The Costs and Benefits of Measuring if States Meet 90% Compliance with Building Codes

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ABSTRACT

States having accepted funds from the State Energy Program (SEP) under The American Recovery and Reinvestment Act of 2009 (ARRA) have agreed to implement the statewide energy code that meets or exceeds IECC 2009 for residences and ASHRAE 90.1 2007 for commercial buildings. The states have also agreed to achieve a statewide level of 90% compliance with these building energy codes by the year 2017. The US DOE's Building Energy Code Program (BECP) has developed a recommended protocol for states to use to determine if they exceed the 90% compliance level with the energy code in new and renovated residential and commercial buildings. This paper reports on a study funded by New York State Energy Research Authority (NYSERDA) and ARRA that tests the BECP protocol and performs an assessment of current energy code compliance in New York State. BECP has undertaken an aggressive program to assist states in adopting and enforcing stringent energy codes that has included development of the codes, development of design tools, and support of energy code training, The protocol that BECP has developed uses third-party evaluators to measure code compliance in a sample of buildings. That protocol is being tested in several states, and this paper reports on the experience in testing the protocol in New York. The study identifies issues with the design of the BECP protocol and the checklists. These issues include: self-selection bias, a likely lack of consistency in implementing the protocol among states and across third-party evaluators within each state, and scores that do not closely track the RES*check*™ and COM*check*™ results commonly used currently to establish actual compliance to each state's energy codes. The study recommends that BECP rethink the idea of using third-party evaluators to score energy code compliance in a small sample of buildings and instead concentrate more on helping states establish comprehensive and universal verification of energy-code compliance in all buildings covered by the codes. The paper also suggests that BECP support the development of a robust code compliance system that matches the plans submitted at permitting to permit drawings, requires field inspection reports documenting compliance and deficiencies, and reports permit and verification results to a central database.

Introduction

Recently enacted Federal policies are pushing the states to develop stricter building energy codes. According to Department of Energy statistics, 18 states have adopted statewide residential energy codes that are equivalent to or more stringent than the newest version of the International Energy

Conservation Code (IECC) 2009.[1] Most of the other states have an energy code, but have yet to adopt IECC 2009. At the other end of the spectrum, nine states have no statewide residential energy code, and another seven have codes equal or less stringent than the IECC 2003 version. Twenty-six states have adopted the latest commercial energy code ASHRAE 90.1 2007/2009 IEEC; fourteen have adopted a less stringent commercial energy code; and ten states have no statewide commercial energy code.[2] An integral part of any code's effectiveness is the degree to which designers and builders comply with the code requirements. Compliance rates are dependent on the how far code requirements exceed typical design and building practices, the willingness of design and construction professionals to be trained and adopt new practices, the demands of the owner/buyer, the demands and budget of the buyer, contractors' adherence to following plan specifications, and the level of enforcement. In many states such as New York, building code enforcement is implemented at the local level and subject to variations in expertise, time allocation, and code enforcement priorities in general. Improving energy code compliance has been recognized as a potent tool in increasing energy efficiency and reducing the effects of climate change. The potential savings from increased code compliance appears to justify significant investments in ensuring energy codes are followed. A fact sheet released by the Institute for Market Transformation (2011) estimates that the US will save $2.7 billion in 2020, rising to $10.2 billion in 2040, if $810 million is expended on energy code education and enforcement in order for each state to reach 90% compliance level with current codes. While the $810 million expenditure is not detailed by the Institute of Market Transformation, the authors of this paper advocate that significant structural, not incremental, change in the personnel, milestones of enforcement, and electronic capture of data would be required.

