New York State Energy Research and Development Authority

New York Energy Code Compliance Study

Final Report

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New York Energy Code Compliance Study

Final Report

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NOTICE

ABSTRACT

This report presents the results of a Study on the rate of compliance with the New York State (NYS) energy code. The Study tested the protocols developed by the US Department of Energy to determine if NYS's new and renovated residential and commercial buildings exceed the 90% compliance threshold that states will be will be required to meet by 2017 as part of ARRA legislation. This Study performed detailed plan review and field inspections on 44 newly constructed residential and 26 new commercial buildings. The Study also included interviews with policy makers, contractors, engineers, architects, and code officials; and surveys of architects, homeowners, builders, and code officials who planned, constructed and inspected renovations. The report found that the building energy code compliance rate for buildings built under the ECCCNYS - 2007 energy code is below 90%. The Study concludes that changes in focus and operation will need to be made by the federal government, NYS, local jurisdictions, builder/contractors, and design professionals if NYS is going to meet the 90% compliance level for the new, stricter ECCCNYS - 2010 energy codes that became effective in December, 2010. The research recommends that NYS adopt procedures that require that permits be required to include signed energy plans, that all energy code requirements be shown on construction drawings, and that an Energy Specialist (ES) certify that all of the components of the energy plan are included in the actual construction. The Study also recommends that the NY Department of State (DOS) oversee certification of Energy Specialists and provide QA/QC audits of the ES process. NYSERDA will play a critical role in bringing the several necessary stakeholders together to in order to ensure these changes are implemented. There also may be several roles that NYSERDA and DOS would collaborate on to determine the most feasible methods for creating this market and enforcement change.

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DEFINITIONS AND ACRONYMS

Acronym	Description
ACCA	Air Conditioning Contractors of America
ACH_{50}	Air Changes per Hour (at 50 Pascals of pressure)
AEC	Architectural Energy Corporation (REM/*Rate*™ developer)
ARRA	American Recovery and Reinvestment Act
As Built	REM/*Rate*™ model of the verified home (as it was built)
BECP	Building Energy Codes Program
BPI	Building Performance Institute
ES	Energy Specialist
CFM_{50}	Cubic Feet per Minute (at 50 Pascals of pressure)
CFM_{25}	Cubic Feet per Minute (at 25 Pascals of pressure)
COM*check*™	Software developed by the U.S. DOE to automate demonstration of commercial energy code compliance
CSG	Conservation Services Group
DDC	Design Documentation Checklist
ECCC NYS	Energy Conservation Construction Code of New York State
ECTD	Energy Code Tracking Database
FCIC	Final Construction Inspection Checklist
FOIA	Freedom of Information Act
FOIL	Freedom of Information Law
Grade	Measurement of insulation installation quality
HERS	Home Energy Rating System
HVAC	Heating, Ventilation, and Air Conditioning
ICIC	Interim Construction Inspection Checklist
IECC	International Energy Conservation Code
PNNL	Pacific Northwest National Laboratory
QA	Quality Assurance
QC	Quality Control
REM/*Rate*™	Residential energy analysis, code compliance, and HERS rating software
RES*check*™	Software developed by the U.S. DOE to automate demonstration of residential energy code compliance
RESNET	Residential Energy Services Network
UA (Overall UA)	Sum of U-Factor times total assembly area

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EXECUTIVE SUMMARY

E1. INTRODUCTION

This New York Energy Code Compliance Study (the Study) was funded by the New York State Energy Research and Development Authority (NYSERDA) with funds from the American Recovery and Reinvestment Act of 2009 (ARRA). The research was conducted by the Vermont Energy Investment Corporation (VEIC), along with subcontractors: Wirtshafter Associates, Inc., Cx Associates, Energy Futures Group (EFG) and Conservation Services Group (CSG), (the Team).

This Study investigated the degree to which recently constructed New York buildings comply with the New York State Energy Conservation Construction Code (ECCCNYS). As a condition of receipt of ARRA funds, New York must achieve a 90% compliance rate by 2017 with the minimum performance levels established by the International Energy Conservation Construction Code – 2009 (IECC) for residential construction and ASHRAE 90.1 – 2007 for commercial construction. A protocol establishing the process to verify 90% energy code compliance was created by the Pacific Northwest National Laboratory (PNNL) as part of the U.S. Department of Energy (DOE) Building Energy Code Program (BECP).

This suggested BECP Protocol, published as "Measuring State Energy Code Compliance" (report issued March 2010) was used as the basis of this Study. The Study evaluated compliance rates associated with the code under which the projects were constructed (2007 code for 44 residential and 22 commercial projects; 2004 code for four commercial projects).

The primary objectives of the Study were to:

1. Calculate the percent of compliance per the suggested BECP Protocol with:

    a. The code in effect at the time each studied building was permitted (ECCNYS – 2007 for residential construction; ASHRAE 90.1-2004/2007 for commercial construction); and

    b. Next-generation codes (implemented after the Study subject buildings were constructed) for residential buildings using the IECC - 2009 (on which the ECCCNYS - 2010 is based).

2. Calculate lost savings from non-compliance.

3. Create a roadmap for New York State to meet the 90% compliance rate by 2017.

To meet these objectives, the Study conducted extensive plan reviews and select onsite inspections using, to the extent possible, the suggested BECP Protocol. The recommendation of the Protocol to perform 176 onsite evaluations (44 for each of the four construction sectors (new construction *and* renovation for both residential and commercial buildings) did not occur due to budget constraints and limitations of the Protocol when applied to New York. However, testing the feasibility and difficulties of the Protocol's suggested methodology for establishing compliance rates proved valuable in establishing a direction for ongoing compliance monitoring, regardless of the edition of the code in effect.

The Study also surveyed 179 active code officials, 61 builders and contractors, 69 architects, and 20 homeowners who undertook renovation projects. Other interviews were conducted with owners, contractors, architects, engineers, and code officials associated with the Study's eight commercial case studies, and eight interviews were conducted with policy makers within and outside the State.

E2. CONCLUSIONS AND KEY FINDINGS

E.2.1 DOE/BECP Methodology and Protocol for Establishing Compliance

The voluntary and early edition of the DOE suggested BECP Protocol - the first national attempt to establish compliance rates - was followed and expanded for this Study. This Protocol provides the means to confirm each state's compliance with minimum energy codes identified by the Secretary of Energy, a condition of receipt of funds available through ARRA.

The suggested BECP Protocol includes recommended directions for minimum code adoption and equivalency, annual measurement, planning for compliance evaluation, onsite compliance evaluation procedures, and evaluation checklists. Of these topics, implementation of components related to generating sample populations, generating building metrics, and using the evaluation checklists were most challenging and required extensive coordination with DOE. *The Measuring State Energy Code Compliance* report explicitly states that the procedures and tools developed by PNNL for measuring compliance are not required and may be adapted as necessary. As a result, the Team adapted a number of the suggestions for practical and budget reasons. The following is a summary of the limitations and challenges associated with the suggested Protocol which make the reported compliance rates approximations, rather than precise results:

A. <u>Scoring Mechanism.</u> Historically there has not been a consistent method of evaluating compliance rates across states. The scoring methodology developed by PNNL is a new way of calculating a compliance rate. Compliance is expressed as the *percentage of all energy code requirements that have been met*, rather than the *percentage of buildings that have met all energy code requirements*. This scoring methodology was developed as a recommendation for evaluations to be performed *in* *multiple stages during construction*. For practical reasons, including lack of timely permit data, the Team adapted this methodology to a *post-construction* evaluation. Since the suggested BECP Protocol was under development at the time of the Study, the numerical findings of this Study should be considered an approximation from observable post-construction conditions. Of more value is the Team's identification of where gaps occur and recommended procedures to address those gaps (discussed below).

While the new method of calculating compliance rates produced unexpectedly high results, the Team also assessed the buildings based on more commonly used methods of evaluating compliance, RES*check*™ and COM*check*™. These methods produced lower compliance rates, confirming the important point is that no single approach can identify an exact rate of compliance.

<u>Under-statement of Energy Impact</u>. The suggested BECP Protocol produces a compliance rate that incorporates *all* requirements of the energy code – both component energy performance and administrative requirements. Because many code requirements have little or no direct *energy* impact, buildings can score relatively high when documentation requirements are met. Although the intention of the suggested Protocol was to weight high energy impact code requirements more heavily, the Team found that the compliance rates produced by the suggested Protocol is not a fully accurate assessment of the compliance gaps as they relate to energy impact for the State. PNNL has indicated that creating a nationwide energy-impact weighting is challenging, if not impossible, given the wide variation in factors that have high energy impact in different climate zones and differing local building practices. For example, only in some parts of the country are buildings typically built with basements, potential locations of high energy leakage.
By contrast, RES*check*™ and COM*check*™ look only at building *component* performance – the HVAC, electrical and *en*velope systems –impacting the building's actual energy consumption. Compliance rates produced by RES*check*™ and COM*check*™ were in a range much lower than other code compliance studies using the suggested BECP Protocol and more aligned with rates expected by the Team.

B. <u>Implementation Cost.</u> This Study was funded at $650,000 for only two sectors – new (not renovated) commercial and residential buildings. The Team estimates it would require a minimum of $1 million for an outside evaluator to follow the suggested Protocol for all 176 buildings included in the four sectors (new *and* renovated commercial and residential buildings)].[1] This

[1] Building selection requires an extensive pre-selection process, made extremely difficult due to lack of easily accessible permit data. Building evaluation requires plan review and up to four site visits during construction. Costs are affected by the high level of code and construction expertise required for the

broad estimate includes some anticipated streamlined, cost-saving recommendations by PNNL but does not include the costs of multiple visits to sites. No costs have been estimated for the time expended by the owners and public sector entities needed to coordinate the effort and to provide data and support.

E.2.2 Application of DOE/suggested BECP Protocol to New York State

Within the diffused code enforcement system of New York, a home rule state, some local governments chose not to participate or did not have the resources available to make the permit data and code submission information available to the Team. The Team adjusted the explicit selection protocol, albeit with extensive efforts to maintain the intentions of randomization, wide geographic distribution, and distribution across commercial building type and size.[2] As previously noted, the Study focused on new construction and did not perform an evaluation of renovation projects.

A. <u>Modifications to suggested Protocol: Sample Sizes and the Random Sampling Process</u>. Precise adherence to the recommended sampling process was not feasible due to: the lack of readily available data on recent construction and renovations; the difficulties encountered in gathering required information; and the funds available for the Study. The Team made adjustments and redoubled recruitment efforts due to several obstacles:

- *Inadequate Data, Statewide Construction Activity.* The Team attempted to use Dodge Data as the source for both commercial and residential project selection. However, because the Dodge Data database is maintained to resell contractor and trade ally information to firms serving commercial projects, it is most accurate in capturing information on mid-or large-scale commercial projects, inadequately covering smaller commercial projects. Dodge Data does not create a statewide compilation of all residential projects, listing only some projects in a non-random selection of key economic areas.

- *Inadequate Data, Specific Projects.* Other than Dodge Data, no other encompassing source of information is available to identify potential projects or evaluate energy-related information on specific buildings. While the on-site evaluation required approximately three to four hours, the most extensive portions of time were in the following tasks:

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evaluation, in particular for larger and complex commercial projects. Travel distances, coupled by the desire to maximize evaluation consistency by using the fewest number of trained evaluators, further increases the cost of the implementation.

[2] Nine other states have recently participated in voluntary pilots with PNNL. Lack of documentation and difficulty in recruiting were cited as some of the top challenges for all of the states, so this experience in New York was not uncommon, as reported by PNNL.

- *Acquisition of sites* due to a lack of permit data for randomized selection, resistance from code officials in some jurisdictions, and difficulty in reaching and obtaining consent for participation by building owners. Code officials could not be required to provide building records or links to projects, and in some instances records could not be readily obtained.

- *QC of data* due to inconsistencies between evaluators for elements which were not observable post-construction or due to interpretation of certain characteristics, such as "conditioned space," (defined differently by ECCCNYS and REM/Rate – the latter being commonly used by the Study's on-site evaluators).

As a result of these challenges, the Team represents the results using the suggested BECP Protocol as likely biased upward due to a higher tendency for participation by building owners with better compliance and code officials providing stronger code enforcement.

B. Inadequate Information on Construction Activity Statewide. The scope of the Study's findings was limited by the under-representation of all construction activity in the state.

- *Renovation Projects.* The lack of recorded data did not permit statistical information to be gathered for residential and commercial renovation as required by the suggested Protocol. (Only 6% of the residential projects noted in Dodge Data are renovation projects, a number likely significantly lower than the actual number of renovations that occurred in New York.) Further, until the December 2010 modifications to Article 11 of the NYS Energy Law, renovation projects were not required to be fully code compliant.

- *High Performance Buildings.*[3] ENERGY STAR® homes, commercial buildings participating in NYSERDA's Commercial New Construction Program (NCP), and LEED-certified buildings were excluded from the Study due to the Team's prioritization of efforts. The Team's prior experience with ENERGY STAR® and NCP programs made it reasonable to assume these buildings achieve or nearly achieve 90% compliance. ENERGY STAR® homes alone are estimated to represent 23% of the new residential construction market; and 32% of the state's non-residential construction (by floor area) participated in NCP between 1999 and 2007.

[3] Estimates based on territories eligible for existing NYSERDA programs.

E.2.3 Compliance Rates and Lost Savings

A. Compliance Rates of Buildings Constructed under the ECCCNYS - 2007 and IECC – 2009.

Using the codes in effect at the time of permitting, neither the commercial nor residential sampled buildings meet the ARRA goal of demonstrating 90% compliance – according to the suggested BECP Protocol which calculates the *percent of all individual code requirements that are in compliance*. The Team also analyzed compliance with the methods (based on a UA pass/fail test) which is commonly used to obtain building permits: RES*check*™ for residential buildings and COM*check*™ for commercial buildings. **This method also shows the surveyed buildings do not meet the 90% compliance threshold.**

Table E-1: Commercial and Residential New Construction Energy Code Compliance Rates of Sampled Buildings

Sector	Code Evaluated	Suggested BECP Protocol Compliance Rate – *Percent of All Code Requirements in Compliance* (Upper 95% Confidence Level)	RES*check*™ (Residential) and COM*check*™ (Commercial) *Percent of Buildings that Pass the UA Pass/Fail test*
Residential	ECCCNYS - 2007	73%	61%
Commercial	ASHRAE 90.1 – 2004/2007	85%	36%

Under the suggested BECP Protocol (for the code in effect at the time each studied building was permitted), the upper confidence bound (95% confidence) compliance rates for residential are 73% and for commercial are 85%. The suggested BECP Protocol expresses compliance as “the percentage of *all energy code requirements* that have been met,” rather than “the percentage of *buildings that have met 90% of energy code requirements,”* which has been a common way of measuring code compliance historically. The suggested BECP Protocol uses a component checklist that follows the energy code requirements with scores for both energy related components and the administrative documentation related to energy consumption. Code requirements with high energy impact are weighted more heavily than code requirements with little or no energy impact, such as administrative documentation. For example, the Protocol’s checklist assigns three points for a gas boiler that meets code energy levels and one point for having system maintenance documentation accessible to the building owner. The Team believes that the final overall score of the building following the suggested BECP Protocol reflects many of these administrative compliance items, overshadowing the score achieved for the components’ actual energy efficiencies.

In contrast, the DOE RES*check*™ and COM*check*™ analysis tools only evaluate building components that directly affect the building's energy consumption – HVAC, electrical system and envelope efficiencies. These tools are currently used by the design industry to prove code compliance, and New York State requires COM*check*™ documents to be submitted with all commercial building permit applications. Instead of a percent compliance score, these tools provide an overall building Pass/Fail score based on UA values. According to the documentation available to the Team, 100% of the buildings with this submitted documentation were designed to meet code. (Note that for the residential sector, only 68% of buildings had submitted the required RES*check*™). On analysis of the actual construction of surveyed buildings, the Team found discrepancies between what was designed and what was ultimately built: 61% of the residential and 36% of the commercial buildings were in compliance with the applicable requirements of the code.

In summary, this sample likely overstates statewide compliance rates because it includes only sites where both the code jurisdiction and building owner volunteered to cooperate. In addition, the differences between the suggested BECP Protocol and the RES*check*™ / COM*check*™ scores indicates the danger of assuming New York buildings are as close to 90% compliance as the suggested BECP Protocol scores indicate. In order to elevate the compliance rates to the 90% requirement and truly impact the energy performance of the buildings, the State will need to encourage changes to actual building practices and strengthen the enforcement of the code. The Team strongly recommends implementing the recommendations developed in this Study and detailed in the following sections.

<u>Renovation Projects.</u> ARRA requires that energy code compliance rates for residential and commercial renovation projects exceed 90% compliance with IECC - 2009 / ASHRAE 90.1 2007 levels by 2017. The Team found few permits issued for residential renovations and a focus in the commercial sector on substantial renovations. Confirmed by telephone surveys, the Team determined that renovation projects (particularly in the residential sector) are likely to have lower compliance rates than new construction since these projects are unlikely to seek permits and subsequently benefit from interaction with the code or code official. Projects that do enter the permitting process in the commercial sector may be less scrutinized for code compliance than their new construction counterparts. It is often difficult and time consuming to determine the portions of a renovation that are required to be brought up to code and, because of the uncertainty, items are often overlooked.

B. Lost Energy Savings.

The lifetime lost energy savings from energy code non-compliance (assuming sample opportunities represent state averages) over a 5-year building cycle (residential and commercial new construction) is a minimum of $1.3 billion and could easily be more, depending on a range of assumptions (five years was chosen as a reasonable planning horizon over which lost savings from energy code non-compliance could be analyzed and presented without appearing over-inflated or unrealistic).

The Study identified the following as having the greatest savings opportunities for ongoing code compliance improvements, as observed through field observations, plan reviews and review of the checklists:

- Residential Construction: basement walls, slabs, floors and above grade walls.
- Commercial Construction: energy recovery and cooling efficiency; interior lighting; envelope efficiency requirements.

C. Compliance with Energy Conservation Construction Code of New York State (ECCCNYS - 2010).

The residential buildings were also evaluated for compliance with IECC – 2009 on which ECCCNYS – 2010 is based. The increased stringency of the energy provisions of this code exacerbates the difficulty of achieving and demonstrating compliance. For example, given new residential requirements for air sealing, duct leakage, and envelope efficiency levels, and the elimination of the ability to trade off higher efficiency boilers and furnaces for lower envelope efficiencies, more data, expertise, and performance testing are required to confirm compliance. The 63% compliance rates for residential buildings tested against IECC – 2009, while lower than the 73% under ECCCNYS – 2007, were surprisingly high given that this code was not in place when these homes were built.

E.2.4 Gaps: Code Compliance and Enforcement Priority, Building Data, and Technical Knowledge

Gaps in the design and enforcement processes and a lack of financial support for the additional time and effort required to improve energy performance, were observed in all aspects of the Study including: the surveys and interactions with code officials, members of the design and construction community; and building owners.

A. Code Enforcement and Priority. Factors influencing non-compliance include the challenges of code enforcement in the context of shrinking local government budgets and the increased level of code complexity that requires more sophisticated tools and expertise. Most active in ensuring that buildings meet fire, health, and safety code requirements, code officials do not devote sufficient attention to energy code enforcement. For commercial construction, code officials rely on design professionals' representations of compliance on COM*check*™ filings submitted with the permit application. Often these compliance specifications are not included in the construction documents and drawings, and therefore not consistently followed by builders. For both residential and commercial construction, few jurisdictions perform field inspections to confirm energy compliance.

B. Building Data. The lack of a centralized source of building data sufficient to conduct the evaluations required for ongoing monitoring is an overarching obstacle affecting the ability to reach federal and state compliance and energy savings goals. In Recommendation E.3.2, the Team recommends that DOS maintain a central database capturing all construction projects. However, the ability to collect data from local governments may be significantly reduced by legislation regarding reporting currently under consideration (see below).

C. Technical Knowledge. The design, construction and energy code communities' lack of current technical information is exacerbated by the advent of more stringent codes and testing requirements. Continued training of all members of these communities, consistent with needs identified by code officials and architects, is required. Ongoing and locally delivered training efforts should be expanded to include owners of both residential and commercial properties.

E.2.5 Energy-Code Specific Legislation

NYSERDA and DOS identified the following key legislation affecting existing and future energy code compliance:

A. Article 11 of the New York State Energy Law (State Energy Conservation Construction Code Act). Changes effective January 1, 2011 expand the scope of code applicability to substantial renovation projects, and, by specific reference to the *American Recovery and Renewal Act of 2009,* New York's required 90% compliance requirement.

B. Executive Law, Article 18 ("Building Code Act") establishes the rules for administration and enforcement of building and energy codes in the state. In particular, Section 381 grants enforcement responsibility to local governments and outlines basic requirements for issuance of building permits and conducting of inspections to ensure completed work is in compliance with code requirements.
http://public.leginfo.state.ny.us/LAWSSEAF.cgi?QUERYTYPE=LAWS+&QUERYDATA=

@SLEXC0A18+&LIST=LAW+&BROWSER=EXPLORER+&TOKEN=35807931+&TARGET=VIEW

C. Part 1203 of the Uniform Code: Minimum Standards for Administration and Enforcement (effective January 1, 2007) addresses local governments' annual reporting requirements. Under current consideration is the elimination of local government reporting requirements as a means to minimize the burden on local governments. http://www.dos.ny.gov/DCEA/part_1203.html

E.3 RECOMMENDATIONS

E.3.1 Establish an affordable and reliable program of ongoing monitoring appropriate to New York State (Findings E.2.1 and E.2.2)

Accurate and continued monitoring of New York's progress is critical. To improve energy performance, and subsequently minimum energy code compliance as required by federal legislation (ARRA) by 2017, it is recommended that efforts to improve and streamline the evaluation process begin immediately. NYSERDA and DOS should determine the most appropriate means to perform periodic assessments meeting DOE and state policy requirements and goals. Building on the experiences of this Study, these assessments must be streamlined, cost effective, and practical. The following approaches merit consideration:

A. Use of revisions to suggested BECP Protocol. It is anticipated that the next generation document, scheduled for publication in October 2011, will include:
   - Changes to the existing guidelines and tools (moderate only)
   - Recommendations for QA/QC
   - Recommendations for streamlined procedures for states (such as New York) which have already undertaken a large on-site evaluation Study. Possible recommendations include a Study evaluating only those elements that have changed with the introduction of a new code, or evaluating those elements identified up as particularly significant compliance problems.

