirements.
FO3	**Slab edge insulation depth/length.**
IN16	Air sealing of all other sources of infiltration, including air barrier, via visual inspection. If applicable, verification via blower door should be marked N/A.
FO1	Slab edge insulation R-value.
IN15	**Air sealing of all envelope joints and seams via visual inspection: dropped ceilings, knee walls, assemblies separating garage, tubs and showers, common walls between units, rim joist junctions.**
IN6	Basement wall interior insulation installed per manufacturer's instructions.
IN14	**Air sealing of all openings and penetrations via visual inspection: Site-built fenestration, Window/door openings, Utility penetrations, Attic access openings.**
FI5	**Heating and cooling equipment type and capacity as per plans.**
FR4	Glazing labeled for U-factor (or default values used).
FR2	Glazing U-factor (area-weighted average). Up to 15 sq ft of glazed fenestration, including skylights, may be exempted from U-factor and SHGC requirements under the prescriptive approach.
IN4	Wall insulation installed per manufacturer's instructions.
FR19	Dampers installed on all outdoor intake and exhaust openings.
FR13	Duct sealing complies with listed sealing methods.
FO5	Basement wall exterior insulation installed per manufacturer's instructions.
FR15	Building cavities NOT used for supply ducts.
FR17	HVAC piping insulation.
FI4	**Duct tightness via post-construction test.**
FR7	Skylights labeled for U-factor (or default values used).
FR16	IC-rated recessed lighting fixtures meet infiltration criteria.