The Federal government is also pushing states to increase each state's enforcement of the code. States having accepted funds from the State Energy Program (SEP) under The American Recovery and Reinvestment Act of 2009 (ARRA) have agreed to implement the statewide energy code that meets or exceeds IECC 2009 for residences and ASHRAE 90.1 2007 for commercial buildings.[3] The states have also agreed to achieve a statewide level of 90% compliance with these building energy codes by the year 2017. The Department of Energy's Building Energy Codes Program (BECP) and Pacific Northwest National Laboratory (PNNL) are implementing a plan to help states achieve a 90% compliance rate. This plan includes code enactment and training support, establishment of a stakeholder group to focus on compliance, interim self assessments. The plan also establishes a protocol by which states will verify that they have achieved the 90% compliance level. PNNL (2010) has published a set of procedures, hereafter referred to as the BECP protocols, with supporting tools that states can use to verify 90% compliance with the codes as required by law in 2017. BECP is funding five cases studies which use the outlined protocols in order to test the merits of and identify issues with the BECP protocol. In addition, several states including New York are performing their own studies to assess the protocol's feasibility and validity. This paper summarizes New York's recently completed experience in testing the BECP protocols in new buildings and evaluating current energy code compliance.

Details of the Building Energy Codes Program Protocols

The procedures outlined in "Measuring State Energy Code Compliance" (PNNL 2010) provide direction on how states can verify that they have met the 90% compliance rate for all building projects covered by the code. Included in the document are detailed instructions on the methodology proposed by BECP for conducting the formal assessment of compliance. This strategy suggests that each state conduct a study by an independent third-party that visually inspects a sample of the state's buildings.

[1] http://www.energycodes.gov/states/maps/residentialStatus.stm
[2] http://www.energycodes.gov/states/maps/commercialStatus.stm
[3] http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_bills&docid=f:h1enr.pdf

The protocol establishes that minimum sample sizes of 44 sites be visited for each of four different categories of construction projects. The categories include new residential construction, new commercial construction, residential renovations, and commercial renovations. The specification of precision is based on a presumed standard deviation of compliance scores of 13% or less. The protocols acknowledge that higher standard deviations will require larger sample sizes; such that if the standard deviation is 20%, the minimum sample sizes rise to 100.

The BECP protocol also describes a number of companion tools that BECP has developed to aid in the assessments. A sample generator that PNNL has developed draws a random sample of counties in which the residential and commercial site visits are to be conducted. BECP has also developed checklists for the evaluators to fill out to determine the degree of energy code compliance of the visited building. An online tool has also been developed to store the raw data from the on-site assessments and to calculate the state's energy code compliance score.

This paper discusses the protocols both in theory and based on the experience in trying to conduct a compliance study while adhering to the BECP protocols. The basis of this report is an assessment of code compliance in New York, see (VEIC 2011). That study tested the BECP protocol for new residential and commercial projects. The study also included surveys and interviews of major stakeholders, a comparison of the BECP protocol results to other compliance algorithms, and additional analysis of energy and dollar savings associated with improved compliance. This paper represents the authors' assessment of the feasibility of implementing the BECP protocols and is not an official position of NYSERDA, which sponsored this research with funding from ARRA.

Implementation of 90% Compliance Test

Sampling and Recruitment

The BECP protocol calls for four sets of samples of 44 each, with the suggestion that as long as the standard deviation of each sample is less than 13%, the results are a valid representation of the compliance level of that category of building. The precision assumes that every building in the state in that category has an equal chance of being selected. Given the sampling and recruiting issues that are discussed below, it is extremely unlikely that states will be successful in drawing random, unbiased samples. The discussion first presents the sampling approach as outlined in the BECP protocol, and then presents a discussion of issues surrounding the sampling strategy and the recruitment of study buildings.

PNNL (2010) and its associate website[4] presents "procedures and tools to help states and jurisdictions measure and report compliance with building energy codes". Included among these tools is a Sample Generator. The Sample Generator begins by assembling the commercial construction starts and residential new construction permits from the US Census. PNNL has assembled the three-year totals of commercial building starts and residential permits for each county in each state. They have also categorized each county into one of the eight DOE-defined US climate zones. If a state has more than one climate zone represented, the 44 sites are allocated to each zone in proportion to the total number of permits/starts in each zone. The sample generator then randomly selects counties, with the provision that any county can be chosen more than once, and with the probability of a county being selected equal to its proportion of permits/starts. The sample plan adds another dimension to the commercial building sampling strategy. The protocol requires that commercial building starts be divided into size categories of small, medium and large to get a better representation of the different size buildings being built in the state.