B. Modification and simplification of suggested BECP Protocol to create a streamlined approach for ongoing monitoring and compliance assessment, focused on key indicators identified in this and other NYSERDA studies to have the greatest energy saving opportunities. In Section 6.7.1 of this report, the Team makes extensive recommendations for DOE and PNNL to:

1.) Streamline compliance scoring using the suggested BECP Protocol, and
2.) Convert the COM*check*™ and RES*check*™ software platforms into comprehensive compliance tools that can be used during the processes of design and construction. Specifically, the Team identified the need to create versions of three checklists according to the applicable phase of construction:
    a. Design Documentation Checklist (modification of existing to provide greater transparency to all parties, including contractors, building inspectors, code officials and owners);
    b. Interim Construction Inspection Checklist; and
    c. Final Construction Inspection Checklist.

3.) Change the PNNL Checklist items to match those of COM*check*™ and RES*check*™. Note: PNNL indicates they are currently working on this recommendation.

C. Confirmation of data to be collected during on-site assessment in order to reliably calculate lost savings.

E.3.2 Systematize New York State Data Collection for Compliance Evaluation and Interpretation (Findings E.2.2 and E.2.3)

It is recommended that NYSERDA and DOS improve the mechanism for collection of permit data and energy plan information from local governments on all construction projects in a consistent and practical format. Reporting format must be easy to use, standardized across the state, and may include the following:

- Improved means to identify and collect permit information for all new construction and renovation projects.

- Use of RES*check*™ and COM*check*™, (enhanced by DOE/PNNL) as a component of data collection.

- Identification of key building energy issues (presented as part of a project's 'Energy Code Compliance Plan,' as proposed by this study in Recommendation 6.3.1) to be documented in permit application materials and project documents in order to facilitate data collection and assist with code review.

- Alternate means to achieve active local government participation (see Recommendation E.3.5).

E.3.3 Address Gaps in Compliance and Enforcement Priority (Finding E.2.3)

Code officials, architects and engineers, and all additional members of the design and construction community must be engaged to increase compliance rates and minimize lost savings. The following are recommended for consideration:

- Expanded Compliance / Enforcement Responsibilities. Increase the requirements to measure and verify compliance from permit stage through construction by expanding the scope of code-required Special Inspections.

- Standardization of Compliance Efforts. Establish means to standardize and support streamlined approaches for code review and enforcement to address code officials' time and staffing limitations.

- Alternate Approaches. Explore new and alternate means, optional based on local government opt-in, to improve compliance without increasing the burden on local governments. Examples include:
    - Fee-for-service programs that support the work of code officials in implementation of energy-code related responsibilities.

    - Expanded roles for this study's proposed private-sector Energy Specialists to support the work of code officials from permit application through project completion. The role of these Energy Specialists is detailed in Recommendation 6.3.1. The skills, training, and any accreditation requirements of such specialists will require clarification.

    - Development of incentive and pilot programs specifically targeting improved compliance rates.

E.3.4 Address Needs for Technical Knowledge throughout Design and Construction Communities (Finding E.2.4)

- Continue support of training and other efforts for all members of the design and construction community to improve design and construction and installation practices and understanding of basic building science.

- Implement research and pilot programs to test efficacy of energy code training, on-site assistance with Energy Inspectors, and other code support opportunities.

E.3.5 Address Legislative Context and Obstacles (Finding E.2.5)

Implementation of all recommendations in this report must be considered in the context of existing and proposed legislation. Future efforts must address the legislative obstacles which could adversely affect the ability to collect data required to demonstrate 90% compliance. .

- Consider amendments to Article 11, the Energy Law of New York State or other legislation as required for third party inspection of building energy features, similar to Underwriter's inspections of building electrical systems). Funding for this may be allowed by implementation of a separate "Energy Compliance Permit".

- Consider amendments to Article 18, the Executive Law of New York State or other legislation to allow for direction of Energy Code Activities including but not limited to the implementation of a central database.

- Consider allowance of future NYSERDA programs to provide direct support of local government energy code compliance activities.

Section 1:

INTRODUCTION

1.1 STUDY DESCRIPTION

This project titled New York Energy Code Compliance Study was funded by the New York State Energy Research and Development Authority (NYSERDA) with funds from ***. The research was conducted by the Vermont Energy Investment Corporation along with subcontractors: Wirtshafter Associates, Inc., Cx Associates, Energy Futures Group (EFG) and Conservation Services Group (CSG).

This Study investigates the degree to which New York buildings comply with the building energy codes. New federal legislation passed as part of the American Recovery and Reinvestment Act of 2009 (ARRA) requires that all states must achieve a 90% compliance rate with building energy codes by the year 2017. The Pacific Northwest National Laboratory (PNNL) as part of the US Department of Energy (DOE) Building Energy Code Program (BECP) has developed a protocol for how states will verify 90% energy code compliance. The main activity of this Study was plan review and on-site inspections of 44 homes and 26 commercial properties using the suggested BECP Protocol to test energy code compliance. This research also included surveys of 179 active code officials, 61 builders and contractors; 69 architects, and 20 homeowners who participated in renovations. Other interviews were conducted with owners, contractors, architects, engineers, and code officials associated with eight commercial case studies and eight interviews with policy makers in New York and the US.

1.2 RESEARCHABLE ISSUES

This project has the stated objective to provide a comprehensive, statewide effort to determine how well provisions of the New York State Energy Code are being complied within both the commercial and residential construction sectors;

1. to identify areas of non-compliance; to determine methods of verifying compliance on building plans and during construction;
2. to present the calculation of the overall rate of compliance; and
3. to present recommendations on ways to improve compliance;
4. to determine the current rate of Energy Code compliance to ensure that the requirements of the American Recovery and Reinvestment Act of 2009 (ARRA) are being met.

1.3 EVALUATION OBJECTIVES

This evaluation has designed the following tasks to meet the research objectives described above. The tasks include:

- **Task 1:** Conduct surveys of important stakeholders, including a telephone survey of 65 builders/contractors, a telephone survey of 20 homeowners who undertook renovations, a web survey of 179 code officials, and a web survey of 69 architects. These surveys collected information on code awareness, typical practices, and the influence of code and code enforcement on what is included in the existing new construction in New York.

- **Task 2:** Conduct home inspections of 44 residential new construction projects collecting information on code compliance. The sample design and data collection was to follow as closely as possible the draft suggested BECP Protocols developed by the US Department of Energy for proving 90% compliance by 2017. The task also performed analysis of the data to determine code compliance and potential energy savings.

- **Task 3:** Conduct 26 inspections of new buildings built using the New York commercial building energy code. The sample selection process and data collection also followed the draft protocols developed by the US Department of Energy for proving 90% compliance by 2017. The task also performed analysis of the data to determine current code compliance and potential energy savings. In addition, in-depth interviews were conducted with contractors, architects, engineers, and code officials for eight case studies. These case studies explored in detail how decisions were made to include or not include major energy-related measures, the level of code enforcement, and the influence that the energy code had on those decisions.

- **Task 4:** Conduct in-depth interviews with ten policy decision makers at NYSERDA, Pacific Northwest National Laboratory, and US DOE, as represented by PNNL, as well as several contractors currently engaged by NYSERDA in code-related training and ARRA contract oversight. Table 1-1 shows the people interviewed.

Table 1-1: Policy Interviews Conducted

People	Affiliation
Dave Conover; Linda Connell	PNNL
Deborah Taylor, AIA	New York City Department of Buildings
Ron Piester, AIA; Joe Hill	Director, Division of Code Enforcement and Administration, NYS Department of State
Ian Graham	Associate Principal, Viridian Energy & Environmental
Liza Bowles	President, Newport Ventures Inc
Ed Farrell	Exec Director, NYS AIA
Mike DeWein	Technical Director, Building Codes Assistance Project
Allen Lee	The Cadmus Group

1.4 ORGANIZATION OF THE REPORT

The remainder of the report is organized into five sections. Section 2 provides a detailed description of the Study methodology. Section 3 summaries the results of the surveys of code officials, builders, renovation homeowners, and architects. Section 4 provides a summary of the residential on-sites, and Section 5 a summary of the commercial on-sites. Section 6 presents a report summary of conclusions and recommendations. A separate document contains all of the supporting appendices.

Section 2:

STUDY METHODOLOGY

The Building Energy Codes Program (BECP) has developed an ambitious protocol for states to measure their percent compliance with the energy code. The VEIC Team worked with the U.S. Department of Energy's (DOE) Pacific Northwest National Lab (PNNL) to finish development of and pilot test their checklist tools as one of the first states to use them to determine statewide commercial and residential code compliance. This Study performed on-site evaluations of 44 residential and 26 commercial new construction buildings, collecting sufficient data for not only determining code compliance to the suggested BECP Protocol, but also enabling full building modeling to generate HERS scores for new homes and calculating "lost savings" due to non-compliance for new buildings in both sectors. Only very limited renovation data was collected.

This was an ambitious Study and required significantly more effort than the VEIC Team had originally estimated for many of the tasks, including tool development, PNNL coordination, participant recruitment, building modeling, QC of the field data and data analysis. For NYSERDA to perform this analysis again in the future, it would not require the development of the two on-site data collection tools (approximately $60,000 for both residential and commercial). Other cost saving measures could surely be found by avoiding some of the problems encountered in this first-time effort. However, because this Study was performed post-construction, only *one* on-site visit was performed for each building. Under the suggested BECP Protocol requiring *multiple* visits during construction, the VEIC Team estimates that on-site evaluation of each sector requiring a statistically valid sample of 44 sites could cost in the range of $250,000 – $350,000 per sector. Multiplying by the four sectors that the suggested BECP Protocol requires to be evaluated – both new construction and renovations in the residential and commercial building sectors – the total cost for NYSERDA to replicate this Study could reasonably be estimated to cost more than $1 million.

Even though they may have been costly, that the VEIC Team carried out these additional tasks has provided many useful insights and can serve as a strong foundation for new code policy and programs going forward. The value of calculating lost savings from non-compliance will be useful to justify expending resources to bolster code compliance. Generating HERS scores allows for comparison to ENERGY STAR® Homes. The development of a commercial front-end on-site data collection tool will be useful for future data collection efforts. States that use the PNNL Checklist in subsequent studies will benefit from this Team having refined and field tested it. And the insights into the workings of New York's code process have allowed the VEIC Team to put forward a comprehensive set of recommendations that can make a significant difference in future code compliance.

The Team recommends that NYSERDA share its experience and lessons learned with the DOE and also consider development of a more robust and cost-effective code third-party enforcement protocol which can result in more statistically accurate future Study results while enhancing code compliance in the State. The Team makes recommendations to this effect and spells them out in greater detail in Section 6: Conclusions and Recommendations.

2.1 BACKGROUND

The Building Energy Codes Program (BECP) of the United States Department of Energy (DOE) has developed a methodology by which each state will measure energy code compliance. For a detailed explanation of the compliance process see http://www.energycodes.gov/arra/compliance_evaluation.stm. The 2017 protocols require that energy code compliance be verified for new and renovation, residential and commercial buildings. Each of these four sub-types has its own separate sample and data collection effort. The intent of this Study was to apply the protocols to evaluate New York State's current level of compliance and test the usability of the suggested BECP Protocols. The suggested BECP Protocol also describes a number of companion tools that BECP has developed to aid in the evaluations. A sample generator that BECP has developed draws a random sample of residential and commercial counties in which the 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. The following sections detail the methodology used for selecting samples, recruiting participants, and recording building characteristics. This Study, due to budget constraints, did not look at commercial renovation and evaluated residential renovation only through phone surveys and on-site qualitative interviews. For the three building types evaluated, each has a discussion of this Study's approach below.

2.2 SAMPLE DESIGN AND USE OF BECP SAMPLE GENERATOR

The procedures developed by the Pacific Northwest National Laboratory (PNNL) are outlined in the document "Measuring State Energy Code Compliance."[4] This document provides direction on how states can verify that they have exceeded the 90% compliance rate target for all building projects covered by the code. Included in the document are detailed instructions on the methodology required in conducting the formal evaluation that verifies compliance. This strategy requires that each state conduct a Study by an independent third-party that visually inspects a sample of the state's buildings. The report establishes that

[4] PNNL, 2010, "Measuring State Energy Code Compliance", prepared by Pacific Northwest National Laboratory for the U.S. Department of Energy Building Technologies Program under Contract DE-AC05-76RL01830.

minimum sample sizes of 44 sites be visited. 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%. The protocols acknowledge higher standard deviations will require larger sample sizes; for example, if the standard deviation is 20%, the minimum sample size rises to 100.

2.2.1 Residential New Construction

Using BECP software and updated data from the US Census [http://energycode.pnl.gov/SampleGen/], a sample was obtained for the 44 sites. The data was drawn using the 3-year average number of new construction permits issued for New York, for each of the state's three climate zones. The data indicates that over the three years, permits averaged 15,635 per year. The sample generator first divides each state by climate zones and then allocates a portion of the full sample to each climate zone based on the relative number of permits within each climate zone. Table 2-1 shows the permit breakdown by climate zones.

Table 2-1: Residential New Construction & Renovations

Location	Total Permits *	Number of Sites in 44 Sample
State Total	15,635	44
Climate Zone 4	4,768	12
Climate Zone 5	7,221	21
Climate Zone 6	3,646	11

*Total permits represent an annual average from the years 2007 to 2009

The BECP Sample Generator chooses a random sample of counties with the likelihood of a county being selected proportional to the average number of permits in that county. Under this selection process, a county can be selected randomly more than once. Table 2-2 shows the selection of the 44 residential sites using the BECP sample generator.

Table 2-2: Residential Sample Drawn from BECP State Sample Generator

Location	Total Permits	Sample Size
Climate Zone 4 Totals	**3,517**	**12**
Bronx County	266	1
Kings County	459	1
Queens County	586	3
Richmond County	319	2
Suffolk County	903	5
Climate Zone 5 Totals	**6,329**	**21**
Albany County	289	1
Dutchess County	349	2
Erie County	785	5
Monroe County	804	4
Onondaga County	589	2
Orange County	525	2
Oswego County	165	1
Rockland County	171	1
Saratoga County	564	2
Washington County	129	1
Climate Zone 6 Totals	**3,095**	**11**
Broome County	154	1
Clinton County	112	1
Jefferson County	355	1
Madison County	123	1
Oneida County	221	2
Steuben County	109	2
Sullivan County	290	1
Ulster County	234	1
Warren County	178	1

The permit data found in Table 2-2 includes permits given to all types of residential buildings, including high-rise apartments and renovations. This creates two problems: a.) renovations cannot be identified and removed, and b.) the residential building energy code for which this sample is drawn covers only structures that are three stories or less.

Larger residential structures are covered under the commercial building energy code. The US Census data clump all multi-family as five+ units and does not distinguish between high-rise and low-rise multi-family. The inability to separate out high-rises results in a larger than intended sample and requires an additional effort to eliminate the multi-family structures. This situation is exacerbated by the likelihood of high-rise buildings being better represented in the number of renovation permits issued. (While it is anticipated that nearly every multi-family building under renovation sought a permit, this assumption does not apply to single-family buildings.)

The implications of these two factors □ inability to remove renovations and inclusion of high-rise buildings □ means that the sample pool is over-represented by high-rise buildings. Because of the inclusion of high-rise and renovation permits in the eligible pool, the sample drawn by the BECP Generator is not strictly representative of the new residential construction covered by the residential energy code. However, because high-rise buildings only represent 263 of the 17,340 buildings (1.5%) in the selected counties, this should not have a major effect on the sample's validity.

There is a concern that the selection process may select a county where there are not enough low-rise buildings to be able to select a suitable site. For example, the BECP Sample Generator included the possibility that Manhattan could be chosen as a county. Manhattan has a large number of permits, but almost no low-rise new construction taking place. For this reason, VEIC stipulated that if Manhattan was selected, the draw was invalid and a new draw was required. As it turned out, the first draw did not select Manhattan.

The process used to select the counties in the step above was repeated to select the permitting agencies. As discussed above, the inclusion of high-rise and renovation data complicate the selection process. Data purchased from Hanley Wood provides the residential unit data at the local permitting agency level for 2008 and 2009 totals.[5] This data needed to be converted to permit values to align with values pulled from the BECP Sample Generator. For the five+ unit column, the Team obtained the U.S. Census data that provides number of permits. For the two unit apartments, the value in the BECP generator was divided in half. There was only an issue in trying to calculate how to convert number of units to number of permits for the three- and four-unit values. Here the Team was forced in a few cases to assume values. Table 2-3 shows the process used to convert the three and four unit values to number of permits.

[5] Values in Table 2-1, 2-2 and 2-3 represent a 2007-2009 average annual number of permits.

Table 2-3: Conversion Protocol for Converting Number of Units to Number of Buildings in 3-4 Unit Category

Number of Units	Assumed Number of Buildings	Comments on Accuracy where Choice Existed	Number of Occurrences
3 or 4	1	No Other Value Possible	
6, 7, 8	2	No Other Value Possible	
9, 10, 11	3	No Other Value Possible	
12	4	Could be 3	1 occurrence
13, 14	4	No Other Value Possible	
15, 16, 17	4	Could be 5	1 occurrence
18 and above	Divided by 3.3	Total number of permits may have ranged from 59 less or 85 more out of 17,340 total permits in selected agencies	Adjustments made for 6 agencies

Using the 44 county sites selected in the first step, permit agencies within each county were identified. Any agency with more than 10 available sites over the 2008-09 period was included in the random draw.[6] The total number of permits (excluding towns with less than 11 permits) was then summed. A random number between 1 and the county permit sum was selected using the random generator at the website RandomResult.com. For example, Albany County has seven permitting agencies; one town within that county - Green Island Village was excluded because it issued less than 10 permits in the 2008-09 period (Table 2-4). There were 579 permits in Albany County in the 2008-09 period (excluding Green Island). A random number is then drawn between 1 and 579. The random number generator selected the value 246. The value 246 falls within the range (164-314) that represents the permit agency, Colonie town. As a result, Colonie Town was randomly selected as the site for Albany County.

[6] The removal of an agency with less than 10 possible sites was required because the Team needed to recruit a site from the available data. Given the high cost of collecting the site information from the agency, the likelihood that many sites would not be willing or eligible to participate in the on-site, and the possibility that some sites will be renovations, the Team needed to have a pool large enough to make sure we found a usable site at each selected agency. The removal of these agencies with 10 or less permits in the 2008-09 period resulted in a removal of 457 potential sites out of the 17,340 sites (2.6%) in the original sample pool.

Table 2-4: Selection Process for Each County

County	Place Name	1-Fam	2-unit	3/4-unit	5+ units	Total	Stacked numbers
Albany County	Albany	57	2	0	1	60	1-60
	Berne town	11	0	0	0	11	61-71
	Bethlehem town	90	1	1	0	92	72-163
	Colonie town	150	0	0	1	151	164-314
	Colonie village	65	0	0	0	65	315-379
	Green Island village	0	0	0	0	0	
	Guilderland town	192	2	0	6	200	380-579
Total Albany		565	5	1	8	579	

The process just described was repeated for each county selected in the first step. For counties where more than one selection was required, additional random numbers were generated. Appendix A represents the selected locations. There are several locations where more than one site needed to be recruited.

2.2.2 Residential Renovation

The project scope did not have funding to include a full Study of residential renovation. It was decided that a phone survey of homes in which renovations had been done would be performed to get some idea of the issues confronted by homeowners undergoing renovation. The research Team used the renovation data that was contained in the residential Dodge data. The Dodge data listed only 491 renovation projects during the three-year period, both private and public. Phone lookup was attempted on the 491 residential renovation projects listed in Dodge. The list produced about 275 addresses, however, 85% of these proved to be non-working, non-eligible or non-reachable. Only 42 projects proved eligible and reachable and 20 of these produced completed surveys. To augment the homeowner feedback, we also completed interviews of homeowners who participated in the new construction on-site analysis work. The Team recorded comments from six of these homeowners.

2.2.3 Commercial New Construction

The suggested BECP Protocol for the commercial sample selection is similar to the one described above for the residential new construction sample. An added complication for the commercial sample is that building size is a stratification variable which affects the sample design. The suggested BECP Protocol calls for the selection of 44 sites drawn across the three climatic zones. The sample is then further divided to select three-different sized buildings (small, medium and large) within each climate zone.

Because this NYSERDA Study includes detailed energy modeling to quantify the "lost savings" from non-compliance, it did not have enough funds to support site visits of 44 commercial sites. The Team proposed to evaluate a smaller sample of 25 -30 buildings drawn from five representative jurisdictions to enable an evaluation to be completed within the allocated budget. Ultimately 26 buildings underwent on-site evaluations; the low end of the range was used because of the difficulty in recruitment (see discussion below).

The sampling strategy used the Dodge data set for 2009-2010 of new construction commercial projects. That DOE Sample Generator automatically selects 44 sites. Table 2-5 shows the sample as selected by the DOE Sample Generator.

Table 2-5: Sample Selected from Dodge List of Commercial Permits

City	County	Zone	Number
Bronx	Bronx	4	688
Brooklyn	Kings	4	1909
Hampton Bay	Suffolk	4	25
Hempstead	Nassau	4	25
Mount Vernon	Westchester	4	25
Manhattan	Manhattan	4	890
Riverhead	Suffolk	4	26
Southampton	Suffolk	4	33
Staten Island	Richmond	4	237
White Plains	Westchester	4	31
Yaphank	Suffolk	4	25
Yonkers	Westchester	4	104
Queens	Queens	4	1338
Albany	Albany	5	108
Amherst	Erie	5	81
Buffalo	Erie	5	136
Cicero	Onondaga	5	29
Clay	Onondaga	5	26
Clifton Park	Saratoga	5	53
Glenville	Schenectady	5	25
Greece	Monroe	5	79
Hamburg	Erie	5	52
Henrietta	Monroe	5	47
Hyde Park	Dutchess	5	26
Lancaster	Erie	5	36
Latham	Albany	5	44
Malta	Saratoga	5	41
New Winsor	Orange	5	30
Newburgh	Orange	5	63
Niagara Falls	Niagara	5	46
Orchard Park	Erie	5	29
Penfield	Monroe	5	39
Poughkeepsie	Dutchess	5	59
Rochester	Monroe	5	182
Saratoga Springs	Saratoga	5	64
Schenectady	Schenectady	5	41
Syracuse	Onondaga	5	94
Troy	Rensselaer	5	57
Victor	Ontario	5	31
Webster	Monroe	5	85
Wilton	Saratoga	5	28
Binghamton	Broome	6	33
Ithaca	Tompkins	6	43
Plattsburgh	Clinton	6	37
Queensbury	Warren	6	50
Watertown	Jefferson	6	43

The Team then selected five counties from those 44 in the same proportion to the climate zone distribution of the sample. The twenty-six case Study jurisdictions were then selected as shown in Table 2-6.