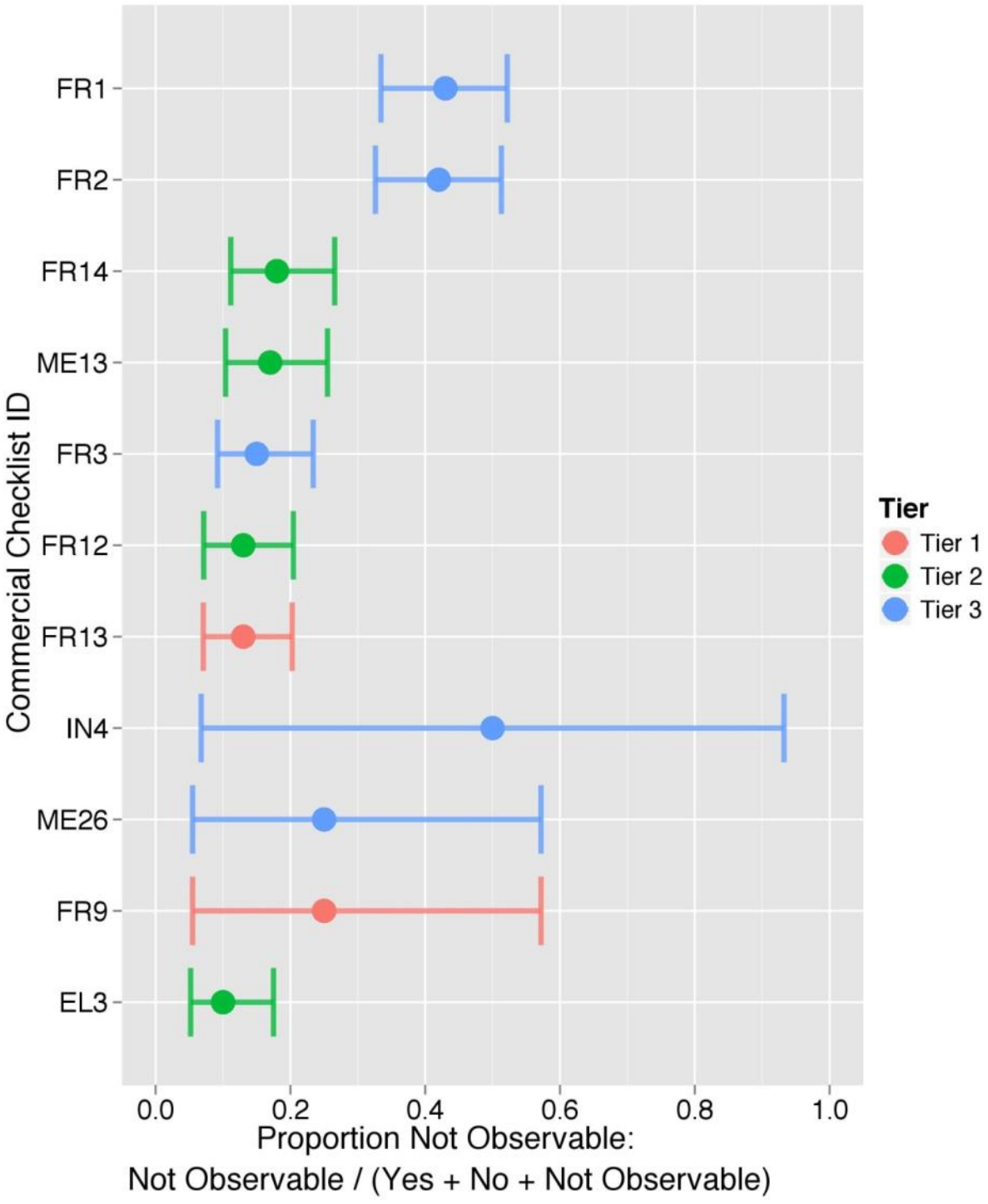

Figure E.22. Commercial Code Requirements Most Often Marked "Not Observable"

Table E.9. Commercial Code Requirements Most Often Marked "Not Observable"Requirements marked in red are also included among the least compliant.

Checklist ID	Description
FR1	**Fenestration meets maximum air leakage requirements.**
FR2	**Doors meet maximum air leakage requirements.**
FR14	**U-factor of opaque doors associated with the building thermal envelope meets requirements.**
ME13	Return air and outdoor air dampers meet minimum air leakage requirements.
FR3	**Fenestration and doors labeled for air leakage.**
FR12	**Fenestration products rated in accordance with NFRC.**
FR13	**Fenestration products are certified as to performance labels or certificates provided.**
IN4	Skylight curbs insulated to the level of roofs with insulation above deck or R-5.
FR9	Skylight fenestration U-Factor.
ME26	Reduce flow in pumping systems of any size to multiple chillers or boilers when others are shut down.
EL3	Automatic lighting controls for exterior lighting installed.

E.8 Compliance by Building System

Code requirements applicable to commercial buildings were grouped by building system (envelope, lighting, mechanical, and service water heating) to produce the plot shown in Figure E.23. Code requirements that were compliant less than 80% of the time are labeled in the figure. The labeled code requirements are the same ones shown in Table E.3, Least Compliant Commercial Code Requirements. This plot highlights that the most non-compliant building system is the building envelope, all of which pertain to air leakage and labeling.

The air leakage rates and thermal properties of fenestration (doors, windows, window walls, curtain walls, storefronts, skylights) are a challenge for third-party evaluators to verify unless each product is labeled to provide the relevant property values. It is difficult for evaluators to time onsite visits to ensure that labels will still be on fenestration, which is one reason for including a "Not Observable" option on the DOE checklists. DOE staff noted many cases where evaluators may have been confused in marking the compliance results associated with these code requirements. For example, in some cases the code requirement for labeling of an assembly was marked as compliant (meaning the labels were present), but the corresponding assembly performance was marked as "Not Observable". In other cases, the air leakage labels were marked as "Not Observable", but the assemblies were marked either compliant or not compliant. It is possible that the compliance of the assembly was found from sources other than the label (such as looking up the relevant data from a third-party certification agency based on make and model number of the fenestration component), but it is more likely that there was confusion in how to treat these requirements. The fact that air leakage requirements (both labeling and performance) show up on lists of the least compliant residential and commercial code requirements, as well as on lists of the most often not observed requirements, is another indication of confusion in how they were evaluated. Perhaps they should be eliminated in future compliance studies, or better guidance should be provided on how to evaluate them. A complicating factor is that not all fenestration is labeled (e.g., site-built fenestration). In such cases, it is very difficult to ascertain compliance other than by using default thermal properties that can be applied based on the type of fenestration product and the number of panels installed.