[4] http://www.energycodes.gov/arra/compliance_evaluation.stm

The Sample Generator provides a convenient means of selecting counties. However, there are several more steps in the sample selection and recruitment process that the BECP protocol does not address. These steps are to select the jurisdictions, select the specific permits to recruit, and recruit the sample. Left to the discretion of the analysts, there is potential for the analysts to take steps that violate the underlying validity of the studies

For the NY study, we purchased residential and commercial data sets of permit data from McGraw-Hill's FW Dodge Reports (Dodge). The commercial data set claims to have all of the individual commercial new construction and renovation projects permitted within the study period for the entire state. From this data source, the study team randomly pulled a statistically valid sample for commercial new construction. For residential data, Dodge only collects projects in a select number of strategic jurisdictions,; thus the sample could not be used to directly generate a sample list. The only comprehensive source of permits is from the jurisdictions. Because it would be costly to visit every jurisdiction in every county selected, the study first selected jurisdictions using the same randomized selection process used to select counties. Because of anticipated recruiting issues, we started with a larger list of potential recruits. The study team then sent letters from the NYSERDA and the NY Department of State (NY DOS) to each jurisdiction alerting them of the study, and our need to obtain a list of all permits issued by that jurisdiction. As the subsequent discussion on the difficulties in obtaining data and recruiting will show, we often had to abandon a selected jurisdiction because we could not get cooperation or the recruiting list was exhausted. This required choosing additional jurisdictions to fill in for those where there were not enough willing buildings to meet the quotas.

The Team met with a wide range of cooperation and access across the jurisdictions. Some jurisdictions sent data after a phone call; many required a personal visit, and a majority insisted that a Freedom of Information Act application be filed (in person) before any data would be released. Clearly, doing the latter, which can take several weeks or months, created challenges for the project timetable and budget. When code officials did cooperate, there was rarely a code official willing or able to provide a list of all or most new construction projects in her/his jurisdiction. In many cases, such lists do not exist electronically. Often a code official would recommend a few homes with which s/he remembered recently working. In other cases, Team members were required to have previously identified new construction sites in order to obtain code official assistance.

The cooperation of the code permitting agency is necessary for obtaining the list of permits and for later obtaining copies of the actual permit application and building plans of assessed buildings. Because New York is a home-ruled state, where the authority rests with the local jurisdictions, neither the Team, NYSERDA, nor the NY Department of State (DOS) had the authority to require that a selected jurisdiction cooperate and turn over the requested materials. When the cooperation of a jurisdiction could not be obtained in a timely manner, the Team was forced to select a new jurisdiction.

The reliance on the goodwill of permit agencies introduces major bias into the process. In general, agencies doing a better job of enforcing codes are likely to be more willing to assist a study on code enforcement, while those doing a less conscientious job may be less willing or able to cooperate. A similar self-selection bias occurs with the recruitment of buildings. This study found that recruitment of participants for on-site studies was much harder than it had been in previous on-site evaluations conducted by the Team. There were two apparent factors limiting participation; this study had nothing to offer the participants except a $100 residential and $150 commercial incentive; and those who did not prioritize energy efficiency did not want to be identified as non-compliant. The study found it was particularly difficult to recruit commercial buildings. To complete the more complex commercial building evaluations, it was necessary for a representative of the building accompany an evaluator for more than one-half day, with virtually no compensating benefits flowing to the building owner/manager. As a result, the Team believes that it only was able to recruit buildings where the building owner/manager was reasonably certain that his/her building had met the code requirements.

The inability to control for self-selection leads the authors to question the validity of the BECP sampling and recruitment protocol. This study began with the full intention of imposing strict control over the sampling and recruitment process to maintain statistical validity. We could not maintain that control both because we could not force randomly selected jurisdictions and buildings to participate, and we did not have a budget that allowed us to spend whatever it took to recruit a statistically valid sample. (For example, we did not have the ability to negotiate a higher incentive payment amount with each potential recruit.) Because the protocol does not have a consistent requirement for selection that is consistently employed by every one of the 50 states, the results of each state will depend on the degree to which evaluation teams adhere to the rules governing valid sample selection. Without strict control from BECP, it is in each state's interest to pay as little attention as allowed to maintaining a valid sample and reducing self-selection bias.