Table 2-6: Sample of Commercial Sites

	Number of Permits	Number of Agencies Selected	Number of Sites	Initial Counties Selected
Total permits, 2-year average	1,587		26	
Zone 4	1,100	3	15	Kings, Bronx, Queens, Manhattan, Suffolk, Westchester
Zone 5	389	1	5	Monroe
Zone 6	98	1	6	Clinton, Franklin

The commercial sample included buildings in the small, medium and large size strata. Small is defined as less than 25,000 ft^2; medium is between 25,000 and 60,000 ft^2; large is everything above 60,000 ft^2. The final sampled sites in Table 2-6 differ slightly from the initial sample design. Because of recruitment issues, the sample in Kings County was extended to include all the New York City counties (Bronx, Queens and Manhattan). Additionally, because of a lack of available buildings larger than 25,000 ft^2 in the Clinton County, Climate Zone 6 added Franklin County to the sample strata. An additional building was visited in Clinton County, making the total sample 26.

2.3 RECRUITMENT OF SAMPLE

2.3.1 Residential New Construction

The sample list in Appendix A represents the full list of jurisdictions as originally pulled and described in the sampling section above. As noted above, the Dodge data for residential is only a partial list of all New York residential permits. The second to last column in Appendix A designates whether Dodge collects data for that agency. The last column indicates for those agencies where Dodge does not collect data, if there are other sites in the county where Dodge collects data. Dodge data were available for 25 of the 44 sites selected, though ultimately, as described in more detail in Section 4, only ten of the 44 on-sites were able to be recruited from the Dodge data.

The Team sent the list of Dodge addresses to a reverse address look-up service to get phone numbers. Of the original 1,042 new construction addresses sent to the service, 268 phone numbers were returned. Of this number, approximately 256 proved to be valid residential phone numbers. The Team also sent a recruitment letter found in Appendix B to all addresses.

In recruiting homeowners, the Team specifically excluded any homes that had participated in New York ENERGY STAR®. The percent of new homes in New York State that participated in the ENERGY STAR® program in 2010 is 23%. Therefore the methodology explicitly excludes these homes, under the assumption that a majority (if not all) were in compliance with the energy code. The Team did not attempt to modify code compliance calculations to include these 23% compliant homes. Instead, the results of this project reflect an analysis only of non-ENERGY STAR® homes.

Another method was needed to fill the names in the other jurisdictions in the sample that did not have Dodge data. In these cases, a Team member was required to contact the jurisdiction and collect the addresses. 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 application be filed (in person) before any data would be released. Clearly, doing the latter, which can take several weeks or months, creates challenges for the project timetable and budget. When code officials did cooperate, there was rarely a code official willing 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.

Gaining the cooperation of new home occupants also proved to be difficult. The difficulties found in recruiting the residential sample became so significant that it began to jeopardize the Team's ability to complete the Study. Continuing to apply the rigorous adherence to the suggested BECP Protocols was costing so much time and money that it was severely cutting into the resources that had been allocated to doing the inspections. Since the purpose of the Study was to test both the suggested BECP Protocol and the PNNL Checklist, it was necessary to abandon strict adherence to the suggested BECP Protocols.

The recruiters of residential Study homes were given permission to go to surrounding communities to find willing households, and to later use referrals from code officials, program staff, and others familiar with local new construction. Even after abandoning BECP sampling protocols, recruiting homes proved to be an enormously time-consuming and costly effort. Given the great lengths the Team went to adhere to the protocols, we would advise that they are not feasible and that other methods need to be created by which to recruit homes and gain the cooperation of code agencies. Alternatively, and as is recommended below and in Section 6, states should maintain a centralized database of permits and energy code compliance filing materials from which samples could be generated from. In the end, the goal of wide geographic distribution across the state was met, but the strict adherence to selecting a valid, unbiased sample was not.

2.3.2 Residential Renovation

All available homes from the Dodge data (only 42 working phone numbers) were called at least five times; the survey Team exhausted the complete list of available data. Twenty phone surveys were completed. As stated earlier, because the number of completions was so low, the Team also interviewed any homeowners who were willing during the new construction on-site evaluations. Ultimately, even with even a small sample, it was abundantly clear that the majority of homeowners were relatively uneducated about building science and the impacts on energy of plan design or construction methods and materials. Therefore the Team felt that significant conclusions were able to be obtained even from a small sample size.

The phone surveys conducted with builders were also extremely difficult to complete. Half-way through the survey process, builders were offered a $25 gift certificate by which to buy coffee and snacks for the construction crews. This offer was indeed sometimes successful in getting by the builders' administrative gate-keeper.

2.3.3 Commercial New Construction

Commercial recruitment was started with a mailing blitz to 153 commercial buildings listed in the new construction Dodge database in the identified five counties. This introductory letter, on NYSERDA letterhead and signed by the NYSERDA project manager, introduced the Study, gave credibility to the project, notified people that they would be called, and invited interested parties to contact the VEIC Team. (The letters and recruitment script can be found in Appendix C). An incentive of $150 was offered for participation, but ultimately only two out of the 26 sites requested this inducement. This letter, however, proved to be instrumental in opening many doors. Approximately eight building owners contacted the Team themselves and all building owners subsequently called on for participation knew of the project and were prepared to discuss it. Toward the end of the recruiting work, the VEIC Team needed to expand into other neighboring counties that did not receive this letter and in these locales, participation was considerably more difficult to obtain.

Simultaneously, the New York Department of State e-mailed a letter of introduction to the code officials in the five identified counties. This letter and a verbal appeal at the code officials' annual meeting in Lake Placid in February 2011 helped achieve cooperation from the code officials and gave credibility to the engineers who called on them. As with the building owners, code officials who did not or who did not remember receiving this official e-mail tended to be less cooperative than ones that were officially asked for participation.

The goal of the recruiting process was to obtain permission to visit a specific number and size of buildings in the five (ultimately nine) identified counties, as well as organize a plan review visit at either the code official's office or the building site.

Initial calls to building owners were made by an administrative person. This person called to follow up on the NYSERDA letter, ascertain the correct contact person, obtain his/her telephone number and determine his/her willingness to participate. The employee used the recruiting script and an outline of the sizes of buildings required in each county. When the required amount of buildings was identified, the Team member did not pursue further buildings in that category for that county. The final building sample is shown in Table 2-7.

Table 2-7: Commercial On-site Sample

County	Small (<25,000sq ft)	Medium (25,000-60,000sq ft)	Large (+60,000sq ft)
Suffolk	Retail, Government	Academic	Government
Westchester	Office	Retail, Housing, Medical Office	Housing
Clinton and Franklin	Retail	Government, Office	Hotel, Hotel, Housing
Monroe	Office, Medical Office, Office	Government Lab	Hospital
NYC Burroughs	Office	Housing	Housing, Academic Housing, Housing

With considerable effort, an administrative person was able to identify approximately 12 interested building owners before project time constraints forced the calls to be taken over by the engineers. The engineers continued these calls as well as followed up with the interested buildings to schedule building site visits. For the recruited buildings, the engineers also scheduled the review of the plans either with the building owner or the appropriate code official. Site visits and plan review visits were scheduled in a manner that minimized travel time.

In summary, the recruiting methodology was arduous, but sound and effective. There were a few lessons learned from the process that are beneficial to consider for future studies:

1. Determining the correct contact information for a building from the Dodge Database is very time intensive. Because the Dodge Construction Database typically lists contacts applicable to the permitting or construction phase, the information becomes out of date as soon as the project is constructed. Often the contact person listed as "owner" is really the architect or builder. Finding the person responsible for the building upon occupancy required many telephone calls and also included internet searches. Incomplete and missing project information was also problematic.

2. Written introductory communication about the project from the Department of State and NYSERDA to building owners and code officials is an essential step in recruitment. It gives the project credibility and eliminates the cold-call challenge telemarketer experience in the introductory telephone call.

3. Providing detailed, albeit high-level, information about the project to an administrative person making the initial calls improves the creditability of the Study during initial outreach. Building owners responded more favorably to the project when the initial caller spoke confidently about the high level details of the project and what will specifically be required of them.

4. An administrative person is the right person to make the initial calls because most of the time is spent determining the correct contact information. The engineer is the right person to make the follow up scheduling calls for the actual site and plan review visit. Only the engineer can answer questions in enough detail to make the building personnel feel confident in what the site visit will entail.

5. Do not underestimate the length of time required for recruitment. Because of the difficulty in finding the correct contact person and obtaining participation, the VEIC Team was still attempting to identify and recruit the final participants throughout the six weeks long site visit timetable.

2.4 BIAS ISSUES WITH SAMPLING AND RECRUITING

One element of the Study that poses a threat to statistical validity is the bias engendered from recruiting in both the residential and commercial samples. All studies generate some degree of selection bias, but on-site studies impose greater opportunities for exacerbating bias.

Residential studies are finding it hard to reach customers and are recognizing a need to increase the amount of the financial incentives. With ever increasing numbers of households with unlisted numbers and no land lines, it is becoming increasingly difficult to identify residential phone numbers to call. Evaluators have recognized a need to offer a large incentive to try to induce potential participants. In fact, the $100 incentive offered in the residential sector and $150 offered in the commercial sector may not have been adequate to overcome self-selection bias for this project. The suggested BECP Protocols do not include any controls over the recruitment process and therefore allow, and actually encourage, evaluators to find ways to fill samples that are the easiest for the recruiter, and likely introduce bias.

The issues for residential recruitment pale in comparison to recruiting a commercial sample. No compliance Study is offering the size of incentive that adequately compensates an owner for the several hours of disruption. So, commercial studies, like this one, tend to attract better-than-average buildings – ones with conscientious owners or building managers that feel confident about the code compliance of their building. . In order to encourage participation in any future Study, a commercial owner should be provided some additional incentives. Some studies include confirmation of energy leadership, free advice on building's energy operations, or they provide a benchmarking report. These incentives may affect the interest in participation, but it may not affect the bias of the sample in the way that enforcement (making participation in future studies a criteria of the occupancy permit) or greater financial incentives might.

While other on-site approaches such as baseline studies have encountered these issues, it is the nature of the compliance Study that makes this selection bias more problematic. Baseline studies seek to determine information about the *typical* building. In contrast, a compliance Study seeks to determine a *rating for all* buildings. Systematically leaving out buildings means the score only covers the limited set of buildings covered. There is an intuitive recognition that volunteers are less likely to have code violations. Owners who knowingly skirted code requirements are not likely to invite in an inspector to have another look at the building. It follows that owners of buildings who knowingly pay greater attention to energy efficiency are more likely to volunteer.

As noted in many cases, the cooperation of the code permitting agency is necessary for obtaining the list of permits. Especially for commercial building studies, cooperation is needed to get as-built plans, which are critical to the evaluation of a complex commercial building. The field evaluation Team made inquiries to selected jurisdictions to ask for cooperation. Neither the Team, NYSERDA, nor the NY State Code Official office had the authority to demand 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 instructions were to select, when possible, a neighboring jurisdiction in the same county.

To ensure that future studies are not biased, the suggested BECP Protocols would ideally eliminate evaluators skipping uncooperative jurisdictions in favor of easier and less costly non-selected alternatives. A process should be in place by governing entities to mandate the jurisdictions' cooperation or evaluators will need alternative procedures to obtain a list of permits. It should be noted that because building plans are needed to complete both the residential and commercial checklists, evaluators will eventually need to get code officials' cooperation in obtaining the plans for sites that become part of the final sample.

The data collection and recruitment process would be facilitated if New York maintained a statewide database of permit records. If permits were logged into a statewide database, some of the issues with the Dodge data and recruitment would be avoided. If the database included the plans and specs then there would be no need to aggressively recruit the code jurisdiction; the self-selection bias of only recruiting cooperative jurisdictions would be eliminated. (This report discusses a recommendation to create an Energy Code Tracking Database in Section 6.)

2.5 ON SITE DATA COLLECTION ISSUES

suggested BECP Protocols call for the independent evaluator to make multiple visits to visually inspect the building to verify code compliance. At the start of this Study, the BECP was still in the process of developing residential and commercial data collection forms, referred to in the protocols as the PNNL Checklists. Given the timing, the Team was required to put the PNNL Checklists into data collection forms, develop techniques to ensure consistency and reliability of the data collection, and propose analysis approaches to measure both energy code compliance and potential energy savings.

In carrying out the data collection process, the Team faced three major issues: 1) the number and timing of inspection visits, 2) the ability of the checklists to measure the critical factors that determine energy saving, and 3) the calculation of percentage of code compliance. For each of these topics, this report first outlines the issue and then reports on the methodology used for the Study.

2.5.1 The Number and Timing of Inspection Visits

PNNL has developed draft commercial and residential checklists for evaluators to use. These checklists were designed to be used while the building was under construction, and called for multiple visits to each building. Code officials doing their job make numerous visits to a building, timing those visits to coincide with critical milestones in the construction practice. For example, code inspectors are supposed to visually inspect wall insulation before dry wall can be installed. PNNL has designed the construction checklist to mirror that process, such that the independent evaluation inspector coordinates the timing of the visits to be able to examine the actual condition as it was installed.

Due to time and funding constraints, the NYSERDA Study faced the problem of only having one site visit per building. It was recognized that no one visit, be it during construction or post-construction, could capture all of the required checklist information. The Team determined that a mixture of in-construction and post-construction buildings would be analyzed, with the emphasis on completed or nearly completed buildings as they allow for the most building information to be collected. The inability to examine all interim construction elements is discussed in this next section.

2.5.2 The Ability of the Checklists to Measure the Critical Factors that Determine Energy Saving

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 suggested BECP Protocol is the first to attempt to capture these interim-construction details. As codes become more complex, code officials or their designees will be required to have more expertise and equipment to perform more sophisticated compliance tests. The current 2009 IECC residential code, which is the basis for the 2010 NYS Energy Conservation Construction Code, for example, requires duct leak testing if the ducts are located outside of the conditioned space. Future energy codes will require both duct and air leakage testing in both residential and commercial buildings. The require the use of duct blaster and blower door tests, respectively. These types of tests have not been asked previously of the code officials.

The commercial codes are not only more complex, but also vary by building size and application. A large hospital, for example, has considerably different requirements than a small commercial retail building. Accurate code compliance assessment requires someone with in-depth knowledge of the energy code, as well as experience with energy construction practices. A generalist, especially a code official who is responsible for fire and safety code compliance as well, would have difficulty performing a thorough energy code compliance measurement using the suggested BECP Protocol.

Another concern acknowledged by BECP is that 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."

2.5.3 Calculating Percentage of Code Compliance

The ultimate purpose of these code compliance studies is to develop a statewide average for code compliance. The suggested BECP Protocol requires that a state's commercial sector compliance score be determined by calculating the compliance score of each building and weight-averaging the individual scores by building floor space. Separate scores would be calculated for the four building type classifications: new and renovated residential buildings, and new and renovated commercial buildings. *"Evaluated buildings are each assigned a compliance rating of 0–100% based on the proportion of code requirements that each has met. The evaluated buildings' scores within a state are averaged to derive an overall compliance metric with an associated confidence. "*

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 2-8 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 2-8: 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%

2.5.4 Costs of Inspection

The suggested BECP Protocol states the higher limits of cost for a residential Study is as follows: "Plan review and four field visits, at the higher end of estimated time, could result in close to 5 hours per building." This estimate is perhaps reasonable for the incremental effort a code official would expend over and above a typical residential compliance check. (Time spent on current plan review is minimal – although this is not ideal, as the report discusses later.) The reality is that the level of effort required for an independent evaluator to thoroughly complete inspections is considerably more than a code official currently spends. An evaluator is likely not local and does not have the easy access to the site that a code official has. An evaluator's tasks include the following:

- Sample design – obtaining a comprehensive database of permitted buildings for each of the four sectors and developing a statistically valid sample from these data;
- Recruitment – this includes outreach to willing and unwilling owner/developers and code officials;
- Scheduling – potentially multiple scheduling calls, tracking and processing participation payments;
- Compliance documentation and reporting – logging data into tools, updating project tracking files and completing compliance evaluation during construction;
- Multiple visits to the code agency to file Freedom of Information Act requests and obtain permission from code official to access plans; and
- Plan review visits in code official offices.

None of these tasks is required of a code official conducting onsite inspection for approved projects in construction and working towards obtaining an occupancy permit.

For some compliance studies, such as this one, the state may be interested in more than just the code compliance rate. In addition to working through the PNNL Checklist to determine compliance, the VEIC Team carried out a number of supplemental tasks that all added to the time and cost of this project but provided some very useful additional information. Collecting detailed building information and conducting performance testing (i.e. blower door and duct blaster tests for residential) in order to facilitate building energy modeling, the calculation of a HERS score/index, and the calculation of "lost savings" were all worthy efforts, but over and above merely calculating a compliance score. The timing of this Study also contributed to higher costs than would be expected for states performing similar studies in the future. The VEIC Team expended a good deal of effort working with PNNL to finish development of their checklist and data collections tools and worked through the bugs in piloting those in the field. On each the residential and commercial side, an entirely new spreadsheet tool was developed to serve as the front-end to the PNNL Checklist. For the commercial sector, this spreadsheet was critical to collecting the information that was used in modeling building energy for calculating lost savings.

Other costs might be avoided through both greater requirements for code official cooperation and incentives for building owners' participation. Still, a protocol that requires a statistically valid on-site evaluation is clearly very expensive.

When it comes time to repeat this Study again, NYSERDA will need to determine what questions it needs to answer, and then to design the Study accordingly, knowing the cost implications of going too far beyond addressing just the BECP 90% compliance protocol. Repeating this Study would be an expensive proposition. However if some of the provisions from our recommendations are in place, it may be relatively simple and inexpensive to take advantage of the data that Energy Specialists collect in the field to address the question "How close has New York come to 90% compliance?".

Section 3:

SURVEY RESEARCH

This section reports on the survey research done with home renovators, building code officials, architects, and builders to establish the current level of enforcement and compliance with energy codes. The DOE Building Energy Codes Program (BECP) code compliance requirements are applicable to new construction and renovations. As envisioned by BECP, states will need to verify that 90% of all new construction and renovation projects meet energy code. Since the budget for this Study did not allow the Team to perform on-site evaluations of renovation projects, a proxy for this information was obtained through phone and e-mail surveys.

3.1 EVALUATION OBJECTIVES

The objective of this set of tasks was to collect survey results from code officials, builders, and home renovators to assess the factors that affect the level of energy code compliance. Some of the issues addressed in these tasks include:

- What compliance activities were done by local builders to verify and enforce compliance?
- What are the levels of training in energy code by code officials?
- What areas of the energy code do code officials pay attention to in plan review and field inspection?
- What areas present the most difficulty for new construction projects?
- What is the availability of renovation permit data? What types of studies will be needed if New York State is to comply with the BECP 2017 code compliance requirements?
- What activities were done by residential renovators to comply with the existing energy code?

3.1.1 Overview

An Internet survey of code officials was initiated to determine the extent to which code officials reviewed plans and field inspected buildings for code compliance. An invitation letter (Appendix C) was sent to the 2100 code officials who are members of the NYS Building Code Officials Conference through the New York State Department of State. The e-mail letter had a direct link to an Internet Survey (Appendix D). 214 code officials initiated the survey, and 35 terminated because they didn't qualify as currently active yielding 179 completed surveys.

3.1.2 Key Findings

1. With the exception of insulation, code officials do not consistently check for or inspect for most code requirements.

2. Code officials will need to widen the breadth and scope of their enforcement if 90% code compliance is to be achieved.

3. While code officials do regularly check for both insulation level and quality of installation, field inspections uncover non-compliance with insulation *installation quality* more frequently in more than 10% of the projects.

4. Lack of staff and time to enforce codes is recognized as a major impediment. On energy-related matters, code officials spend an average of approximately 100 minutes for each residential building and 200 minutes on commercial buildings. This represents less than 14% and 10% repectively, of all time code officials spend on all code enforcement per residential and commercial building. These minutes are skewed upwards by a few respondents who report spending very large amounts of time on energy code enforcement. More than 40% of the respondents spend less than 10 minutes reviewing the energy-related components of residential code plans. More than half of the respondents spend less than 20 minutes on the energy-related review of commercial plans and approximately 20 minutes on the field inspection of energy-related commercial code elements.

5. Code officials believe that a lack of training of contractors and code officials is a major impediment to increasing code compliance. Code officials cite lack of contractor knowledge as the most significant impediment. The authors also surmise that contractors may take short-cuts on elements of both air and duct sealing and the quality of insulation installation. This is due to the common practices of a builder awarding subcontracts to the lowest bidder, as well cutting costs in "unseen components" when cost-overruns threaten the project's budget.

6. New requirements, such as duct sealing and HVAC load calculations, of the recently enacted 2010 New York ECCC are currently implemented infrequently.

3.1.3 General Discussion

Table 3-1 shows the job responsibilities of the 179 respondents currently active as code officials. The survey was answered by an additional 35 respondents who noted that they were no longer active. Code officials representing almost 150 different jurisdictions across the state participated in the survey.

Table 3-1: Job Responsibilities of Active Respondents

	Active Respondents (n=179)	
	Number	Percentage
Manage or supervise staff who do Plan Check/Reviews	63	35%
Conduct Residential Building Plan Check/Reviews	131	73%
Conduct Commercial Building Plan Check/Reviews	127	71%
Manage or supervise Field Inspection Staff	65	36%
Conduct Residential Field Inspections	131	73%
Conduct Commercial Field Inspections	132	74%
None of the above	4	2%

Table 3-2 below shows the responsibilities of respondents in plan review. Most respondents or other staff or contractors in the office conduct plan reviews. The survey did not ask how detailed the plan review was, or how many minutes was dedicated to it. Anecdotal evidence was told to the VEIC Team during later tasks – i.e. case studies and policy reviews that code officials do not re-run any calculations in RES*check*™ or COM*check*™ , but only look to make sure the architect or engineer has signed the submission.