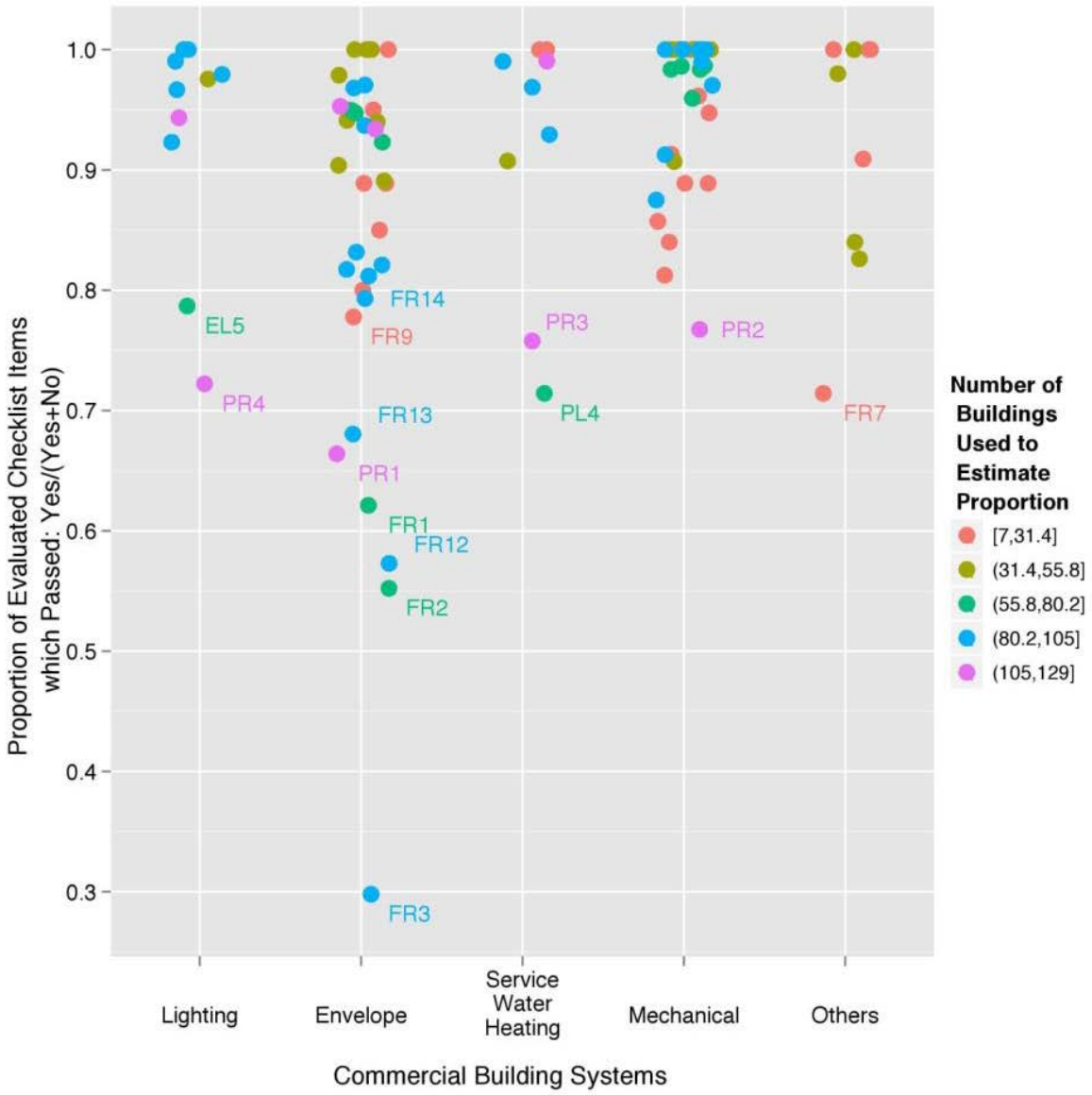

Figure E.23. Commercial Code Requirements by Building System

E.9 Data Analysis Summary

These results show some of the early findings and methods of examining the compliance data from the pilot studies at a national level. As more states complete compliance studies, a more comprehensive set of data will help solidify some of the findings. For example, a large majority of the conclusions for new commercial construction rely heavily on two completed studies, with a few observations from other states.

The process of electronically collecting, storing, and scoring this compliance data can provide valuable benefits in the future. DOE's Score + Store online application proved successful as a central repository for data, and could be developed further to facilitate collection of other sources of compliance data.

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