Implementing a Residential Renovation Study

While it was not included in the Scope of Work for the New York study, the 2017 90% compliance requirements extend as well to residential and commercial renovations. When design professionals are involved in larger commercial renovations, a permit is generally pulled. These commercial renovations are captured by Dodge, and the same study approach used for new commercial can be used to look at these types of projects. Getting to 90% for small commercial and residential renovations will be a major challenge for New York, given the almost total lack of permit filing, absence of a database resource listing such construction activity, and current compliance with the energy codes. Improving renovation compliance represents a significant opportunity for energy savings. Very few residential renovation projects in New York pull the required permits. Renovations, additions, and installing heating or cooling systems all require a building permit to be pulled. The newest residential code, 2010 NYS ECCC, requires that all components covered by the code that are "touched" by the renovation project must meet the current energy code requirements. Still, most residential renovations fail to file a permit; therefore whether or not they adhere to the building energy code is unknown.

There is no obtainable data from New York on how many residential renovations are done each year that would trigger efficiency upgrades required by the energy code, but it is quite probable that the number exceeds the number of new homes constructed. As an indication of how few of these renovations have pulled permits, renovation permits constituted just *six percent* of all of the residential permits in the residential file obtained from the Dodge data set. In those homes where permits for renovation were filed, it does not appear that any energy code plan review or energy code enforcement was done. Via phone interviews, the Project Team surveyed the few (20) reachable homeowners doing renovations who filed permits; none of them reported having any interaction with code officials regarding energy code requirements**.** The code compliance study strongly recommends that for renovations New York find ways to better enforce the permit filing requirements first, and then concentrate on enforcement of the energy code. The energy saving potential of doing this may ultimately exceed savings from enforcing new construction codes.

The BECP protocol limits the residential renovations that need to be assessed to "Any work on or in existing residential buildings where all or part of the work being performed is required to meet code and for which a permit was issued, including additions, alterations, and repairs." Limiting the assessment to only those where a permit is pulled is a concession that "PNNL believes is practical." As the New York case illustrates, while practical, the provision produces a distorted view of a small minority of renovations in New York. Limiting the study to only those projects that did apply for code is like testing only college graduates when assessing the effectiveness of the education system. At a minimum BECP should require that states try to quantify to what degree permit data represent renovations. A more meaningful measure of a state's progress towards code compliance would be obtained if data were collected on the progress states are making in getting permits filed, and then on the number of these where the energy code review and inspections are implemented.

Structuring the Inspection

The protocols call for the independent evaluator to make multiple site visits to visually inspect the building to verify code compliance. The BECP protocol has developed a draft commercial and residential checklist for evaluators to use. This paper looks at the reality and costs of completing these checklists and the accuracy with which the checklists reflect energy savings opportunities. The issues focus on three limitations in the proposed protocol: 1) the number and timing of inspection visits, 2) the ability of the checklists to measure the critical factors that determine energy savings, and 3) the calculation of percentage of code compliance.

The number and timing of inspection visits. BECP has developed draft commercial and residential checklists for evaluators to use. These checklists represent an important contribution in that they provide a comprehensive list of all energy code requirements. These checklists were designed to be used while the building was under construction, and call for multiple visits to each building. Code officials doing their job make numerous visits to a building, timing those visits to coincide with critical construction milestones. For example, code inspectors are supposed to visually inspect wall insulation before dry wall can be installed. BECP has designed the construction checklist to mirror that process, such that the independent evaluator coordinates the timing of the visits to be able to examine the actual condition as it was installed.

The authors suggest that relying on multiple visits by a third-party evaluator is neither practical nor appropriate. The independent evaluator does not have access to the building that the code official can obtain. In practice, should an independent evaluator gain the level of access that would be necessary to completely fill out the checklist, that access will have Hawthorne effects, where the observation process itself affects the results. The continued presence of the evaluator or the coordination needed to inform the evaluator that it was time to inspect wall insulation would destroy the independence of the evaluator. Designers, owners, and builders knowing that their site was being inspected would change their behavior. In effect, the evaluator would become a surrogate for the code inspector and the evaluator would end up influencing the results, not measuring them.