Table 3-2: Who Is Responsible for Plan Review

	Number	Percentage
Respondent	137	81%
Other in-house staff	102	60%
Outside consultants or company	22	13%
Other jurisdictions or government agencies	5	3%
Not done	1	1%
Don't know	2	1%

Table 3-3 below indicates that most respondents are also responsible for field inspections. Almost all of the active respondents personally do field inspections and most also rely on other staff members to supplement their own inspections.

Table 3-3: Who Is Responsible for Field Inspection

	Number	Percentage
Respondent	134	79%
Other in-house staff	107	63%
Outside consultants or company	15	9%
Other jurisdictions or government agencies	4	2%
Not done	0	0%
Don't know	4	2%

Table 3-4 shows the level of energy code training that respondents and staff have received. [Of note, since August 2010, Newport Ventures Inc. has performed 140 trainings for code officials specifically on energy codes. This survey did not inquire whether or not code officials had attended these trainings.] 74% of the respondents and 68% of their staffs are currently participating in annual energy code training. Others have received some formal training every other year.

Table 3-4: Level of Training

	Respondent n=155		Staff	
	Number	Percentage	Number	Percentage
Receive annual training on the energy code	115	74%	45	68%
Attend periodic training on the energy code (1 time every other year)	32	21%	14	21%
On-the-job training on the energy code but little to no formal training	7	5%	5	8%
Neither formal energy code training or on-the-job training	0	0%	0	0%
Don't know	1	1%	2	3%

Table 3-5 also shows that most of the respondents have received some training on the new ECCCNYS - 2010.

Table 3-5: Attended Training on ECCCNYS - 2010

	Respondent		Staff	
	Number	Percentage	Number	Percentage
Yes	134	86%	55	82%
No	22	14%	9	13%
Don't Know	0	0%	3	4%

Table 3-6 summarizes code officials' estimation of the percentage of submitted plans using each of the three code compliances approaches. Code officials indicate that most applications (46%) use the Trade-off approach. Almost 20% of homes and 14% of commercial properties are now using the Performance approach. All of these are likely homes participating in either NYSERDA's or LIPA's ENERGY STAR® Homes programs.

Table 3-6: Code Compliance Approached Used

	Prescriptive	Trade-Off	Performance	Don't Know
Residential (n=90)	35%	46%	19%	1%
Commercial (n=43)	38%	46%	14%	1%

Table 3-7 compiles the (open ended) responses to the question "What major issues impede your ability to enforce the energy code." The most frequently cited impediment is the lack of knowledge about codes by residential contractors. Lack of sufficient time and staffing, quality installation of insulation and cooperation of contractors are other frequent responses.

Table 3-7: Major Impediments to Code Compliance – Number of times each category was listed

	Residential	Commercial
Contractor Knowledge of Code	30	2
Insufficient Code Staff	12	1
Insulation Installation Quality Issues	9	
Contractor Cooperation	6	1
Timing of Field Visits, Contractors Installing Sheathing Before Inspection	5	
Unspecified Costs	4	1
Insufficient Training of Code Officials	3	2
Complexity of Code	2	1
Unspecified Need for More Training	2	
Renovation Projects	2	
Other	8	

Table 3-8 reports the estimated time respondents spend on plan review and field inspection relative to energy components. On average, respondents spend approximately 100 minutes to review the energy elements of a residential building: 45 minutes for plan review and 54 minutes doing field inspections. This 100 minutes per residential building indicates that code officials spend approximately 14% of their time on residential buildings. For commercial buildings, code officials spend more time, an approximate total of 200 minutes □ 72 minutes for plan review and 121 minutes doing field inspections. (see column C below).

Table 3-8: Time Spent on Energy Code

	A Average Minutes Spent on All Code Aspects	B Average Minutes Spent on Energy Code	C Standard Deviation Minutes Spent on Energy Code	D Percent of All Code Enforcement Time Devoted to Energy Code
Residential Plan Review (n=99)	161	22	45	14%
Residential Field Inspection (n=93)	322	44	54	14%
Commercial Plan Review (n=48)	411	47	72	11%
Commercial Field Inspection (n-41)	519	51	121	10%

Figure 3-1 shows that the distribution of the times spent on energy-related code matters is skewed towards smaller amounts of time devoted to energy code tasks. More than 40% of the respondents spend less than 10 minutes reviewing the energy-related components of residential code plans. More than half of the respondents spend less than 20 minutes on the energy-related plan review of commercial codes and 20 minutes on the field inspection of energy-related commercial code elements.

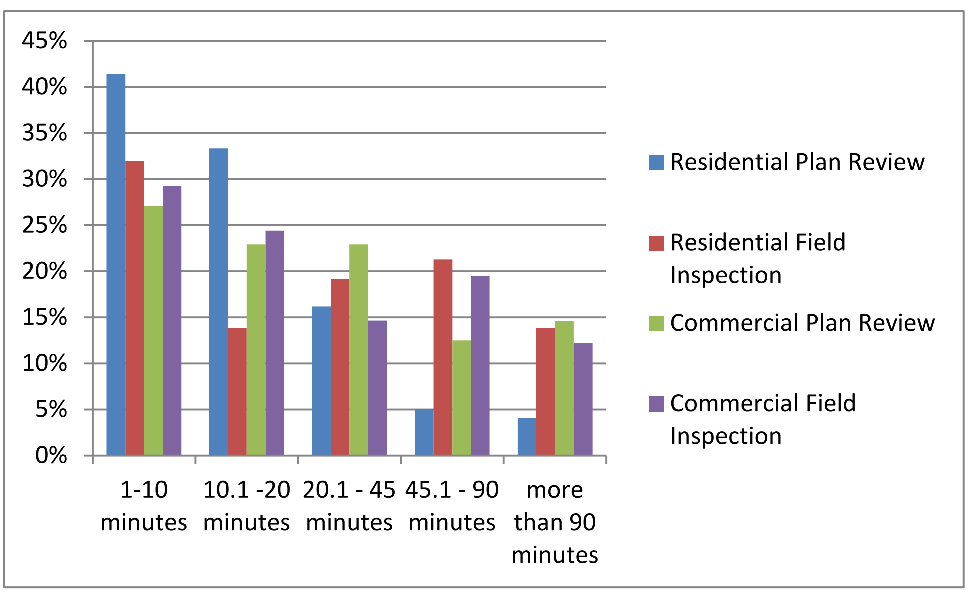

Figure 3-1: Distribution of Energy-Related Code Activity Times

A final set of questions asked code officials to estimate the percentage of time that they checked a specific code requirement and how often they found the code requirement in violation. These results are presented in Figures 3-2 to 3-5. Figure 3-2 indicates that most code officials (85%) check more than 75% of the time if the insulation quality is adequate before walls are closed. On the other hand, less than a quarter check duct sealing that often; less than a third check heat loss calculation and lighting efficiency levels that often; and only half check the mechanical system, pipe and duct insulation, fenestration, and air sealing that frequently.

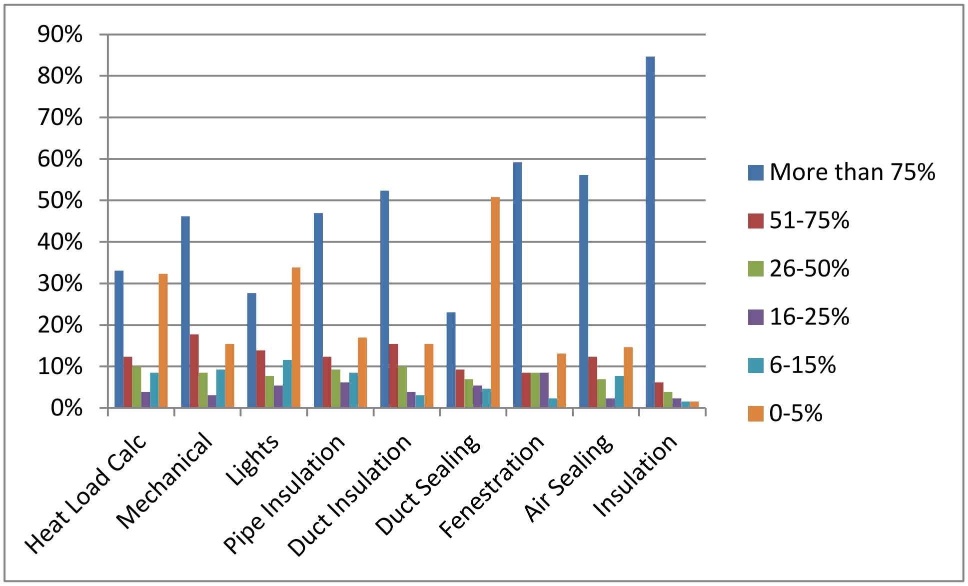

Figure 3-2: Frequency Residential Measure Checked

Figure 3-3 indicates that insulation is the most residential code requirement that is most frequently found to not be in compliance. This is not surprising as this is the measure that is most often checked by code officials (Figure 3-2), and they therefore have the greatest likihood of identifying this violation.

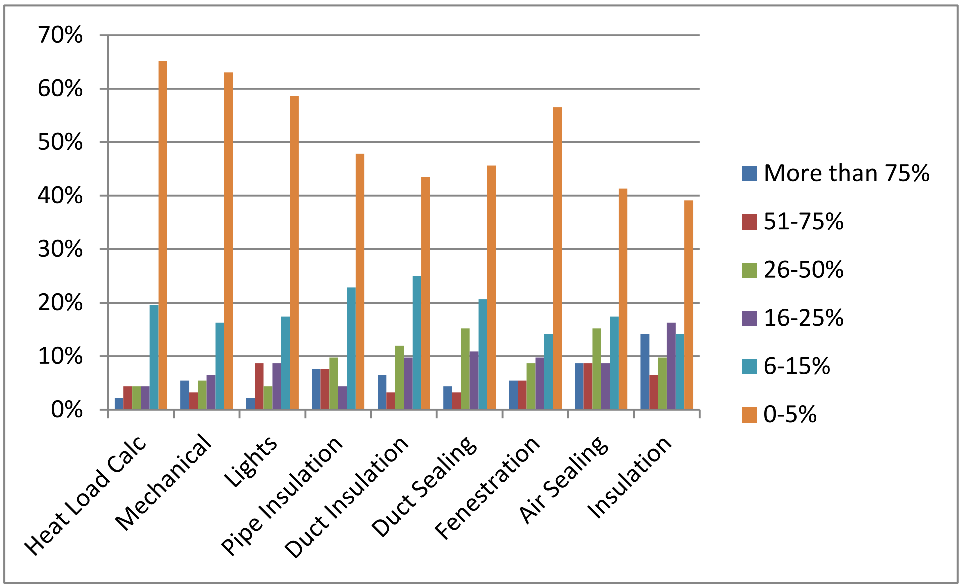

Figure 3-3: Frequencies Residential Measures Found Not in Compliance

Similar trends are reported for those doing primarily commercial code compliance checks. Figure 3-4 shows that envelope fenestration is the measure most often checked by code officials. This is followed by pipe insulation, infiltation, and water heaters.

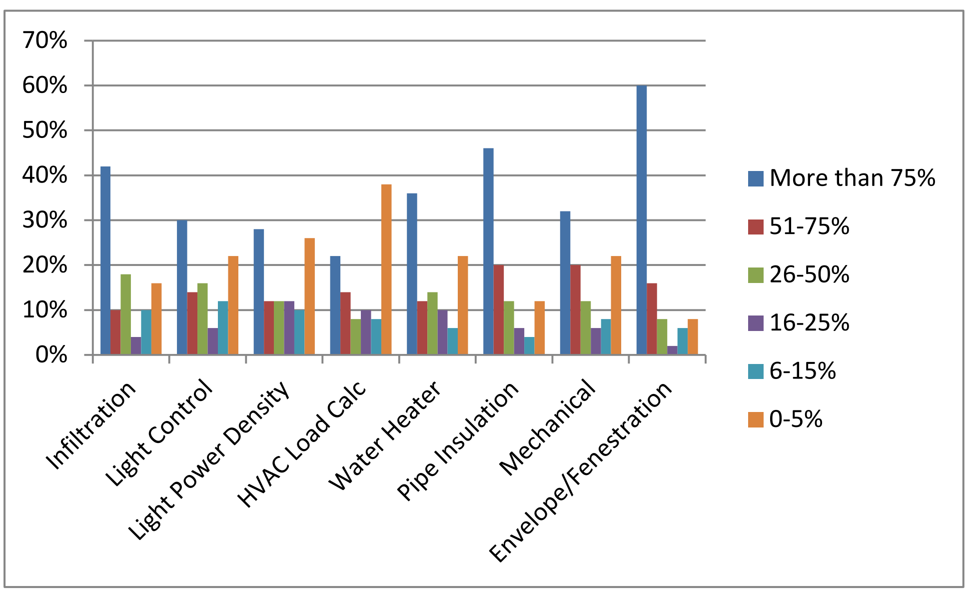

Figure 3-4: Frequency Commercial Measures Checked

As Figure 3-5 shows, again those code elements that are most often observed and checked by code officials looking at commercial buildings are the elements that cose officials most often find to not be in compliance.

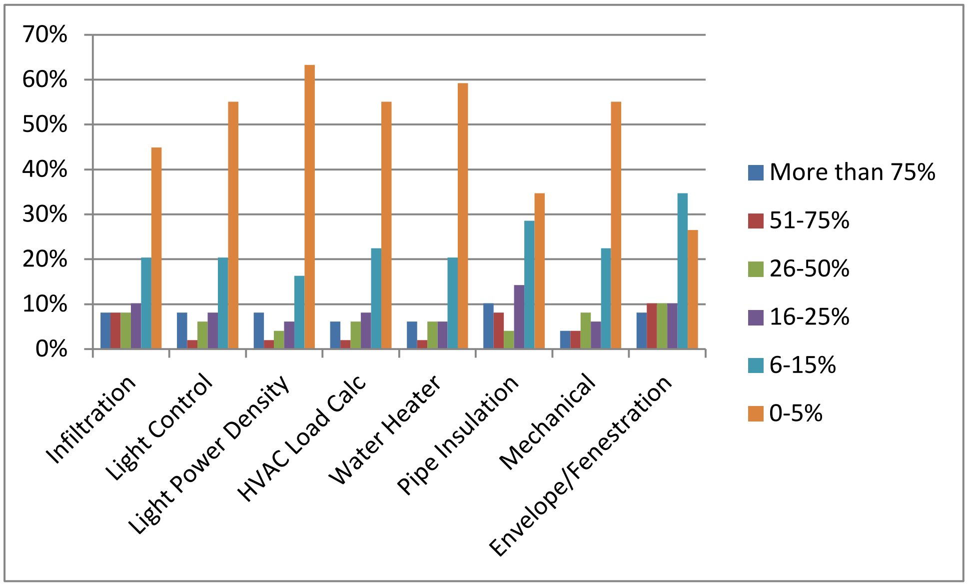

Figure 3-5: Frequency Commercial Measures Found Not in Compliance

3.2 SURVEY OF BUILDERS

3.2.1 Overview

A telephone survey of 61 builders was conducted to measure the level of code compliance of builders across the state. The builder names were drawn from two sources: a FW Dodge commercial project list and an InfoUSA list of residential builders.

3.2.2 Key Findings

1. Most builder/contractors (65%) report that a code official reviewed the energy code section of their building *plans* "all or most of the time." However, approximately only 50% of the builders report that insulation and HVAC efficiency were field-checked "all or most of the time."
2. Most builders of commercial-code properties think there is a good likelihood that code officials will check their *plans* regarding new commercial energy code requirements. These respondents think it is less likely that code officials will *field inspect* their buildings. Most of the builders are unsure how hard it will be to comply with the changes in the new energy code.

3. When asked what method residential builders use to make sure homes they build meet the energy code, the ENERGY STAR® Homes builders noted the use of HERS raters. RES*check*™ is the most frequently cited approach by non-ENERGY STAR® Homes builders.
4. Builders/contractors not previously involved with ENERGY STAR® Homes are not very familiar with advanced energy diagnostic techniques such as blower doors, duct blasters, and Manual J and D calculations. Most cannot even judge how difficult it will be to incorporate these practices into their building approaches.

3.2.3 Sampling Methodology

The Dodge commercial dataset includes a list of general contractors associated with each permit filing. The dataset contained 1,856 names of general contractors associated with commercial projects in the last two years.

A list of all of the residential builders based in the State of New York was purchased from InfoUSA. InfoUSA builds their list using phone directories, licensing lists, and other sources. This list was matched to the Dodge list and common firms were removed from the InfoUSA list. The list contained 1,856 names. The list was randomly divided into two equally sized sections of 928 each so that this Study and another NYSERDA Study could each conduct interviews without worrying about builders being contacted twice.

The survey shown in Appendix E was administered to 61 builders/contractors who had built at least one project in New York in the last two years. Table 3-9 shows the type of buildings built by the sample. Forty of the active builders reported on the length of time they have been in business. The average length is 27 years. Only 6 of the 40 (15%) have been in business less than 10 years. Forty-five businesses reported their number of employees, with the average number being 17. However, this relatively large number is skewed by two large firms each with over 100 employees. Half of the firms have eight or less employees.

Table 3-9: Type of Buildings Built in Last Two Years

	Response total	Response percent
Single family or townhouse homes	39	60%
Multi-family buildings (4 or more stories)	15	23%
Non-residential commercial, industrial, or governmental buildings	20	31%
No activity	0	0%
Don't know	1	2%
Refused	2	3%

Respondents were asked if they have participated in any of the new construction programs sponsored by NYSERDA or the Long Island Power Authority (LIPA). Table 3-10 indicates that approximately one-quarter of the respondents report that they have participated in a new homes program. One other respondent reported that s/he had participated in a commercial new construction program (not listed in below chart).

Table 3-10: Participation LIPA or NYSERDA ENERGY STAR® Homes

	Response total	Response percent
Yes	16	26%
No	42	69%
Don't Know	3	5%
Refused	0	0%

Table 3-11 shows the frequency with which builders used the following residential codes.

Table 3-11: Build Using What Residential Code

	Response total	Response percent
ASHRAE 90.1 2003	23	8%
ECCC NYS 2003	27	15%
ASHRAE 90.1 2007	21	30%
ECCC NYS 2010	27	43%
Total Building to New Code	33	50%

Respondents were asked, "Thinking again of all the buildings you have built in New York over the last two years, did the code official discuss with you any of the building elements covered by the energy code?" Table 3-12 indicates that energy code issues were discussed with about half of the builder/contractors.

Table 3-12: Did Code Officials Discuss Elements of Energy Code

	Response total	Response percent
Yes	27	44%
No	22	35%
Don't Know	12	19%
Refused	1	2%

Respondents were asked the frequency that code officials performed plan and inspection functions. Figure 3-6 shows the frequency of the following four actions:

- Building permit submission was checked for energy code compliance
- Building permit was required to be changed to comply with energy code
- Code official visited site to inspect insulation prior to covering it up
- Code official checked the installed HVAC equipment to see that the efficiency matched that indicated on submission

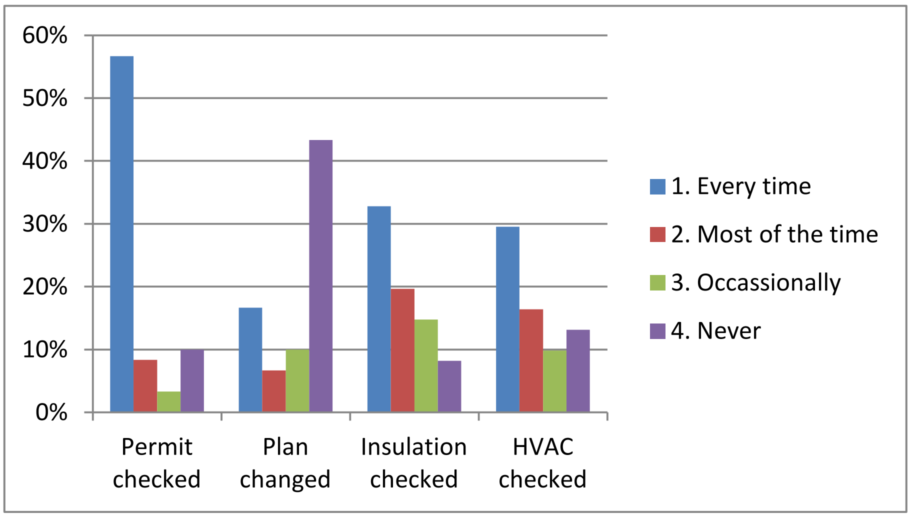

Figure 3-6: Frequency of Energy Code Actions

Four respondents identified specific measures that code officials required they change or fix. The list includes, insulation (two responses), lighting, insulation on foundation, and tape at every joint and to cover floor and ceiling.

Respondents were asked to rate the knowledge of the code officials for their understanding of the energy code components of the code. Table 3-13 indicates that builders/contractors are split between whether code officials are extremely or somewhat knowledgeable about the energy code

Table 3-13: How Informed Are Code Officials on Energy Code Issues?

	Response total	Response percent
Extremely knowledgeable	25	40%
Somewhat knowledgeable	29	47%
Somewhat uninformed	0	0%
Extremely uniformed	2	3%
Don't know	6	10%
Refused	0	0%

Respondents were asked if they had attended a training session for the new building code. As Table 3-14 indicates, only 11% of the respondents have done so.

Table 3-14: Attended Training for New Energy Code

	Response total n=62	Response percent
Yes	7	11%
No	52	84%
Don't know	3	5%
Refused	0	0%

Table 3-15 indicates that the training was only fully comprehensive for three of the seven attendees.

Table 3-15: Usefulness of Code Training Content

	Response total n=7	Response percent
Training provided all of the information I need to comply with the new code	3	43%
Training provided me the information I need in some areas but only general information in others	2	29%
Training provided me a general idea of what it will take to comply with the new code	2	29%
Training did not provide much useful information	0	0%

Builders of commercial projects were asked about new elements of the commercial energy code. Table 3-16 shows their responses to the ease or difficulty with which they see new code elements being incorporated into their buildings. Most of the builders were not sure what was going to happen. Those that knew were generally either already complying or would find it easy to adopt the code change.