Because the independent evaluator does not control the inspection process, the builder is not required to inform the evaluator when sheetrock is to be installed, nor is the builder required to hold off putting up sheetrock until the evaluator has seen the insulation. Under these circumstances, the evaluator will need to persistently monitor the site to make sure that s/he sees the insulation installed. While this may be doable within a local jurisdiction, the BECP protocol calls for a selection of sites across a state, making it impossible for a small set of evaluators to monitor all of the sites. For commercial properties, the construction process takes between six months and several years. Tracing a building’s development would not fit with the BECP requirement calling for annual reports of compliance.

The New York study only had budget to accommodate one visit per site. It was determined that a post-construction visit gathered the most elements of the PNNL Checklist that were obtainable from one visit. The one-visit meant that some elements of the checklists were not observable. This is one of the factors affecting the BECP compliance code scoring process, which is discussed next.

The ability of the checklists to measure the critical factors that determine energy saving. In developing the checklists, BECP faced significant challenges in providing a tool that was comprehensive and could be used consistently by all evaluators. While the visual inspection at the end of the process can capture some items, the most crucial factors are those that require a more sophisticated examination.

As energy codes become stricter, the critical elements move from simple prescriptive qualification, such as a minimum R-value, to ones dealing with quality of installation and performance. The BECP Protocol is the first to attempt to capture these interim-construction details.

Our team recognizes the value of the checklists in their ability to categorize all aspects of the energy code. We have recommended that BECP incorporate these same checklists into existing energy code RES*check*™ and COM*check*™ design software, and BECP, through PNNL has indicated its intention to do this. The checklists will give code enforcers a comprehensive tool that they can use to check plans and field inspect buildings.

The remaining issue for the proposed BECP protocol is whether the use of the checklist by evaluators can be done accurately and consistently by all evaluators so that scores are meaningful. As BECP has acknowledged, some of the code requirements are subjective criteria, as indicated in their draft protocol manual: *"For example, the 2009 IECC has prescriptive code requirements for infiltration, listing 12 generic areas that should be sealed. Section 402.4.2.2 of the 2009 IECC allows visual inspection as an alternative to an actual leakage test in verifying this code requirement. Verifying this requirement through a visual inspection of items related to "caulking and sealing" can be subjective, and it is quite possible that what a code official deemed acceptable would not be deemed acceptable by a third-party evaluator, or vice versa*."

The experience of the NY evaluators is an indication that consistency will be extremely difficult without much greater training and quality control. Even within the NY study, using three inspectors from the same company with similar training and many years of building data collection and auditing experience, the initial results were so sufficiently inconsistent that they required the analysis team to go back over every entry with the inspectors to ensure all used the same criteria. One example of an inconsistency is the definition of conditioned space. The precise definition of conditioned space is central to many of the calculations which are expressed in terms of per square foot. This is a critical value to collect because values such as air and duct leakage rates are built off the square footage. New York code defines conditioned space differently from the definition used by HERS ratings, requiring the study team to re-train its evaluators to calculate conditioned space based on the precise code definitions. In Table 1, we outline some of the issues that arise related to checklist scoring.

Table 1. Data Collection Issues for Energy Code Requirements

Data Collection Issue	Residential	Commercial
Data cannot be collected until end of project	Duct leakage (to outside) rate, house air leakage rate	Lighting power density, commissioning and balancing reports, as-built drawings, O&M manuals
Data can only be collected at specific construction point	Insulation quality, window UA and SHGC	Insulation quality, window UA and SHGC
Data require sophisticated diagnostic tool or specialized training	Air leakage rate, duct leakage rate	Air leakage rate, duct leakage rate, voltage drop
Data collection is subjective	Insulation quality, prescriptive infiltration rates	Insulation quality, infiltration rates, testing of building controls

Calculating Percentage of Code Compliance

The ultimate purpose of these code compliance studies is to develop a statewide average for code compliance. The BECP protocol requires that a state's sector compliance score be determined by calculating the compliance score of each evaluated building using a three-tiered point system. The required measures in the BECP Checklist are divided into tiers that are meant to account for the measures' importance in overall energy saving. Tier 1 measures are given 3 points, Tier 2 measures 2 points, and Tier 3 measures 1 point. Table 2 provides an example of the scoring mechanism from the protocol. In the example below, the building achieved a rating of 37 out of 45 or 82%.