Table 3-16: Ease or Difficulty in Adopting New Commercial Energy Code Provisions

	Standard procedure under buildings you built under the old code	New procedure easily adopted	New procedure that will be difficult to always meet	Don't know
Temperature set point dead bands between heating and cooling within allowed tolerances?	34%	6%	9%	50%
R-20 or higher above deck roof insulation	41%	3%	3%	53%
Maximum voltage drops on feeder conductors are less than 2% and branch conductors are less than 3%	19%	12%	0%	66%
Occupancy sensors in all classrooms, meeting rooms and lunch rooms	25%	6%	3%	66%
Lighting power densities (LPD) are provided as part of the design drawings	31%	12%	0%	56%
Demand-Controlled Ventilation (DCV) systems in spaces larger than 5,000 square feet.	22%	3%	9%	66%
Include detailed control schematics for lighting and mechanical systems in submission	19%	9%	9%	62%
Assure fan/pump motor horsepower is not oversized	19%	9%	9%	62%

The survey asked commercial contractors the likelihood that code officials would stringently check the permit's application to see if code elements are included. Table 3-17 shows that commercial builders think code officials are most likely to check the *design plans* (in advance of field inspections) for the installation of occupancy sensors, the required lighting densities, and deck roof insulation. The contractors think code official are least likely to check for fan and pump horsepower and demand control ventilation.

Table 3-17: Likelihood Code Official Will Check Plans

	Extremely likely	Somewhat likely	Somewhat unlikely	Extremely unlikely
Temperature set point dead bands between heating and cooling within allowed tolerances? (n=17)	41%	41%	12%	6%
R-20 or higher above deck roof insulation (n=14)	57%	43%	0%	0%
Maximum voltage drops on feeder conductors are less than 2% and branch conductors are less than 3% (n=11)	54%	36%	10%	0%
Occupancy sensors in all classrooms, meeting rooms and lunch rooms (n=11)	64%	36%	0%	0%
Lighting power densities (LPD) are provided as part of the design drawings (n=16)	56%	31%	0%	12%
Demand-Controlled Ventilation (DVC) systems in spaces larger than 5,000 square feet. (n=10)	40%	40%	10%	10%
Include detailed control schematics for lighting and mechanical systems in submission (n=13)	46%	54%	0%	0%
Assure fan/pump motor horsepower is not oversized (n=14)	29%	50%	7%	14%

Table 3-18 asked a similar question regarding the likelihood that code officials will *field inspect* the same code requirements. With the exception of roof insulation, contractors think that it will be less likely that code officials will inspect items in the field than the code officials will review plans.

Table 3-18: Likelihood Code Official Will Field Inspect

	Extremely likely	Somewhat likely	Somewhat unlikely	Extremely unlikely
Temperature set point dead bands between heating and cooling within allowed tolerances? (n=15)	20%	67%	13%	0%
R-20 or higher above deck roof insulation (n=14)	57%	43%	0%	0%
Maximum voltage drops on feeder conductors are less than 2% and branch conductors are less than 3% (n=12)	33%	67%	10%	0%
Occupancy sensors in all classrooms, meeting rooms and lunch rooms (n=13)	38%	46%	8%	8%
Lighting power densities (LPD) are provided as part of the design drawings (n=13)	46%	54%	0%	0%
Demand-Controlled Ventilation (DVC) systems in spaces larger than 5,000 square feet. (n=9)	22%	78%	0%	0%
Include detailed control schematics for lighting and mechanical systems in submission (n=9)	33%	56%	11%	0%
Assure fan/pump motor horsepower is not oversized (n=12)	8%	67%	17%	8%

The survey asked builders of residential buildings to address the degree to which they previously used practices that are now part of the new residential energy code. Figure 3-7 shows the frequency with which practices are used. Remember that the survey contains 16 respondents who claim to have participated in an ENERGY STAR® Homes program, and those respondents were likely to have used *some* these practices on all of all their buildings. It does not appear as though builders outside of the NYSERDA and LIPA programs are performing blower doors tests.

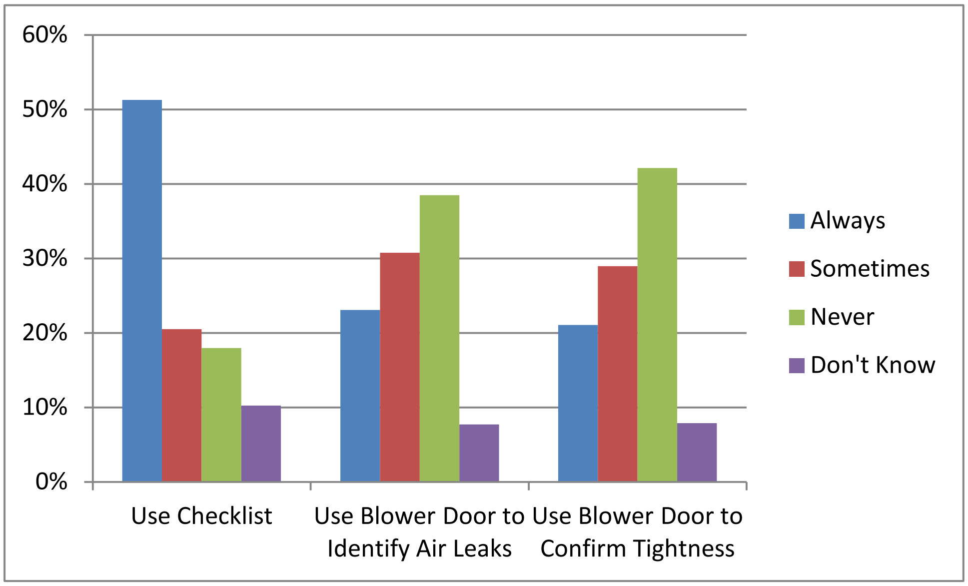

Figure 3-7: Frequency Using Techniques by Single Family Builders

The survey also asked all builder/contractors the extent to which they use Manual J, Manual D, and diagnostic test for air and duct leakage. As Table 3-19 indicates, there has been a decided increase in the use of these applications. However, most respondents do not use these techniques.

Table 3-19: Use of Building Diagnostic Practices

	Two Years Ago	Now
Manual J load calculation	6	13
Manual D for duct installation	6	13
Conduct a room pressure balance test	4	10
Duct leakage testing	7	14
Blower door testing	8	16
Location of all ducts within the building thermal envelope	5	11

The 16 builders who have participated in an ENERGY STAR® Homes program were asked if code officials accept the ENERGY STAR® Homes certification as a verification of passing the energy code. Table 3-20 indicates that this is not universally done. Most of the respondents report that at least sometimes ENERGY STAR® Homes designation is in part accepted as proof of compliance.

Table 3-20: Acceptance of ENERGY STAR® Homes to Verify Energy Code Compliance

	Response total	Response percent
Code officials always accept ESH label as sign of code compliance	3	19%
Code officials sometimes accept ESH label as sign of code compliance	4	25%
Code officials sometimes accept ESH label and also want to supplementary compliance verification	2	13%
Code officials never accept ESH label as sign of code compliance	1	6%
Don't Know	6	38%

Residential builders were asked what type of compliance approach they use. Table 3-21 shows that many of the ENERGY STAR® HOMES builders noted the use of HERS raters. RES*check*™ is the most frequently cited approach by non-ENERGY STAR® HOMES builders.

Table 3-21: Residential Code Compliance Approach

	Response total	Response percent
Prescriptive path	4	10%
RES*check* (Trade Off path)	14	44%
REM/Rate (Performance path)	0	0%
HERS Home Energy Rating System (HERS), (Performance path)	14	44%

Residential builders were asked how easily they could adopt the newest energy code practices into their construction. Table 3-22 indicates that half of the respondents have not yet become sufficiently exposed to the practices to be able to project how easily their businesses can incorporate the new code-required practices.

Table 3-22: Easy of Adopting New Residential Code Requirements

	Standard procedure under buildings you built under the old code	New procedure easily adopted	New procedure that will be difficult to always meet	Don't know
Installation of high-efficiency lamps, such as fluorescent, in at least 50% of permanently installed lighting fixtures	15	9	3	23
Blower door testing for air leakage	12	8	4	26
Duct blaster testing to measure duct tightness	10	7	6	27
Requirement that any home addition, alteration, renovation or repair conform with the provisions of the new code requirements	13	7	4	25

Given the complexities associated with the new energy codes, the survey asked respondents to rate the suitability of particular types of individuals to perform energy code compliance tasks. Table 3-23 reveals that 66% of builder/contractors feel that code officials are well suited to doing this type of work, but many feel that other professionals could be used.

Table 3-23: Suitability of Different Entities to Perform Energy Code Compliance

	Well suited	Neither well suited or poorly suited	Poorly suited
Code officials	66%	20%	15%
Home Energy Rating System (HERS) raters	53%	35%	12%
Architects	22%	60%	17%
Engineers	43%	47%	10%
Building Performance Institute (BPI) certified contractors	55%	32%	13%
Another independent contractor	29%	37%	34%
Self-testing	13%	29%	58%

3.3 RESIDENTIAL RENOVATION SURVEY

3.3.1 Overview of the Renovation Survey

In the original framework established by DOE, states were intended to test the energy checklist on 44 residential and 44 commercial renovation projects. In framing the research objectives for this Study, it was determined that a phone survey of 55 owners who did a residential renovation would be done in lieu of the more expensive on-site data collection specified as part of the BECP 2017 protocol. The Team purchased the only available list of residential permits from Dodge, which included renovation projects, and tried to call all available names from that list. The survey Team was only able to complete 20 surveys due to both a very small amount of permits available on the Dodge database (only 491 over three years), as well as the difficultly in reaching live phone numbers.

3.3.2 Key Findings

1. The majority of homeowners in NY State do not file a permit when performing a home renovation, thereby severely compromising the ability of code officials to provide oversight and enforcement of the code.

2. The BECP requirement that states complete an on-site survey of 44 residential renovation projects will be problematic. The Dodge data proved to be useless for generating a large enough sample of renovation projects. Not only are most projects not filed, but those few that are included in the Dodge reports are mostly not connectable to a valid phone number or are commercial – rather than residential – renovation projects.

3. None of the small number of homeowners spoken recalled any code official activity specific to the energy code.

3.3.3 Sampling and Recruiting Issues

A phone survey instrument found in Appendix F was developed to find out what type of renovation was undertaken, what interactions there were with code officials, and the extent to which energy code requirements were checked, inspected, and enforced.

The most difficult aspect of this sub-task was trying to find a source for recent renovation projects in New York. Most renovation projects in New York whether they are minor additions or structural changes are required to file a building permit. (The 50% of conditioned square footage rule no longer applies.) The FW Dodge reports from McGraw Hill collect permit data from approximately 40 percent of the New York State permitting jurisdictions, so it was thought that this would be a good source. The project purchased the residential permit data for all of New York for the three-year period from 2008 through 2010.

The Dodge data proved to be an extremely poor option for finding renovation permit projects. Of the 2,938 unique projects listed in the Dodge single-family (1 to 4 houses) file, only 491 were for renovations, representing about 17% of all of the projects in the state. The authors believe this ratio must severely understate the number of renovations that occurred in these selected areas. The ratio of renovation to total permits for the non-residential Dodge data for the same period was 64%. *It is clear that the majority of people doing residential renovation projects in New York fail to draw a permit.*

Of the 491 names of renovation projects that were acquired, telephone numbers from a reverse-directory service produced only 275 phone numbers. As Table 3-24 indicates, most of these numbers proved to be incorrect or unreachable. The project was only able to complete 20 surveys from the available renovation list. Therefore, in addition to performing the telephone surveys, the Team obtained qualitative feedback from homeowners who built new homes as part of the data intake from the 44 intensive on-site home evaluations (see Section 4).

Table 3-24. Residential Renovation Disposition Summary

Disposition Report	Number	Percent of Original Sample
Original Dodge Sample	**491**	
Phone Number Match	275	56%
Non-Working Number	69	14%
Unable to Contact (5 Attempts)	60	12%
Refused	22	5%
Not Eligible	104	21%
Completes	20	4%

3.3.4 Interview Results

The surveys produced 20 completed interviews, though two of these could not recall or did not know most of the details. *In no cases did the homeowner report that a code official commented on or required changes to any energy-related component of their renovation***.** Six of the 20 homes reported that the code official required them to make changes in their renovation plans, but in no cases was the change related to energy efficiency. No one reported any code official mentioning any energy code requirements. The lack of attention to energy related code is not a reflection of disregard for *all* code matters. All of the nine households who remember visits by code officials to their projects remember at least two visits. Five of the nine report that code officials made more than four visits.

Sixteen of the 18 respondents say that energy efficiency was considered in plans before showing plan to code officials. Yet, the responses to what materials they installed do not suggest that renovators did anything more than meet minimum levels of energy efficiency. Few used anything resembling state-of-the-art practices. There was one respondent who says s/he installed a solar thermal system. Most of the respondents (12) thought that their building (8) or their energy consultant (4) was Building Performance Institute (BPI) certified. However, only one of 20 projects used a blower door to help identify air leakage. One other do-it-yourself renovator used an infrared gun to find leaks. Only two of the respondents could identify the R-value of the walls (in both cases the answer was 19).

Twelve of 18 respondents installed a new heating and/or cooling system. Eleven of these involved ductwork. One reported that ducts were sealed with approved duct tape (not likely true); another indicated that spray foam was used. The rest did not know how their ducts were sealed. No homeowner mentioned the now commonly-used mastic sealant. Only one person knew the efficiency of his heating system 83%. In general, homeowners demonstrated a very low level of knowledge about the energy components of their homes.

3.4 QUALITATIVE FEEDBACK FROM HOMEOWNERS WHO BUILT NEW HOMES

The Team obtained thorough feedback from six homeowners whose new homes were included in the on-site evaluation work discussed in Section 4. The feedback can be classified into four categories of homeowners that the Team believes are representative of the homeowner community.

1. **Highly educated and involved:** One of the six respondents could be considered to be among a small group of homeowners who are very well educated on opportunities for energy savings in new construction. These homeowners have taken the time to become educated and are highly involved in the process of interacting with both the architect and overseeing the installation of critical energy measures by the construction crew. Due to self-selecting participation, the sample of homes inspected is likely to be biased towards homeowners who have a higher than average interest in energy efficiency elements. These homeowners are also in the financial position of being able to invest more money upfront to achieve future energy savings. The VEIC Team observed one of the 44 homeowners fit this category, and the quality of the construction reflected the homeowner's high involvement.

   "*The homeowner cared enough to upgrade from Icynene (specified by the architect) to high density foam everywhere. The exterior foundation walls are insulated. This is one of the three best houses I've evaluated in the last three years."* - CSG Rater

2. **Somewhat aware, but need more education:** One of the homeowners was also the builder and therefore was very involved in the process. While the home showed evidence of very high quality construction, several critical air sealing opportunities were missed, thereby creating thermal bridging throughout the building envelope.

3. **Budget-constrained:** Two of the six written comments specifically identified homeowners who, due to budget constraints, made choices to not install higher quality or amounts of insulation or to select high efficiency HVAC equipment. These respondents did not opt to use foam insulation.

4. **Lacking energy awareness:** Two of the written comments identified homeowners who were totally uninformed of the energy elements of their building envelope or HVAC equipment. The following comment was honest, and not atypical:

   "We pressured the builder to make cosmetic upgrades, but we didn't consider energy factors."

   -Homeowner participating in on-site evaluation

   In this case, as in many others, the homeowner's lack of knowledge about air sealing was reflected in the quality of the construction.

   "I've seen worse houses, but they are mostly hunting shacks built in the forties. There was no attempt to air seal. Insulation and duct installation doesn't meet current code. The homeowner has called the builder back several times to fix prevalent cracking drywall seams. But the problems beneath the drywall are of an even greater severity. It is unfathomable to me that this house passed inspection." -CSG Rater

3.5 ARCHITECTS SURVEY

3.5.1 Overview

The Team sent an e-mail survey to 6,000 architects who are American Institute of Architects (AIA) members and received 69 responses. The survey is shown in Appendix G. The questions in the survey were deliberately open-ended so as to enable these highly trained professionals to express their views of the greatest barriers to constructing highly energy efficient new buildings (residential and commercial).

3.5.2 Key Findings

Architects point to several reasons that there are gaps between the code requirements and how buildings are designed, as follows:

1. **Code requirements:** the issues identified fell into three categories:

a. **Insufficient sophistication** – Especially architects who design large and medium-sized commercial buildings indicated that the code does not adapt well to the huge myriad of specific circumstances of a large, complex buildings. They also cited COM*check*™, the checklist used to verify that plans meet the commercial energy code, as being too simplistic.

b. **Standards being too low –** Many architects feel that the current NYS Energy Code does not go far enough, and that stricter energy codes should be enacted. Several pointed to the inconsistencies between LEED and the NYS Code, with neither providing sufficient emphasis on the building envelope. Others faulted the lack of requirements for *"commonly understood new 'smart' design concepts"* such as increased daylighting and natural ventilation.

c. **Complexity** – On the other hand, several *residential* architects complained that the code is too complex. Given the size of the building they are designing, the energy calculation and documentation requirements appear overly burdensome relative to the budget of the project. Some requested simpler compliance paths. One suggested simplifying the code and deferring to the professional industry standards in ASHRAE, etc.

2. **Costs:** Architects of all sizes of buildings very frequently cited owners' focus on first costs – rather than lifecycle costs – as a major impediment to including the optimal energy design and highest efficiency equipment. Architects complained that they are "seldom-to-never" hired to perform commissioning to ensure quality installation which meets their design specifications. Architects indicated that the owners having this low level of appreciation for the impact of energy specifications was absolutely one of the largest reasons why Construction Documents weren't even specified to be built to meet the energy code. Even worse, after the Construction Document is issued, the actual construction on the site is very often compromised by either the builder needing to control cost over-runs, or by "business as usual" construction techniques by each of the subcontractors. [The construction industry is often cited as one of the greatest resistant to change, given the common generation-to-generation workforce and on-the job apprenticeship, rather than formal training.]

3. **Education:** Nearly all architects cited lack of education as being a major contributor – even education for their own profession.

> "*No one in an official capacity is sufficiently knowledgeable to check on accuracy of the energy components of my design. I myself sometimes don't know if I've designed it correctly, even with my continuing AIA training. I'm less confident of energy code compliance than I am with many other parts of my design – especially since the standards continually are increasing – albeit a good thing. I have no one outside my firm to provide peer review, much less enforcement. I've*

> *seen some pretty leaky buildings – including LEED buildings – that never should have been allowed."* -Architect responding to e-mailed survey

The respondents also saw a need for significantly greater education on energy issues for all stakeholders in the process, including: owners, engineers, code officials, general contractors, sub-contracting trades, end-users, and even architects themselves. While training currently exists for code officials, architects cited the need to dedicate significantly more resources to training at all stakeholders in the process. Some progress in this area is also being encouraged by more builders and subcontractors who focus on retrofits working to receive BPI (Building Performance Institute) certification – but this is the exception, rather than the norm. [Building Performance Institute, Inc. is an organization focused on standards development and certification, and this certification is required in many states for residential energy auditors, as well as HERS rates.]

In one of our eight Policy Interviews with high level stakeholders, one professional remarked on the prevalence of lack of life-cycle cost considerations by Building Department Project Managers within municipalities. Where a substantial percentage of the market-based development is done by builders who will re-sell the property, clearly municipalities will own the buildings for a very long time – potentially as long as 100 years. Therefore the lost opportunity for energy savings by attention to first costs (driven naturally by tight municipal budgets) is even more disappointing.

4. **Lack of enforcement:** Several architects expressed frustration that the code officials have neither the training nor tools to provide real enforcement. One architect suggested creating an inspector role specifically to review both *insulation design details and installation* since proper air sealing and insulation is extremely complex and so often a missed opportunity. (As an aside, cases of thermal bridging were observed as one of the most prevalent problems in the VEIC Team's on-site evaluations of both residential and commercial buildings. This will be discussed in detail in Sections 4 and 5 in this report.) Many architects citing lack of enforcement referred to the need for an energy inspector of some sort to *continually* evaluate the energy elements *as they were being installed* – and not just post-construction. Several architects expressed frustration that there is no enforcement of energy use projections being compared to post-occupancy audited actual usage. Some respondents suggested penalties to architects for lack of code compliance which originates with the architectural design.

5. **Insufficient credit given to re-use of existing buildings:** Architects who design major renovations to existing buildings commented that the "rigid" requirements of the NYS Code provide insufficient consideration of the difficulty in improving a pre-existing non-compliant infrastructure. Another commented that the energy code doesn't give sufficient credit and leeway in saving historical buildings. Similar comments indicated that some architects believe the code should provide some trade-offs and code relief for saving an existing building, compared to the high energy use and construction waste created in demolishing an existing building and replacing it with a new one.

1.5.3. Respondents' recommendations

The survey requested respondents to identify their suggestions for new requirements for increasing the energy efficiency of new and existing buildings. It also asked for specific recommendations for new efforts that New York State and NYSERDA should undertake. The recommendations can be summarized into four categories:

1. **Higher requirements of several types**:

    a. **Commissioning** was the most widely recommended requirement. Some suggested commissioning specifically the wall assemblies and air infiltration barriers. Others indicated that they felt the entire building needs to be commissioned. The respondents did acknowledge that the largest barrier to implementing commissioning is the cost that the owner will not want to bear. This led to a further emphasis that perhaps the most important set of stakeholders to educate are building owners – especially those in the commercial sector.

    b. **Third party raters** were a frequent recommendation. Several architects focused on the specific need for *"certified energy / insulation detailers and inspectors – just like electrical and plumbing inspectors."*

    c. **Energy use auditing post-occupancy** was mentioned by several respondents.

2. **Education:**

Overall the architect respondents emphasized a need for training, training, training of the group that is the most critical, but which receives very little training currently – the owners!

> *"Most owners still have never heard of integrated design and life cycle analysis because they don't obtain any type of certification or training which requires it. This is the group that needs to be educated into understanding they have a responsibility to reduce the environmental impact from cradle to grave."*

One residential architect offered some very specific recommendations:

> *"1.) Grant current ENERGY STAR® Homes raters the option of training certification for Version 3 at no cost.*
>
> *2.) Work with the AIA to develop one free software program (performance-based like REScheck^{TM}), with free training.*
>
> *3.) Require mandatory training, exam and certification for general contractors and construction managers."*

Other architects emphasized the need to refocus training within their own profession:

> *"Every local AIA chapter has classes on the handicapped code. The same emphasis should be placed on the energy code."*

One architect mentioned educating more architects on EQuest, which he/she characterized as:

> "*A complex but free Energy Performance software program* [EQuest] *currently used only for commercial buildings, but could easily be required for residential construction."*

Equally important, several architects advocated for the need to educate building managers and occupants, given the huge impact of user behavior. [Recently more sophisticated energy performance management systems and behavior modification programs have been introduced, but these are relatively new and still evolving.]

3. **Renewable energy:**

Architects repeatedly mentioned their desire to see renewable energy receive greater incentives or requirements to be included in commercial buildings. One architect offered the suggestion that innovation with renewables be encouraged – for example trading-off over-sized glazing with PV arrays. Another suggested the eventual goal: *"Buildings should be designed to function off the grid."*

4. **Incentives:**

Some architects recommended preferential zoning treatment. Others advocated for more incentives for owners to pay for upfront costs and to replace existing poorly-performing equipment. Several mentioned their desire to see greater incentives – and greater marketing of those incentives – paid to builders through NYSERDA's New York ENERGY STAR® Homes and C&I-focused The New Construction Program (NCP). One suggested a property tax incentive that relates to a metric of energy consumed. One suggested a "visionary" – but perhaps currently politically improbable – tax on energy usage. Another mentioned a harsh impact on the construction of larger and leaky homes – a *"tax-guzzler tax!"* Similarly, another mentioned a *"requirement for a maximum energy budget per square feet – including all forms of energy use: space heating and cooling, hot water and electricity."* And several mentioned the (failed-to-date) federal effort for home energy ratings. While many of these suggestions are likely difficult to implement in the short-run, the range and frequency of suggestions suggests the passion that architects carry regarding their pride in developing energy efficient buildings of the future. Often architects are considered the best educated and the thought-leaders in the energy efficiency campaign.

3.6 SUMMARY

Homeowners are clearly not a significant stakeholder in promoting energy efficiency, as their knowledge base is generally very low and they have virtually no interaction with code officials. There are some examples of rare exceptions – homeowners who are highly educated and who monitor the quality of the installation of energy elements. However, many stakeholders indicate that owners are the biggest source of the problem, in that they do not recognize the value of life-cycle, instead of first costing. These comments were primarily directed at commercial building owners who are under constant budget pressure and generally have little interest in building above code. Meanwhile, builders are not motivated to pay strict attention to the energy code elements because they experience the enforcement as being lax. Only 65% of builders felt that the code official checked the original plans; only 50% felt that the code officials did on-site inspection of energy-related elements; only 44% had had a conversation with a code official about an energy code concern. There is also a theme of some elements that builders are aware code officials are more likely to inspect – insulation levels quality of installation, occupancy sensors, the required lighting densities, and deck roof insulation. By the same token, builders believe code official are least likely to check for fan and pump horsepower and demand control ventilation. Code officials will need to widen the breadth and scope of their enforcement if 90% code compliance is to be achieved.

The architects repeated these overall concerns of owners' lack of education and focus on first cost budgets, as well as not being faced with sufficient enforcement threats. Architects appealed for greater training of all stakeholders – including their own profession – and not just of code officials. Architects believe that training for builders is uncommon.

Meanwhile, code officials demonstrated difficulties in performing their enforcement role. Lack of staff and time to enforce codes is recognized as a major impediment. On energy-related matters, code officials spend an average of approximately 100 minutes for each residential building, and 200 minutes on commercial buildings for both plan review and on-site inspection. On-site inspections during construction are highly time-consuming and not likely driven by the specific timetable necessitated for inspection of energy-related elements. As for training, only seven of the 65 interviewed had attended energy-specific training, and of those, only three felt that the training was sufficiently comprehensive to enable them to adequately perform their role.

Section 4:

RESIDENTIAL SECTOR ASSESSMENT

This portion of the project was conducted by a sub-contractor, Conservations Services Group (CSG) – a firm with extensive experience with in-field residential evaluation conducted by HERS (Home Energy Rating System) Raters who have Building Performance Institute (BPI) certification. The requirement for participation in the residential building on-site evaluation was that the home needed to have been built in the past four years (2007 – 2010) and had not participated in the New York ENERGY STAR Homes® program.

The Project Team anticipated that leads for the field survey would be provided by a run of residential Dodge data (electronic list of permits pulled). Unfortunately this data proved both inadequate in terms of sufficient quantity of data needed for specific counties, as well as inaccurate by including remodeling projects and commercial (not residential-only) projects. No other data sources were available, as New The VEIC Team conducted on-site assessments of 44 single- and two-family non-ENERGY STAR® residential homes across New York to determine compliance rates with the residential energy code requirements of the ECCCNYS - 2007. A compliance assessment was also made against the IECC - 2009 and guided the conclusions and recommendations section of this report. The details of the sampling design and recruitment methodology were described in detail in Section 2. A summary of the data collection process, results of the compliance analysis and the energy impacts of non-compliance are presented in this section. A detailed description of methodology and results is found in Appendix I, Residential Detailed Methodology and Analysis. The forms used as part of the residential on-sites are included as Appendix J. Other appendices associated with the residential on-site include: Appendix M: PPNL Checklist Summary Results, Appendix N: NYSERDA Residential Compliance Assessment Summary Sample Data, Appendix O: Code Compliance Project Field Data Collection Overview; Appendix P: Residential Recruitment Results, and Appendix Q: QA/QC of Residential Survey Data and Data Entry.

4.1 DATA COLLECTION FOR RESIDENTIAL SECTOR

4.1.1 Lead Generation

York State does not have an electronic central database of either residential or commercial permits. As a result of being forced to use this data, only 25 of the 44 locations identified in the sample design had any Dodge data available, and of those, the CSG call center was only able to schedule 10 sites.

To supplement the Dodge data, CSG utilized field staff to try to locate leads in the designated area. Two individuals did the bulk of this work, although others helped based on location. This process met with mixed success. Initially, this effort was primarily directed to code official offices. Some locales were very forthcoming with permit information, but the majority required Freedom of Information Act (FOIA) requests or simply did not respond to the requests. A few sites were identified by using an internet search of cross-referencing tax rolls, property sales and Google searches. Some designated locales did not have any projects during the target period or were unable to provide them. As a result, CSG was directed to expand the lead generation to neighboring towns and subsequently neighboring counties. Although this process was extremely labor intensive it yielded 24 of the 44 sites. The final sites came from a combination of those that responded to a second letter requesting participation (2) and an appeal to friends or family that might have a qualifying site (8). The final breakdown of lead sources for the 44 sites is as follows:

Dodge Data: 10
CSG Field Visits and/or Research: 24
Customer Requests: 2
Referrals: 8
Total: 44

4.1.2 Pre-Site Visit Activities

Owners were contacted by the Rater, one to two days prior to the site visit. This call served multiple purposes including:

- To confirm that the home was suitable for this Study, i.e. built between 2007 and 2010;
- To let the owner know what to expect regarding testing and to answer any questions that may have developed after the initial appointment was made by the CSG Call Center;
- To confirm the time element and verify that the homeowner will be available for duration of the appointment (the call center had already prepared the homeowner for a two to three hour inspection duration);
- To instruct the owner to extinguish a wood fireplace or stove if relevant; and
- To determine if the home had a forced air heating system with ducted distribution. Houses with duct systems require two technicians to complete the inspection in the time allotted.

4.1.3 On-Site Home Inspections

Owners were generally accommodating of the inspection process although they were aware that they would not be given a report presenting the findings. Homeowners were particularly interested in the ‘real time’ analysis. Only one customer expressed that s/he was inconvenienced during the inspection. Outside of the normal inspection and rating, the Raters also performed some additional diagnostics including:

- One Rater provided exhaust fan capacity diagnostics on two homes where concern of tightness and moisture were present;
- Infrared (IR) thermography was conducted on a home where the owner was interested in the quality of self-installed fiberglass batt insulation in an attic that was not accessible at the time of inspection; and
- Digital photographs were taken of the exterior of all homes. Additional photographs were taken of areas or issues that related to inefficient energy use, moisture concerns, building durability concerns, or apparent code violations. These images often assisted in the creation of the REM/Rate™ file.

Following the inspection, REM/Rate™ models were created using the data collected from the site visits. Where model inputs could not be based on visual confirmation, code office documentation was used.

4.1.4 Code Office Visits

The CSG HERS Raters conducted on-site inspections prior to obtaining documents from the Code office. This approach provided for on-site data collection to be unbiased by documents available from the code offices. It was assumed by the Rater that the code offices would be familiar with the NYSERDA energy code compliance project after having received the project description on NYSERDA letterhead. Nonetheless, CSG Raters brought a copy of this document in anticipation of suspicion by the Code Office staff, as many did not remember receiving the letter. By the nature of the project title, “Code Compliance,” it was expected that Code Officials might have perceived the Team’s efforts as evaluating their work. As a result, the VEIC Team emphasized the aggregation of all data and that no one code official would be attributed to an individual building’s evaluation. However, the Team still experienced lengthy delays in obtaining plans. Most code officials felt no requirement to participate, despite letters from both the NY Department of State and NYSERDA. The project kick-off training and Field Data Collection Manual instructed the Raters to attempt to access building plans, RES*check*™ compliance reports, and ACCA (Air Conditioning Contractors of America) Manual J equipment sizing data (based on heat loss/gain calculations – not always done by the equipment installer). The Raters’ experience is that several of these documents were not on file at the code office.

Ultimately all documents that were present at the Code offices were delivered to CSG Raters. The method of obtaining these documents varied from one office having the documents waiting when the CSG Rater arrived (without prior request), to delaying delivery until the full FOIA time window of 20 working (not business days) was to expire. Some local jurisdictions did not meet this 20-day window, citing the inability to jump these requests to the front of the cue of extensive FOIAs filed by lawyers for information discovery. Many town halls cited budget cuts and furloughed work days; the code officials had no ability to influence the separate department that handles FOIAs. Three code officials indicated that the request would require lengthy legal review by their busy legal departments before they would cooperate in providing access to building plans. A total of 25 code offices were involved, and 23 code offices required FOIA forms, resulting ultimately in CSG filing 42 FOIA requests. No documents were withheld due to privacy concerns. The VEIC Project Manager also intervened in three cases where the process with code officials was stalled – once calling a code official nine times before he would respond.

The project had originally projected two weeks to perform recruitment and five weeks (two per day, with some slippage) to perform the on-site evaluations. Instead, the recruitment process carried over for two- and one-half months and the on-site evaluations and obtaining plans from the code agency were conducted over three months.

4.1.5 REM/Rate™ Issues

Numerous issues resulted in delays and significant amounts of additional labor for the Raters. Some of the issues regarding creating energy models for this project are:

- Six weeks into the project Architectural Energy Corporation (AEC) released a new version update of REM/Rate™ from 12.89 to 12.9. This temporarily affected the CSG QC process when updated file versions were sent back to the Rater which then could not be opened..

- Additionally, during the course of the project, AEC released version 12.91. Upon advice from VEIC, this version update was not installed on computers involved in this project because the new release included ECCCNYS - 2010 as the reference code. The code in effect at the time homes were built for this project was ECCCNYS - 2007 - the NYS reference code in REM/Rate™ version 12.9 and earlier. Therefore the Project Team continued to use version 12.9.

- This project took place as the RESNET community was attempting to identify and clarify the definition of a “Conditioned Space.” In December of 2010, RESNET issued “Formal Interpretation 2010-02 Definition of Conditioned Floor Area.” Because of the enormous variety in building construction, the definition of this term is not trivial and has a large impact on determining code compliance and energy use modeling. This lack of a clear definition had a significant impact on the time invested in modeling for this project. Because many REM/Rate™ screens with multiple data inputs rely on the state of conditioning of the basement, all of the REM/Rate™ files were affected by this issue.

- VEIC anticipated the “Conditioned Space” definition issue by creating a supplemental Excel spreadsheet in its on-site data collection tool, but the lack of clear definition still led to additional time spent ensuring that the homes were modeled correctly and that compliance was evaluated accurately.

- Well into the process, it was determined that the REM/Rate™ Help did not accurately translate RESNET standards regarding the state of basement conditioning as it relates to conditioned floor area and volume modeling inputs. This led to revisions of numerous files and confusion on the part of Raters, which were ultimately fixed through an intensive QA/QC process.

In the end, after many unanticipated hurdles, changes and challenges, the VEIC Project Team was able to recruit, visit, collect and analyze the data from the 44 targeted New York houses.

4.2 COMPLIANCE RESULTS FOR RESIDENTIAL SECTOR

The VEIC Team examined multiple compliance approaches to address the question "What is the energy code compliance rate of new homes in New York State?" Compliance rates using the DOE's suggested BECP Protocol for the sample of non-ENERGY STAR® ranged from 73% vs ECCCNYS – 2007 (the code at the time of permitting), and 63% vs ICEE – 2009 (as an illustration of future code requirements). (The suggested BECP Protocol allows states to claim that they have exceeded the 90% compliance rate if the upper bound of the confidence interval at 95% confidence is higher than 90%). In this case the upper-bound of 73% of the sample does not exceed 90% and New York does not meet the 90% compliance rate for residential new construction. It needs to be pointed out that the 73% represents the value for the sample of homes visited and that one cannot project the results to all NY homes. The Study did not include ENERGY STAR® homes in the sample because it was originally assumed that all ENERGY STAR® would be 100% (or nearly 100%) compliant with the ECCCNYS - 2007. Subsequent analysis has indicated that the HERS rating process does not cover all energy code requirements and some ENERGY STAR® homes would not receive a 100% score using suggested BECP Protocol. Secondly, the issues with sampling discussed in Section 2 have likely produced a sample of homes that is better than the average non-ENERGY STAR® home built in this period. Because of these issues, the Study can only report compliance rates for the selected sample. The most fully accurate statement this Study can make with certainty regarding the state compliance rate scored according to suggested BECP Protocol for that the residential sector is not above the 90% goal for ECCCNYS - 2007.

4.2.1 Compliance Calculation Methodology

The suggested BECP Protocols are the only method to quantitatively score each requirement of the code and thus are the focus of this Study in determining the energy code compliance rate of homes in New York State. However, the Team underwent an extensive effort to also score buildings against the appropriate code applicable at the time of permitting.

There are multiple approaches to energy code compliance. New York State has basic code requirements that are mandatory for all buildings. These basic requirements are either compliant or non-compliant.

Compliance with the remaining code requirements, such as insulation and window requirements, can be shown using the following four approaches:

1. The **Prescriptive Package Approach** allows builders to choose from packages of insulation and window requirement developed for each Climate Zone and building type;

2. The **Trade-Off Worksheet Approach** enables builders to trade-off insulation and window efficiency levels throughout the building;

3. The **Software Approach** is a Trade-Off compliance path that automates insulation and window components by trade-off calculations through the use of approved software (RES*check*™). This approach also allows heating equipment efficiencies to be traded off with building envelope components; and

4. The **Simulated Performance Alternative** may be demonstrated with an approved Home Energy Rating System (HERS) energy modeling software. This approach requires the total annual energy cost of the modeled design home be less than or equal to the total annual energy cost of the standard reference design.

As there are multiple approaches to *demonstrate* energy code compliance, there are also multiple approaches to *evaluating* energy code compliance. The three methods discussed in this residential section of this report include:

1. **"suggested BECP Protocol,"** developed by the Pacific Northwest National Lab (PNNL) for the U.S. DOE's Building Energy Codes Program (BECP) to demonstrate 90% compliance;

2. **"Trade-Off (e.g. RES*check*™),"** used to evaluate overall UA compliance. (The sum of U-factor multiplied by assembly area for the sample home must be less than or equal to that calculated for the code reference home); and

3. **"Simulated Performance,"** used to evaluate the overall energy performance of the home. (The annual energy cost of the sample home must be less than or equal to the annual energy cost of the reference code home).

The suggested BECP Protocol evaluates compliance quite differently than either the Trade-Off (e.g. RES*check*™), or Simulated Performance methods. The suggested BECP Protocol calls for the evaluation and quantification of all energy code requirements, with the exception of a few items that are either purely administrative or have no energy impact. The PNNL Checklist is the tool created by PNNL to calculate compliance by the suggested BECP Protocol methodology. The PNNL Checklist, specific to each Climate Zone, lists each code requirement as a separate item and evaluates each item as compliant or not compliant. Energy code requirements are weighted so that code items with a high energy impact receive a higher score (three points) when in compliance, and items with little or no direct energy impact receive a lower score (one point) when in compliance. For example, foundation wall insulation R-values, depth and quality of installation checklist items are all worth three points, while exposed foundation insulation protection is worth two points. Code requirements with a low energy impact, such as fenestration leakage rates, receive only one point. An overall compliance percentage "score" is calculated for each home by dividing the total received points by the total possible points. In cases where a given code requirement is not applicable to the home being assessed (e.g. on-grade slab insulation where no on-grade slab exists), or a code requirement cannot be assessed because it is not visible (e.g. the quality of insulation installation), these checklist items are not scored and thus do not affect the overall compliance percentage score of the home. The compliance percentage scores of each home are then averaged to produce an average compliance rate for the state.

The PNNL checklists were originally designed to assess compliance rates with IECC - 2009. VEIC adapted the checklists to the applicable code at time of permitting (for residential, ECCCNYS - 2007; for commercial ASHRAE 90.1 – 2004 or 90.1-2007) so that a compliance rate with the code in effect at the time of this Study could be generated. For the residential sector, compliance rates with both ECCCNYS - 2007 and IECC - 2009 are reported here.

The Trade-Off (e.g. RES*check*™) and Simulated Performance methods of compliance evaluation differ from the suggested BECP Protocol in two ways. The first difference is that the Trade-Off (e.g. RES*check*™) and Simulated Performance methods evaluate a home as either compliant or not compliant; whereas the suggested BECP Protocol provides a compliance percentage score (i.e. the home is 80% compliant with all the requirements of the code. The second difference is that, as stated above, the suggested BECP Protocol quantifies *all* requirements of the energy code, whiles the other two methods do not, per the explanation below.

The Trade-Off (e.g. RES*check*™) method evaluates and quantifies compliance with the insulation and window requirements of the code, and when applicable, the heating equipment efficiency levels (i.e. the Overall UA of the sample home is X% more or less than the Overall UA of the reference code home). The Simulated Performance method evaluates and quantifies the overall energy performance of the home (i.e. the annual energy costs of the sample home are X% more or less than the annual energy costs of the reference code home). Some basic code requirements (such as duct insulation and overall fenestration UA) are evaluated distinctly and built into the final compliance check produced by the software. This means that even if the home meets the overall UA (Trade-Off (e.g. RES*check*™)) or annual energy cost (Simulated Performance) requirement, if it does not also meet the basic code requirements, it is not compliant with the Trade-off or Simulated Performance approach. Many code requirements, however, are either included only as a manual checklist but not quantified, or not included at all. For example, a RES*check*™ Compliance Certificate only reports the Overall UA calculation. Code requirements such as insulation installation, duct insulation, and temperature controls are printed on a separate non-quantified

Inspection Checklist. Other code requirements, such as heating and cooling equipment sizing calculations and whether or not a compliance certificate has been posted are not treated at all. The Trade-Off (e.g. RES*check*™) and Simulated Performance methods only quantify about 25% of the code requirements quantified by the suggested BECP Protocol. This is discussed in more detail below and in Appendix I.

This Study reports the compliance rates resulting from each of these three compliance evaluation methods. The suggested BECP Protocol compliance rate is expressed as "percent in compliance," i.e. the average percentage of all code requirements that are in compliance for each home. The Trade-Off (e.g. RES*check*™) and Simulated Performance compliance rates are expressed as "percent pass," the total number of homes that are fully compliant with the requirements of the evaluation method. Appendix I also reports compliance rates with the Trade-Off (e.g. RES*check*™) and Simulated Performance methods with and without inclusion of the distinct basic code requirement check. This allows insight into whether homes are not in compliance due to the Overall UA requirement (Trade-Off (e.g. RES*check*™)) or annual energy cost requirement (Simulated Performance), or due to the basic requirements of the code.

4.2.2 Compliance Results Summary for Residential Sector

The CSG team of field inspectors collected or reviewed at the code offices the code documentation for all of the 44 homes where it was available. RES*check*™ reports were found in the code offices for 30 homes, or 68% of the total sample. An additional six homes had construction documents (i.e. stamped plan inspection reports) on file, demonstrating intended construction compliance. The remaining eight homes had no documentation whatsoever demonstrating energy code compliance. No Prescriptive Package or Trade-Off Worksheet documentation was found during the code office visits for any of the 44 homes. There was also no documentation found showing that the Simulated Performance approach was taken. (This is not surprising as the Study did not include homes that had participated in the ENERGY STAR® programs offered by NYSERDA and the Long Island Power Authority – a program that uses the Simulated Performance approach). A more detailed discussion of administrative compliance and findings from the code office visits is included in the administrative compliance sub-section in Appendix I.

Table 4-1 summarizes the rates of compliance by method of compliance evaluation for ECCCNYS - 2007 and for IECC - 2009 by Climate Zone and for the whole sample. The Home Energy Rating System (HERS) energy rating Score (where 100 is best) and Index (where 0 is best) are also reported. At the time these homes were evaluated, New York State used the HERS Score method to determine ENERGY STAR® Home program compliance. The 2006/2007 New York ENERGY STAR® requirement was HERS 84. The scores given for the suggested BECP Protocol score is the upper bound of the confidence interval. The scores for the other tests are presented as the percentage that passed. HERS scores are mean values.

Table 4-1: Summary Compliance Rates by Compliance Evaluation Method

	Metric	Climate Zone 4	Climate Zone 5	Climate Zone 6	Entire Sample
		n=9	n=26	n=9	n=44
ECCC NYS 2007					
Trade-Off (e.g. RES*check*™)	Percent Pass	11%	81%	56%	61%
Performance	Percent Pass	22%	81%	56%	64%
Suggested BECP Protocol	Percent In Compliance (upper bound of confidence range)	59%	81%	66%	**73%**
IECC - 2009					
Trade-Off (e.g. RES*check*™)	Percent Pass	11%	27%	11%	20%
Performance	Percent Pass	11%	15%	11%	14%
Suggested BECP Protocol	Percent In Compliance (upper bound of confidence range)	53%	69%	62%	**63%**
HERS					
NY Score	Mean HERS Score	83	84	84	84
HERS Index	Mean HERS Index	86	79	81	81

Details and notes behind this table can be found in Appendix I. The code compliance data from the above table can also be presented graphically.