Table 2. Example of Commercial Building Compliance Rating

Building Evaluation	Checklist Requirements	Possible Points	Requirements Passed	Points Received	Compliance Score
Tier 1 Requirements	10	30	8	24	
Tier 2 Requirements	5	10	4	8	
Tier 3 Requirements	5	5	5	5	
Totals		45		37	82%

The individual scores are then averaged. The upper bound of the confidence interval is established by taking the confidence interval at 95%. The BECP protocols allow a state to claim 90% compliance if the upper bound of the 95% confidence interval is above 90%.

We tested the validity of the BECP protocol by comparing the compliance score to two other means of calculating compliance: a trade-off approach and a simulated performance approach.

1. Trade-Off (e.g. RES*check*™ or COM*check*™): used to evaluate overall UA compliance. (The sum of U-factor multiplied by assembly area for the sample building must be less than or equal to that calculated for the code reference building). The score is the percentage of buildings that pass.
2. Simulated Performance (e.g. REM/*Rate*™ or EQuest): used to evaluate the overall energy performance of the building. (The annual energy cost of the sample building must be less than or equal to the annual energy cost of the reference code home.) The score is the percentage of buildings that pass.

The results of the compliance comparisons are shown in Table 3. The comparisons indicated that there is a large discrepancy between the scores produced by BECP and the conventional means by which compliance is assessed. This discrepancy results because the different approaches have different scoring algorithms and because the calculations do not have the same set of inputs, or treat the inputs differently when a value is not observed. For example, because the quality of the insulation was not observed, the actual values could not be entered. For the BECP protocol, unobserved elements are not included in the equation. So insulation quality, a Tier 1 criterion, is left out of both the numerator and the denominator of the formula presented in Table 2. Any code requirements that are Not Applicable (N/A) or Not Observable are not factored into the BECP compliance score. In contrast, RES*check*™ does not account for insulation quality, but only assesses nominal R-values. The Performance approach does account for insulation quality, but when insulation cannot be observed it is rated, by default, a poor quality installation.

Table 3. Comparison of Compliance Approaches

	Metric	Residential (n=44)	Commercial (n=26)
Trade-Off (e.g. RES*check*™ or COM*check*™)	Percent Pass	61%	36%
Performance Path	Percent Pass	64%	NA
BECP Protocol	Percent In Compliance (upper bound of confidence range)	73%	85%
BECP/PNNL Checklists	Percent of Buildings with ≥ 90% of All Code Requirements in Compliance	0%	21%

The higher BECP protocol compliance is due to the fundamental difference in how compliance is calculated by the different methodologies. As stated above, the BECP protocol (as measured by the checklists) evaluates the *proportion of all energy code requirements* that are in compliance. The Trade-off (RES*check*™ and COM*check*™) and Performance (REM/*Rate*™) methods evaluate the *proportion of buildings* that are in compliance. Because the BECP protocol assesses compliance with the energy code in its entirety, there are more code requirements to "get right" or "get wrong" as the case may be. Only about one-third of the residential checklist and twenty-five percent of the commercial tier-scoring points are captured by RES*check*™ and COM*check*™ compliance certificates, respectively. All of the code requirements captured by a RES*check*™ *and* COM*check*™ compliance certificate are designated as Tier 1 (high energy impact) by the checklist. There are, however, many additional Tier 1 code requirements not directly captured by a RES*check*™ and COM*check*™, such as quality of insulation installation and documentation of construction drawings detailing compliance. Thus the PNNL checklist offers an enhancement in the evaluation of those elements (although many of them were not observable in the post-construction study in New York).

One of the concerns regarding the BECP protocol is that it produces a relatively high score that may have the unintended result of leading states to complacency rather than to action. The New York scores are not that far off 90%. By comparison, when looking at the total percent of buildings that were compliant with *at least* 90% of the energy code, the result for residential buildings is 0% and for commercial 21%. The residential score would likely have been even higher if the study had not excluded the 23% of residential new construction that participates in the ENERGY STAR® programs. Our study did not include ENERGY STAR® or commercial New Construction Program buildings because we assumed that the vast majority of these buildings would be 100% code compliant. Given the small budget, it did not make sense revisiting these buildings since a detailed assessment was already available. It was our intent to add these buildings back into the results; however, it became apparent that ENERGY STAR® buildings are not 100% energy code compliant. These programs focus on aspects of a building that affect energy use, and do not necessarily look to make sure that every energy code requirement is met. The BECP checklists include a number of energy code requirements not covered by the residential and commercial new construction programs.