Figure 4- 1shows the same information for each Climate Zone for the 2007 Code.

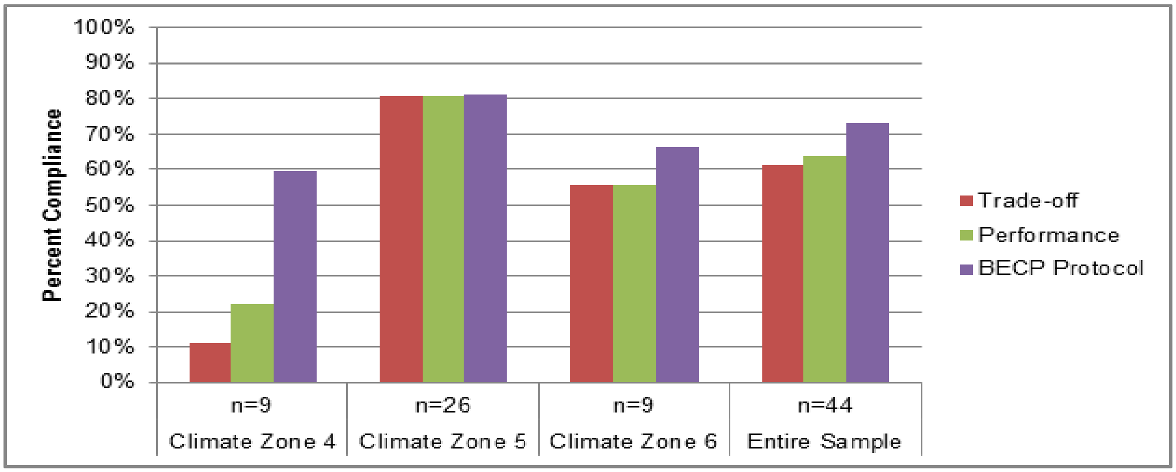

Figure 4- 1: Percent Compliance with ECCCNYS - 2007 by Evaluation Method

For the entire sample, compliance with ECCCNYS - 2007 ranged from 61% to 73%, depending on the evaluation method. The compliance results from each of the three approaches evaluated appear to be comparable, with the exception of Climate Zone 4 (New York City and downstate areas). In general, the reasons for this low compliance rate for Climate Zone 4 versus the other two climates could be attributed to a number of factors including a lack of emphasis on energy issues in this warmer Climate Zone, less skilled or under-trained subcontractors, code compliance oversights, self-certification policy, etc.. It is possible (although the Team has no direct evidence) that the larger homes in Zone 4 were built with more complex designs and high attention to aesthetic details, rather than the wealthier homeowners being focused on energy costs. However, with only nine homes in the sample, it would be unreasonable to draw any firm conclusions without further investigation.

Why the suggested BECP Protocol compliance rate in Climate Zone 4 is so much higher compared to the Trade-Off or Performance approaches can be attributed to the fact that the suggested BECP Protocols quantify *all* aspects of the code, whereas the Trade-Off (e.g. RES*check*™) and Simulated Performance approaches do not, as described above. The suggested BECP Protocol has many more code requirements to “get right” (or wrong). The suggested BECP Protocols quantify construction documentation, HVAC sizing calculations, fenestration and recessed lighting infiltration, posted code certificates etc. – any of which could have been emphasized in Climate Zone 4.

Looking at the full picture, Climate Zone 5 shows the highest compliance at 81%. At the same time, Climate Zone 4 compliance levels are as low as 11% for both 2007 and 2009 codes. The entire sample compliance for ECCCNYS - 2007 ranges from 61% to 73% across the three evaluation methods. However, when analyzing compliance against IECC - 2009, full compliance rates range from 14% to 63%. It is clear that builders have a long way to go to reach 90% compliance with IECC - 2009. Some of the reasons that the compliance rates are so low for IECC - 2009 are not only the more stringent overall insulation and performance requirements, but also the inability to trade-off more efficient mechanical equipment against lower envelope R-values. Specifically, ceiling and wall insulation show relatively high compliance under the 2007 code due to the ability to trade-off the higher insulation requirements with high heating system efficiency, infiltration or duct leakage rates. Most homes will need to improve component insulation levels. Homes in Climate Zone 4 will also need to significantly improve infiltration and duct leakage rates to meet the new code.

4.2.3 Building Component Compliance Rates

In addition to overall compliance, individual components were also analyzed for compliance. Table 4-2 summarizes individual component compliance as well as the average installed efficiency values observed from the on-site visits statewide and by Climate Zone. Detailed results by Climate Zone are shown in Appendix I.

Table 4- 2: Sample Building Component Compliance Rates to ECCCNYS - 2007

Component	Sample Size	Unit	Verified Value	Percent in Compliance
Building Thermal Envelope				
Doors	44	U-Factor	0.29	93%
Windows	44	U-Factor	0.35	82%
Ceiling, attic	44	R-Value	36	82%
Ceiling, vaulted		R-Value	32	
Above-Grade Walls	44	R-Value	18	86%
Frame Floor	24	R-Value	25	75%
Basement Walls	40	R-Value	13	78%
On-Grade Slab, unheated	14	R-Value	5	21%
On-Grade Slab, heated		R-Value	6	
On-Grade Slab, depth		Feet	1.4	54%
Air Leakage	44	CFM50	2803	n/a
		ACH50	5.5	n/a
Mechanical Systems				
Programmable Thermostat	44	Present	n/a	91%
Duct Insulation	36	R-Value	4.3	81%
Duct Leakage to Outside	29	CFM_{25}	171	n/a
		Percent floor area	5%	
Furnace Efficiency	31	AFUE	89	n/a
Boiler Efficiency	12	AFUE	86	n/a
Air Conditioner Efficiency	33	SEER	13	n/a
Hot Water Efficiency, gas tank	27	EF	0.62	n/a
Lights and Appliances				
Efficient Lamps	44	Present	29%	n/a
Efficient Fixtures	44	Present	30%	n/a
Ventilation dampers	35	Present	80%	89%

The results in Table 4-2 are evaluated considering the following points. Additional table details are included in Appendix I.

1. Not all homes have features subject to all code requirements (e.g. on-grade slab). Average efficiency and compliance values are calculated only from homes with the required code component (e.g. average slab R-values and compliance rates are only for homes with on-grade slabs).

2. Frame floor values do not include un-insulated floors over basements where basement walls are insulated. The sample includes one home with R-0 insulation where foundation walls were also not insulated.

3. Basement wall values do not include basement walls where overhead floors are insulated. The sample includes two homes with R-0 insulation where the overhead floor was not insulated.

4. Slab values are for on-grade slabs only. The sample includes slabs with R-0 insulation. The average slab includes the distance (in feet) under the slab only in homes where perimeter insulation also exists (i.e. if only under slab insulation was present and no slab perimeter insulation, the under slab insulation distance is not included in the average.)

5. Duct insulation and leakage compliance rates include ducts that are located inside conditioned spaces (these are considered in compliance). Average duct insulation values are only for ducts not in conditioned spaces.

Figure 4- 2 shows graphically how individual components compare against ECCCNYS - 2007 in each Climate Zone and for New York State as a whole.

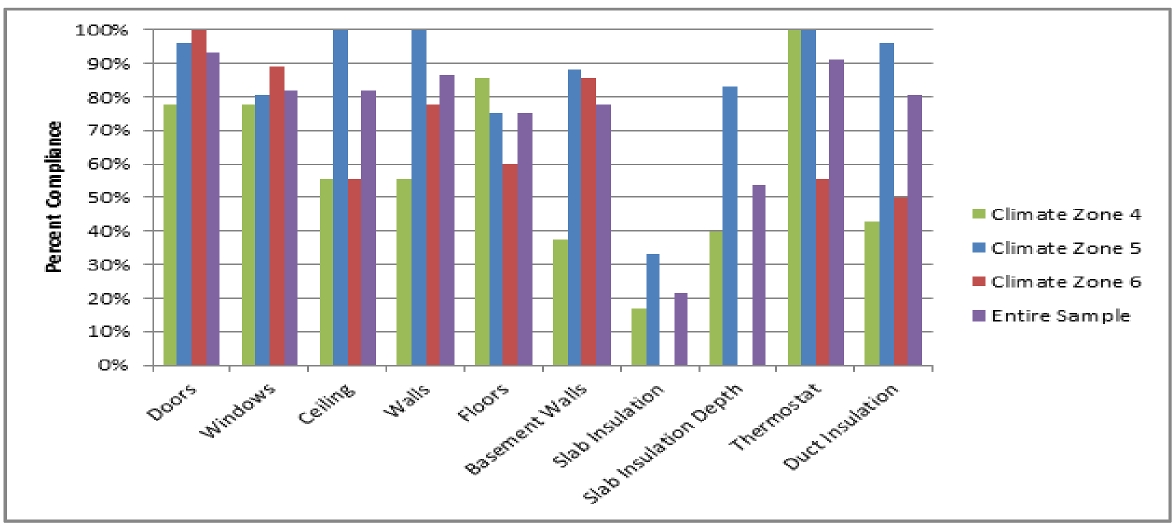

Figure 4- 2: Summary Component Compliance with ECCC NYS 2007 – Residential Buildings

While on-grade slabs are clearly a building component that needs attention in order to improve compliance rates above the current statewide 21% rate, there are also other components that deserve focus in order to help builders comply with code. Ceilings in Climate Zones 4 and 5, above grade and basement walls in Climate Zone 4, as well as duct insulation in Climate Zones 4 and 6 all need improvement. On the other hand, fenestration compliance rates are relatively high statewide. Furnace and boiler efficiencies (at 89%

and 86% AFUE) are also quite a bit higher than federal standards (78% and 80% respectively). While historically these higher efficiencies have been used to trade-off against lower thermal envelope values in past codes, this is no longer permitted under the IECC - 2009 (and ECCCNYS - 2010) Code, which will make it that much more difficult for builders to move from current construction practices to the new energy codes unless they improve the efficiency of other building elements. Identification of areas of non-compliance should aid in future training and support efforts to help builders understand how to improve their homes. This analysis should also inform code officials on where to focus their inspections.

At 5% duct leakage statewide, this value is almost half of the 8% (of CFM_{25} leakage to outside) required by IECC - 2009. Low duct leakage rates can be explained in part because the method for deriving that rate is by dividing the total duct leakage to outside by the total conditioned floor area. The code definition of conditioned space, which includes most basements, increases the total conditioned floor area. This issue is discussed further in the sub-section on average building characteristics in Appendix I. Average duct insulation, however, is below code in all Climate Zones for ducts running in unconditioned spaces.

Efficient lighting was installed only about 30% of the time. This will be a consideration with the IECC - 2009 efficient lighting requirement since it requires 50% efficient lighting for homes that use the prescriptive compliance path. The requirement is mandatory for all homes under the ECCCNYS - 2010.

Ceiling and wall compliance rates are relatively high for the entire sample when evaluated against ECCCNYS - 2007, but drop significantly when evaluated against IECC - 2009. Infiltration and duct leakage compliance rate (as noted above) are also high across the entire sample, with the exception of Climate Zone 4, where the reported average infiltration ACH_{50} rates were almost twice the full sample average and duct leakage CFM_{25} rates were over twice the full sample average. As stated previously however, with such a small sample size in Climate Zone 4 (n=9), it would premature to draw any firm conclusions without further investigation. Average mechanical system efficiencies are all above the Federal minimum requirements. Only two cooling systems were found below the Federal minimum requirement (both SEER 10), both were secondary supplemental systems. All gas and oil-fired central heating systems were at or above Federal minimum requirements. Components that fall very short of the code are slab insulation statewide and interior basement wall insulation in Climate Zone 4. Ceiling insulation compliance rates in Climate Zones 4 and 6, as well as above grade wall compliance rates statewide will also need to rise significantly to be in compliance with the higher values in IECC - 2009. Cooling systems are greatly oversized in all Climate Zones by an average of 1.5 tons. Table 4- 3 below summarizes compliance for those building elements that are both more often in compliance and those with lower compliance rates. This information can be used to design future trainings and for code official focus.

Table 4- 3: Compliance Rates of Residential Building Elements to ECCCNYS - 2007

Higher Compliance	Lower Compliance
• Fenestration • Exterior basement wall insulation • Duct leakage rates (Climate Zones 5 and 6) • Infiltration rates (Climate Zones 5 and 6) • Mechanical system efficiencies	• Slab insulation • Interior basement wall insulation (Climate Zone 4) • Ceiling insulation (Climate Zones 4 and 6) • Wall insulation (Climate Zones 4 and 6, and Climate Zone 5 when evaluated against IECC - 2009) • Infiltration rates (Climate Zone 4) • Duct leakage rates (Climate Zone 4) • Mechanical system sizing

4.2.4 Average Residential Building Characteristics

This section reports on the average building characteristics found during the on-site visits. Summary information is included here; more detail can be found in Appendix I. Average building characteristics are presented in Table 4-4 below. For this report, “Single Family Attached” is defined as a single unit or a duplex or townhouse, and “Multi-Family Whole Building” is defined as the entire building of either a townhouse or duplex, or other multi-family building of three stories or less than five units.

Table 4- 4: Average Residential Building Characteristcs for New York State

	Climate Zone 4	Climate Zone 5	Climate Zone 6	Entire Sample
	n=9	n=26	n=9	n=44
Conditioned Floor Area and Basement Type (as defined by ECCCNYS - 2007)				
Basement	1463	1466	1270	1439
Above Grade	3398	2316	1855	2443
Total	4699	3725	2560	3686
Conditioned Basement	89%	96%	56%	86%
Unconditioned Basement	11%	4%	44%	14%
Housing Type				
Single Family Detached	44%	92%	89%	82%
Single Family Attached	33%	4%	11%	11%
Multi-Family Whole Building	22%	4%	0%	7%
Number of Stories (Single Family)	2.6	1.8	1.8	2.0
Number of Stories (Multi-family)	2.0	2.0	n/a	2.0
Number of Stories (Overall)	2.4	1.8	1.8	2.0
Number of Bedrooms (Single Family)	3.7	3.3	3.3	3.4
Number of Bedrooms (Multi-family)	3.5	6	n/a	3.4
Number of Bedrooms (Overall)	3.7	3.4	3.3	3.5
Mechanical Systems				
Central Air Conditioning	67%	92%	33%	75%
Space Heating Fuel				
- Natural Gas	92%	83%	60%	80%
- Propane	8%	7%	30%	12%
- Oil	n/a	7%	n/a	4%
- Electric Resistance	n/a	n/a	10%	2%
- Wood	n/a	3%	n/a	2%
Space Heating System Type				
- Forced Hot Air	42%	86%	50%	70%
- Hydronic	58%	14%	50%	30%
Lighting				
Total Lamps in Permanent Fixtures	142	60	56	76
High Efficacy Lamps in Permanent Fixtures	46%	19%	42%	29%
Total Permanent Fixtures	92	36	32	47
High Efficacy Permanent Fixtures	47%	19%	43%	30%

4.2.5 Qualitative Feedback from Raters who Evaluated New Construction Homes

After the CSG Raters completed their site visits on each building to collect the data for this Study, they were asked to complete a two page "General Observations Form" (see Appendix J) to collect their subjective observations. The data below summarize the findings for each of these data sets.

Ranking of Constructions Quality and Energy Opportunities

1. Construction Quality

Sixty-three percent of the responses stated that construction quality ranked very good or excellent, with almost 90% of the responses indicating that quality was at least three on the scale of one to five. No Raters ranked construction as "poor," although several comments indicated concerns of construction quality.

2. Missed Energy Opportunities by Builder

While overall construction may have been quite good, the Raters indicated that there were plenty of opportunities for improving energy efficiency. Two-thirds of the responses ranked the homes as having some or many missed energy opportunities. No homes were found to have no missed energy opportunities.

3. Recommendations for Energy Improvements

The Raters found that 60% of the homes had some or many energy efficiency or health and safety improvements that they would recommend. In 40% of the homes Raters had few recommendations, and in 0% of homes they had no recommendations.

Worst Energy Features Found in the Sample Homes

Raters selected from a list of energy features and rated them as the #1, #2, #3 and #4 worst energy features. From all of the home components examined, Raters identified house air leakage, lighting, duct system tightness, and bathroom fan effectiveness in the top four worst energy features of these homes. Second-tier energy features deserving attention included insulation R-values, insulation installation, heating system and water heater efficiencies, and duct system installation.

4.3 ENERGY IMPACT OF NON-COMPLIANCE IN RESIDENTIAL BUILDINGS

The VEIC Team modeled and analyzed the impact that non-compliant energy components have on the operating energy costs for new homes, in addition to the impact on the electrical grid. Those results are presented below.

4.3.1 Energy Impact of Non-Compliance Calculation Methodology

In order to assess which components of the code have the greatest impact on energy consumption and to calculate "lost savings" due to non-compliance, five different analyses were run. A different lost savings analysis approach was taken depending on the approach used to determine if a home was in compliance.

1. "Prescriptive Analysis" – When no compliance documentation was found showing compliance by the Trade-Off (e.g. RES*check*™) approach and components were found to be non-compliant in the REM/Rate™ models, the home was analyzed using a prescriptive approach. In this analysis, all components were modeled in REM/Rate™ to prescriptive code values, the non-compliant component(s) were then set back to the verified value. The difference in consumption is the lost savings potential for that component.

2. "Trade-Off (e.g. RES*check*™) Analysis" – When documentation was found demonstrating envelope compliance (e.g. RES*check*™) but either one or more basic code requirements were non-compliant, or observed features of the home did not match the documentation, the home was analyzed using a trade-off approach. The REM/Rate™ model for the verified condition of the home was compared to the same model, but with the non-compliant component(s) brought into compliance

3. "Overall Lost Savings Analysis" – This analysis compares, for all homes, how the verified condition of homes in New York compared with the prescriptive requirements of ECCCNYS - 2007.

4. "Insulation Quality Analysis" – This analysis looked at the issue of insulation installation quality. This approach estimates the energy savings from homes that are in compliance on paper but may still have lost savings opportunities due to poor or improper installation techniques.

5. "Cooling Equipment Oversizing Analysis" - The final analysis looked at cooling equipment oversizing. Nearly all homes had oversized cooling equipment. REM/Rate™ models for homes with the verified cooling capacity were compared to the same homes modeled with cooling capacity in line with the design load as calculated by REM/Rate™.

Each of these analyses provides a picture of how homes in New York are performing overall, as well as on a component basis. These analyses also allow quantification of the lost savings due to non-compliance with the energy code.

4.3.2 Energy Impact of Non-Compliance Results for New Construction Homes

Summary Results

Overall, there is an estimated "lost savings" opportunity of approximately 18.6 MMBtu/ per home for non-compliant homes built in the sample. This results from 15.2 MMBtu of sub-code component efficiency levels, and 3.4 MMBtu of inadequate insulation installation. At 2010 fuel prices, this translates into approximately $373 of annual lost energy savings per non-compliant home, about 8% of the average home's total modeled annual energy costs, and 14% of the heating and cooling costs. Over the average non-compliant home's 50-year lifetime, this is a cumulative lost savings of more than $18,000 (in today's dollars). When looked at on a statewide basis, assuming first that this small sample did represent the average of homes built in this period, adjusting for the fraction of new homes that are out of compliance (27% to 39%, depending on the evaluation methodology), and the 23% of homes that are ENERGY STAR® qualified and thus assumed to be code compliant, this translates into total lost energy savings of 1.0 - $1.4 million annually. Over the 50-year life of the average 12,250 single-family and low rise multi-family new homes built annually, this translates to approximately $58 million cumulative lost savings on a statewide basis. Assuming that a similar amount of lost savings occurred from the 12,250 homes built each year, over five years of construction, the 50-year cumulative lost savings from these homes would be approximately $300 million. Energy code non-compliance is a significant expense to New Yorkers.

Note that these lost savings are for the 2007 code. As the more stringent 2010 code goes into effect, the leap from current construction practices to the 2010 code will be even greater, resulting in greater lost savings than reported here unless compliance rates dramatically increase.

On a building component level, the "Prescriptive" lost savings analysis showed that basement walls by far provide the most opportunity for reclaiming lost savings. Lost savings due to under or non-insulated basement walls accounts for about half of the total component level lost savings opportunity; averaging about 18 MMBtu annually in those homes with non-compliant basement walls. Above-grade walls, slabs and floors are the second largest contributors to lost savings, at approximately the same rate for each component, about three MMBtu annually. For homes with a compliant envelope but with one or more non-compliant mandatory requirements, the "Trade-Off (e.g. RES*check*™)" analysis showed that lost savings were primarily due to the overall fenestration UA requirement, and averaged about five MMBtu annually. Figure 4- 3 shows the proportion of lost savings opportunities by component using the weighted average savings from both the "Prescriptive" and "Trade-Off (e.g. RES*check*™)" component level savings analyses.