Ultimately, the checklist and code design tools will need to be closer so that the BECP code compliance test reflects what is required in practice. In this case, we recommend that RES*check*™ and COM*check*™ be updated to include the checklist elements that are not covered by the tools. It is heartening that early indications are that PNNL is pursuing this goal. If the tier system is to be used, it will likely need to be tweaked to get points closer to each element's effect on energy use. There may need to be more tiers to differentiate elements with the largest energy impacts from other Tier 1 elements.

Costs of Inspection

The BECP Protocol does not give any estimates of the costs involved in doing these studies. BECP may be drastically underestimating the level of effort for doing these projects. For example, the following is stated in PNNL (2010) as the higher limits of costs for a residential study: "Plan review and four field visits, at the higher end of estimated time, could result in close to five hours per building." That estimate seems reasonable for the effort a code official would expend doing a thorough residential compliance check. The problem is that the evaluator is not in the same position as a code official, and those differences add considerable time to that required builder/code arrangement. In the evaluator's case, s/he will not know when to schedule the four on-sites to coincide with the building's progress. To accomplish what a code official can do in four visits may require many more visits. While the code official is local, the odds of the evaluator being so are small. Remember, to gain consistency the study should have as few field evaluators as possible. This means one evaluator may be covering regions hundreds of miles wide. Finally, the evaluator has no authority to inspect the home and can only do so with the cooperation of the code official and the building owner. The five hours does not build in any time to obtain sufficient data and recruit participants; an effort that the New York study proved to be extremely time-consuming (approximately 14 hrs per residential site).

Preliminary estimates for the NYSERDA study indicate that onsite inspections for these studies will be expensive to implement. It is easy to see the costs of the 44 on-sites specified for each of the four sectors costing more than $1 million annually.[5] While it may be possible to do these more cheaply, the less budget allocated, the less able are studies to make the multiple visits or to use recruitment approaches that lower self selection bias.

Policy Discussion

The authors' experience in testing the BECP protocol's proposed third-party evaluation of compliance suggests that the current approach has significant issues and will need attention if it is to be used to produce a valid scoring mechanism to compare states' progress towards meeting the 2017 energy code 90% compliance requirement. The current approach would require the states to spend upwards of a combined $50 million to produce test scores that are compromised by a series of issues: serious self-selection bias; a lack of standardization in application among states and across evaluators within each state; scores that do not closely track the RES*check*™ and COM*check*™ approaches used to establish actual compliance to the state's energy codes; the ability of third-party evaluators to gain proper access to buildings and building records; and potential biases from those buildings being observed increasing their compliance (Hawthorne effects).

The authors acknowledge that there are substantial arguments as to why tracking compliance is needed. By all accounts, better enforcement of stricter building energy codes is a massive opportunity for saving energy. All states need to be involved and the Federal government has a responsibility to see that all of the states, because they accepted ARRA funds, rigorously enforce the new building energy codes. This section of the paper discusses whether there might be better ways to measure states' performance in meeting energy code compliance that BECP should consider instead of proceeding with implementation of the current BECP protocol.

[5] It is worth noting that the standard deviation for the New York residential study had a standard deviation well above the 13% anticipated by BECP. Under the BECP protocols, the required sample size would be closer to 100.

The study done for NYSERDA not only tested the BECP protocol, it also included a broader evaluation of the current code compliance status in New York and a policy assessment of what steps New York will need to take to improve energy code assessment. These broader evaluation tasks produced a more thorough assessment of current code compliance, and they provided many clues as to where and why current compliance falls below 90%. The study also produced a roadmap for New York State to guide it in improving code compliance. That roadmap indicates that significant structural, legislative, and economic changes will need to be made if New York is to seriously improve compliance with future energy codes that are becoming stricter and more complex.

It is our recommendation that BECP concentrate on encouraging states to identify the barriers to compliance and develop comprehensive plans to address them prior to 2012. While states are encouraged to do some self-assessment of the current situation, there is no formalized requirement that states do so. What's needed in addition to the assessment envisioned under the protocol is a more robust evaluation of the entire market to identify the reasons behind non-compliance. A full evaluation of code compliance, such as was done in New York, can give states the information they need to vastly improve energy code compliance. Many of the more important recommendations from the NYSERDA study will require years to develop. If other states are to implement these types of changes, they need to begin now to identify the problems and implement changes. A strategy from BECP that focuses most of its evaluation attention on the 2017 scoring test from a sample of buildings diverts attention from much needed *during-construction* evaluation that is needed right now.

One of the focuses of the NYSERDA study was to develop mechanisms by which the state can monitor its own progress towards energy compliance. The approaches suggested in that study are applicable on a national basis, and may offer BECP alternative ways for some or all states to verify that they are achieving 90% compliance. The heart of the New York recommendation is greater collection of actual permit and code compliance data. Currently New York does not have a centralized database of permits or other energy code information. Constructing such a database will be a challenge given its home-rule status, but such a database is necessary to monitor energy code compliance.

The study finds several issues with the current compliance process that if changed would greatly enhance energy code compliance. The first issue is that energy code compliance documentation is not consistently submitted at the time of permitting and when it is submitted there is seldom more than cursory review of that documentation by the code officials. The study suggests that projects produce construction drawings that clearly show the specific location of each element mentioned in the energy code plan and document critical calculations, such as HVAC loads and lighting power density, on the drawings. The study also sees a need for someone to check and verify that the elements included in the energy plan are in fact properly installed during construction. The study also sees a need for someone to check and verify that the as-built building has the same elements included in the energy plan. We have identified three forms we think BECP should add to the RES*check*™ and COM*check*™ software packages: 1.)a Design Documentation Checklist to match energy plan to drawings, 2.) an Interim Construction Inspection Checklist for inspector to use in collecting data during construction, and 3.) a Final Construction Inspection Checklist that certifies that as-built construction matches the energy plan.. These checklists would transform RES*check*™ and COM*check*™ from design assistance tools to full energy code implementation tools.

The NYSERDA study reveals that code officials focus most of their attention on health and safety matters and leave most of the energy code compliance responsibility to the design professionals or builder representatives who fill out the energy plans submitted with the permits. While there will be a few code officials with the expertise, time, budget, and willingness to police energy codes, the study recognizes that the dependence on design professional and builders for energy compliance is unlikely to change in the future. To address the limited capacity of NYS code officials to assess and verify compliance with energy codes, the study recommends that NY DOS establish a "Certified Energy

Inspector" (CEI) accreditation or license to perform these checks for the builder. Recognizing that someone will need to monitor the work of the CEI, the study recommends that NY DOS and local code officials collectively provide QA/QC to make sure that CEIs are doing a good job. It is our recommendation that New York adopt this type of first-party (design professionals and CEIs representing the building owner) verification, with some second-party (local code officials and NY DOS) providing oversight be used to verify energy code compliance.[6]

The relevance of these recommendations to BECP is that this approach, if properly monitored, would provide a much more complete assessment of code compliance than could be gathered by an independent third-party evaluator. More importantly, complete sets of data are collected in every building in real time and not just from a small biased sample collected after the fact. This approach is first-party self-reported. However, the process includes certification of the CEIs and design professionals who would be required to put their signature and stamp on the documents. Threats of loss of livelihoods, coupled with QA/QC and periodic evaluation of the program should keep the vast majority of professionals honest and accurate in their reporting.

We offer this example of how New York can improve its own code compliance efforts as a way of suggesting that more effort needs to go towards actual verification of energy codes during the construction of all buildings. States should be encouraged to establish mechanisms that verify that buildings built in the state comply with the code. And BECP should move towards allowing first-party reporting to measure compliance. BECP should also consider other metrics that demonstrate the degree to which a state is enforcing the code: these could be number of permits with RES*check*™ and COM*check*™ included, number of jurisdictions requiring that building drawings match the energy plan, and number of buildings receiving post-inspection inspections.

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[6] Because of New York's homed-ruled status, this program would need to start as a voluntary program. Studies would need to be done on compliance rates in non-participating jurisdictions.