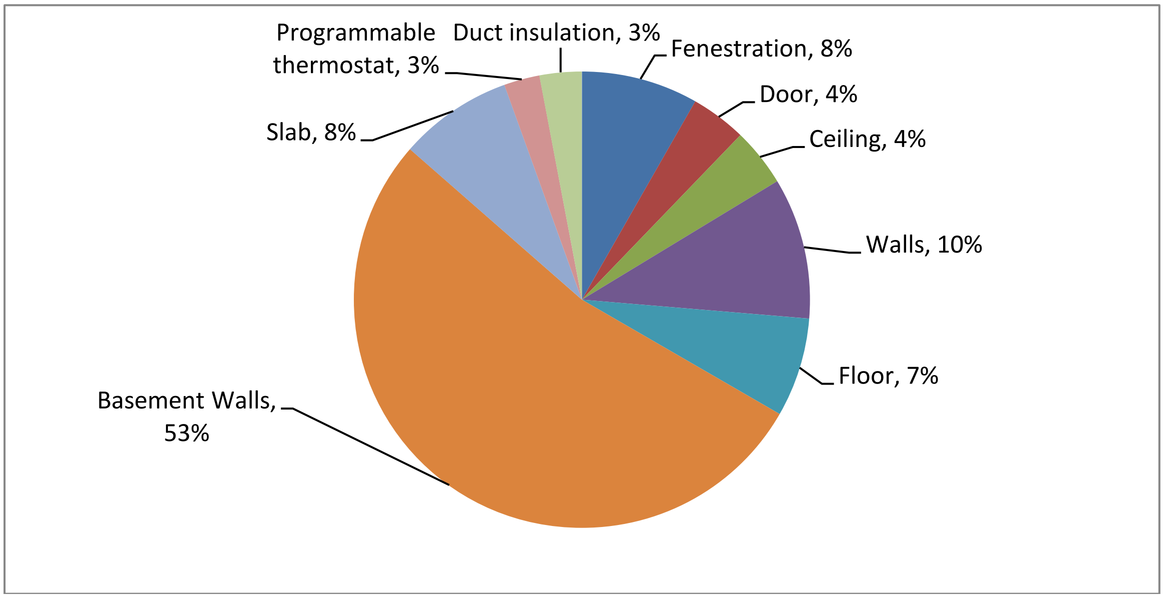

Figure 4- 3: Proportion of Lost Savings Opportunity by Component – New Construction Homes

Figure 4- 3 shows that insulating basement walls clearly provides the highest opportunity for reclaiming lost savings. It should be noted, however, that while basement walls show the greatest opportunity for savings *when* they are not in compliance, overall about 78% of foundation walls are found to be compliant. The basement wall savings presented here are primarily from homes in Climate Zone 4 which had significantly lower compliance rates (at 43%, about half that of the statewide average) and include two homes with un-insulated basement walls. For the next tier down of components above grade walls, frame floors and slab edges provide similar lost savings opportunities. Of these three components, 32% of homes had a slab-on-grade foundation, 55% had frame floors and all had walls. While there are similar savings from each of these components, slabs and floors are seen much less frequently

What is not shown in Figure 4- 3 is the lost savings from one home where the filed RES*check*™ report indicated the home had a high efficiency furnace. The on-site visit found that a standard efficiency furnace was actually installed. With the standard efficiency furnace, the envelope was no longer compliant. Modeling the home with the high efficiency furnace indicated on the RES*check*™ report resulted in significant savings, about 10 MMBtu annually.

All homes included in the "Prescriptive" lost savings analysis had more than one non-compliant component. To see the overall lost savings from these homes as a whole, the fully code compliant model was compared to the field verified As-Built model. Analyzed this way, any above-code components were left as is, representing a more accurate, or real world, estimate of the lost savings opportunity from bringing only the non-compliant components into compliance. The average overall whole home savings was 15.2 MMBtu per home. It is this estimated 15.2 MMBtu per home average overall lost savings value that makes up the sub-code component efficiency portion of the total 18.6 MMBtu per home lost savings opportunity for non-compliant homes built in New York.

The "Overall Lost Savings" Analysis that compared the average energy consumption of all homes in the sample to the average energy consumption of those homes had they been built to prescriptive requirements of ECCCNYS - 2007 showed an average savings of 14.6 MMBtu per home. These "Overall Lost Savings" results correlate well with the whole home savings produced by the "Prescriptive" component level analysis.

The "Insulation Quality" lost savings analysis shows there are significant savings to be found simply by ensuring proper installation of materials. Taking a worst case scenario, an average of 10 MMBtu could be saved per home if all insulation were properly installed. However, it is uncommon for all insulation to be extremely poorly installed; thus actual savings should be somewhat less than this worst case scenario. A more realistic estimate is 3.4 MMBtu, as discussed in more detail in Appendix I. Figure 4- 4 shows examples of Grade III (poor quality) insulation in photos taken from this Study sample.

Photo Credit: Conservation Services Group, 2011

Figure 4- 4: Examples of Grade III (poor quality) Insulation

The "Cooling Equipment Oversizing" lost savings analysis showed that proper sizing of cooling equipment did not show significant energy savings. Cooling system oversizing, however, has other undesirable impacts including higher installation and operating costs to the homeowner, as well as decreased comfort and humidity control. The largest impact from cooling equipment oversizing is the potential increase in peak demand of more than 7 MW from New York's electrical grid.

4.4 CONCLUSIONS AND RECOMMENDATIONS FOR RESIDENTIAL SECTOR

The residential sector faces a large hurdle to reach 90% compliance with IECC - 2009. ***The VEIC investigation of compliance rates for ECCCNYS - 2007 show approximately one third of non-ENERGY STAR® new homes were not built to the 2007 code.*** With the more stringent IECC - 2009 code now currently in place, the leap for all builders will be challenging. Compliance rates for individual building components vary across New York's Climate Zones, but there are a number of areas that deserve particular focus when it comes time to train builders, guide code officials, and inform Energy Specialists (see below for more explanation). These problematic areas include slab insulation, interior foundation wall insulation, ceiling and wall insulation, air infiltration rates and cooling system sizing. ***The impact of these non-complying components results in a rough estimate of approximately $1.2 million annual lost energy savings and a minimum of $300 million of lost savings over the 50-year lifetime for non-compliant homes built within a 5-year planning period.*** At higher IECC - 2009 code levels, this lost savings will be even greater.

New York has a significant opportunity to stop this loss. Setting up a support system to help builders understand and build to code through training, technical assistance, tools and access to energy professionals can go a long way. To close the gap, the State needs to take code compliance more seriously and find ways to better support local code officials. Fully funding code support and compliance enforcement systems will be necessary to make this progress. Setting up a mechanism to enforce code through a new third-party system of "Energy Specialists" who are equipped with the knowledge, testing tools and responsibility to both support builders and code officials with an objective of ensuring compliance with the energy code can be an effective solution towards improving New York's code compliance rates. The Team's specific recommendations are included in Section 6: Conclusions and Recommendations.

Section 5:

COMMERCIAL SECTOR ASSESSMENT

The VEIC Team conducted on-site assessments of 26 new construction commercial buildings, including multi-family residential, in selected counties in New York. The details of the sampling design and recruitment methodology are described in detail in Section 2. The results of the compliance analysis and the energy impacts of non-compliance are presented in this section.

5.1 DATA COLLECTION FOR COMMERCIAL SECTOR

Data collection for new construction commercial buildings was performed in three parts: plan review, building inspection and code official or building owner interview (when possible). Recruitment of commercial participants is discussed in Section 2.

5.1.1 Plan Review

The first step for each building was to obtain the plans and input the building components into the Survey Tool. The Survey Tool is an Excel spreadsheet developed specifically for this Study. It calculates building compliance with ASHRAE 90.1 (2004 and 2007), completes the ASHRAE 2007 90.1 PNNL Checklist (November 2010) and captures data required for eQuest modeling. Survey Tool capabilities and development are discussed in detail in Appendix P and Appendix Q-1.

This part of the data collection process took between 4-6 hours per building, depending on the complexity of the buildings. When possible, plans were obtained electronically and the compliance data was input into the Survey Tool before the site visit. If that was not possible, a plan review at the building site or the code official's office was conducted prior to the building inspection. This arrangement allowed the engineer to become familiar with the building prior to performing an on-site inspection. Where feasible, the team made copies of building plans to enable future review.

In general, the plans were informative, but lacked crucial data related to the energy performance of the components. Items such as window and door U-values and Solar Heat Gain Coefficients (SHGC), motor efficiencies, variable speed drives (VFD), lighting power density (LPD), lighting controls, HVAC controls and control schedule, and air and duct sealing procedures were not included on the plans. Items such as heating, cooling, and domestic hot water (DHW) loads were not documented on the plans and, although when model numbers of the HVAC and DHW systems were listed (typically included), their efficiencies were typically not. In addition, although the State requires a COM*check*™ report for every building permit, only about 30% of the plans had accompanying COM*check*™ reports and specifications were only available on approximately half of the buildings. As-built drawings and product submittals were not available for most projects.

For this evaluation, the subsequent site inspection provided more information with which to complete the BECP Checklist and ascertain the modeling parameters on a number of specific component efficiencies not found on the plans.

5.1.2 Interviews

The second step of the analysis involved an interview with the code official or the building owner. The interview was focused on the building construction (refer to Appendix Q-2 for the Code Official Interview Guide). Code officials were also asked questions about the commercial building code, their ability to enforce the code and their impression of the energy efficiency levels of new construction in their jurisdiction. Upstate code officials and building owners were generally gracious with their time and very forthcoming and open with their input. An incentive of $150 was offered to cover the building owner's time, but only two out of 26 buildings accepted this offer. Owners seemed interested in the assessment of the building and many spent time or gave their facilities manager's time to walk with the engineers and discuss their findings. Several code officials seemed willing to help because they felt taking part in these types of studies was part of their job. They also did not seem hesitant to answer questions about the limitations of their jobs when it was made clear that their names would not be used in the Study. The code officials in New York City boroughs were significantly more difficult to recruit. The high level of construction activity in these areas may have affected their ability to participate.

5.1.3 Building Inspections

The final step of the data collection process was the on-site inspection of the building construction. The sampled buildings consisted mostly of buildings that were complete and occupied (65%), with nine projects in the sample under construction. Each building was examined for agreement with the building plans and to inspect the quality of construction. If the building construction was complete it was difficult to ascertain window, door or insulation efficiency levels, but light fixtures, lighting power density and mechanical equipment were reviewable. For buildings under construction the opposite was true.

The on-site visit consisted of a visual inspection of the building components documented from the Plan Review in the Survey Tool and a review of compliance with the PNNL Checklist. Overall the site visits were paramount to determination of actual building compliance, but there were some technical components such as insulation levels, window and door efficiency levels, motor efficiencies and controls that were difficult to ascertain on completed buildings. Either the compliance levels could not be determined because the insulation was covered, or the windows were not labeled, or the component was not accessible in the field. For buildings under construction, elements such as HVAC equipment, controls, light fixtures and lighting controls were not installed and therefore not reviewable.

The suggested BECP Protocol was designed for inspections made over the course of construction from permit submission to final construction. The reality is that a complete assessment can only be obtained if the Protocol is followed in this manner and the project is visited multiple times during construction. A thorough review of the construction over the entire duration of the project, as stipulated in the suggested BECP Protocol, will enable verification and documentation of actual energy components and, more importantly, will provide more assurance that the buildings reach their energy efficiency potential. Poor installation of the insulation, for example, will be flagged at a time when the walls are still open, the subcontractor is still on-site and the problem can be remedied. Non-compliant HVAC equipment can be exchanged before the building is occupied and the contractors have left the project. In commercial construction the duration from building permit to occupancy can be six months to over two years. In order for the suggested BECP Protocol to be followed, a much longer Study period (i.e. a minimum of two years) is required. In addition, commercial construction is almost entirely unique, so the suggested approach of using similar buildings with staged construction is not feasible for commercial building compliance assessment.

5.2 COMPLIANCE RESULTS FOR SAMPLE NEW CONSTRUCTION COMMERCIAL BUILDINGS

The VEIC Team examined three compliance approaches to address the question "what is the energy code compliance rate of new commercial buildings in New York State?" They are the suggested BECP Protocol (described in the following section), the Energy Cost Budget Method as detailed in ASHRAE 90.1 Chapter 11, and the ASHRAE 90.1 Prescriptive/Trade-Off Compliance Method. The Compliance Scores show that the small commercial buildings (less than 25,000 sq ft) are 77% compliant under the suggested BECP Protocol Method and do not comply under either the Energy Cost budget or the Prescriptive/Method Trade-Off Method. The medium sized buildings (25,000 sq ft – 60,000 sq ft) are 85% compliant according to the suggested BECP Protocol, 100% compliant according to the Energy Cost Budget Method and 63% compliant according to the Prescriptive/Trade-off Method. The large size buildings (above 60,000 sq ft) are 85% compliant with the suggested BECP Protocol Method, 100% compliant with the Energy Cost Budget Method and 39% compliant with the Trade-off Method. Compliance levels were generally consistent by building size between the upstate and downstate sample populations. Figure 5-1, below, shows this data.

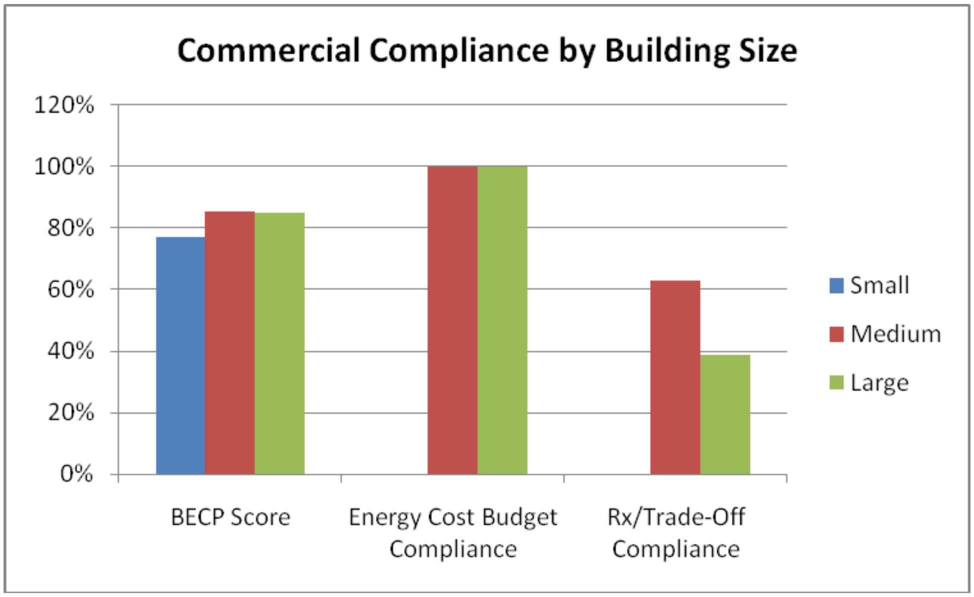

Figure 5-1. Commercial Compliance by Building Size

In the chart above the compliance % for Small Buildings were 0% for each of the Energy Cost Budget and Rx/Trade-Off methods.

Compliance rates ranged from 60% to 94% according to the suggested BECP Protocol, with most of the buildings ranging from 79% to 89%. This indicates that approximately 15% of the new construction not participating in NYSERDA's New Construction Program did *not* achieve compliance with the applicable energy code as measured using DOE's suggested BECP Protocol. (Compliance was measured against either ASHRAE 90.1 2004 or 2007, depending on the applicable code at the time the building permit was issued. Four of 26 projects were designed to the 2004 standard.)

When technical compliance of energy efficiency levels are evaluated using Prescriptive/Trade-Off method, compliance was determined on a pass/fail basis and was seen to vary widely across all three main system types (HVAC, lighting, and envelope)and across all building sizes. A fairly similar percentage of buildings fail due to envelope, HVAC and lighting system non-compliance (30% fail due to envelope non-compliance, 28% due to HVAC non-compliance and 19% due to Lighting non-compliance). Out of the sampled buildings, 15% failed on non-compliance of two out of the three system types and none failed on all three system types. This indicates that there are deficiencies in the installed levels of efficiency relative to code requirements in all building components and equipment.

Compliance of composite buildings modeled using the ASHRAE 90.1 2007 Chapter 11 Energy Cost Budget Method is measured in energy cost – if the design building energy cost is less that the code compliant building energy cost, then the building is in compliance. Composite models representing typical features of the buildings in the sample were used for this analysis. Individual buildings were not modeled.

The small composite building had a higher energy cost budget than the code building and was not in compliance. The composite models of the medium and large buildings had lower energy cost budgets than the code baseline models and therefore indicated that the average of the sampled buildings would be expected to comply.

The Study found that the current compliance rate in New York is below the 90% goal; there is still attention needed to building energy efficient buildings, particularly in the medium and large sized projects.

5.2.1 Compliance Calculation Methodology

Demonstrating Compliance

There are multiple approaches to energy code compliance and New York State requires buildings to submit documentation of a compliant design before a construction permit is granted. These approaches are typically deployed based on the building complexity with most small commercial buildings seeking compliance using a prescriptive methodology. Larger buildings, even those that ultimately develop energy models, typically file for code compliance using the COMcheck™ software.

a. The *BECP Compliance Protocol,* developed by the Pacific Northwest National Lab (PNNL) for the U.S. DOE's Building Energy Codes Program (BECP), is comprised of the PNNL Checklist that quantifies component and equipment efficiencies, documentation, control strategies, installation quality and other requirements of the ASHRAE 90.1 Standard. This approach generates a compliance score for each project. The scores are then averaged across the size strata and weighted by area to determine the overall mean and standard deviation. The BECP then allows a state to claim 90% compliance if the upper bound of the confidence range at 95% confidence is above 90%.

b. The *ASHRAE 90.1 Prescriptive/Trade-Off Method* analyzes the technical compliance of the HVAC, Lighting, and Envelope Systems and provides a pass/fail result. HVAC and lighting equipment efficiency levels must comply with the ASHRAE tables stipulated in the ASHRAE 90.1 Standard. Envelope components can be traded-off with each other and compliance is determined by an overall envelope consumption level (UA) developed by the ASHRAE 90.1 Trade-Off Method and typically documented using COM*check*™ software. This method allows a building envelope to comply with below-code windows, for example, if other envelope components such as the wall, roof or floor insulation are above code enough to compensate for the increased energy loss through the windows. This enables architects to be creative with the envelope to meet architectural or other specific design requests for a building.

c. The *Energy Cost Budget Method* uses the analysis methodologies outlined in ASHRAE 90.1 Chapter 11 to demonstrate code compliance based on building energy performance as evidenced by the modeled energy cost of the building. This approach requires the total annual energy cost of the modeled building to be less than or equal to the total annual energy cost of the baseline code compliant building. The use of this compliance method was not encountered in the review of building permits and energy compliance documentation for the sampled buildings in this evaluation. This compliance method differs from modeling to evaluate energy efficiency opportunities and for documenting LEED points, which is performed based on the methodology outlined in ASHRAE 90.1 Appendix G.

Evaluating Compliance

As there are these multiple approaches to *demonstrating* energy code compliance, there are several ways to *evaluate* energy code compliance. This commercial buildings' evaluation analyzed the buildings using all three methods to demonstrate compliance and the differences between the three methods. The methods utilized include the "suggested BECP Protocol," "Prescriptive/Trade-off," and "Energy Performance Modeling" (Energy Cost Budget Method).

a. The suggested BECP Protocol compliance approach is designed to evaluate compliance with all code requirements using a single checklist that includes quantitative and qualitative observations of code requirements from design through occupancy as described in the section above. These Protocols evaluate compliance quite differently than either the Prescriptive, Trade-off, or *Energy Cost Budget* methods. Checklists were designed to quantitatively assess, or score, each requirement of the code. Each code requirement is weighted on a scale of 1 to 3 so that requirements with a high energy impact receive a higher score when in compliance, and requirements with little or no direct energy impact receive a lower score when in compliance. A compliance "score" is calculated for each building by dividing the total received points by the total possible points. In cases where a given code requirement is not applicable to the building being assessed (e.g. water economizer set point requirements in buildings without chillers), or a code requirement cannot be assessed because it is not visible, these checklist items are not scored at all and thus do not affect the overall compliance percentage of the building. The scores for each size stratum are divided by the stratum sample size, multiplied by the percent of the building market attributable to each stratum and summed to obtain the overall mean score and standard deviation. The BECP Protocol then allows a state to claim 90% compliance if the upper bound of the confidence range at 95% confidence is above 90%. The checklists used for the commercial evaluation were originally designed by PNNL to assess compliance with ASHRAE 90.1 2007 and IECC - 2009. These checklists were modified by the VEIC Team to assess compliance with ASHRAE 90.1-

2004 or 2007 depending on the applicable code of the sampled building. The suggested BECP Protocols are the only method to quantitatively score each requirement of the code and are the focus of this Study in evaluating compliance.

b. The *Prescriptive/Trade-off Method* evaluated basic code compliance for envelope, HVAC and lighting efficiency levels in the sampled commercial population. This provided insight into the areas of non-compliance relative to component efficiency levels. Buildings analyzed for compliance under the Trade-off approach include buildings that were found to have levels of envelope components, such as insulation and windows, which were not in compliance with prescriptive requirements. The Trade-Off Method analysis for envelope compliance was conducted using COM*check*™.

c. *Energy Cost Budget Method* was used for two purposes – to develop an overall estimate of the modeled level of efficiency of composite "typical" buildings and to quantify the lost savings for areas of non-compliance. The Energy Cost Budget Method uses building simulation modeling of energy consumption and applicable energy costs to provide a cost based code compliance evaluation based on predicted energy costs of the design and code buildings. Building models created using this method provide energy consumption and cost information both of which are useful in analysis of building performance. The evaluation used the cost basis for compliance determination as required by code and used both cost and energy consumption findings in the results analysis.

Modeling was conducted on three composite buildings of differing sizes. The small composite building is a 9,700 ft^2, one-story office building with rooftop units in Climate Zone 6A (Northern New York) and was aggregated using the sampled buildings under 25,000sq ft. The medium composite building is a 38,700 ft^2, two-story building L-shaped building in Climate Zone 5A (Central New York) with retail on the first floor and multi-family housing on the second floor. HVAC systems consist of air handling units in the retail space and PTAC units in the residential space. The large composite building is a 131,000 ft^2, 7-story building in Climate Zone 4A (Southern New York) with retail, residential, and institutional space. The HVAC systems include rooftop units, a central plant system and PTAC units. Details of the components and spaces of each composite building are found in Appendices Q-3 to Q-5.

Energy modeling and lost savings of these composite buildings was conducted using eQuest software. The three composite buildings were modeled with the aggregated components of each sampled building in each building size. A second iteration of each building was modeled with the composite building system efficiencies set to 100% code requirements in order to establish energy consumption of the baseline building. Lost savings was calculated by running modeling iterations on each 100% code compliant building against the components that were below-code levels in the composite building. These lost savings represent the value of energy savings that can be realized by improved code compliance.

5.2.2 Compliance Results Summary

The VEIC Team of field engineers collected or reviewed the code documentation for all of the 26 commercial buildings at the code official's office or at the building site with the owner. COM*check*™ reports were found in the code offices for 6 buildings, or 23% of the total sample. Compliance documentation as required in the PNNL Checklist was rarely available for projects in the sample. This lack of energy compliance documentation significantly impacts compliance with the suggested BECP Protocols. Improved compliance rates can be achieved by enforcing energy code documentation requirements in permit submissions. Ensuring design professionals clearly document minimum energy efficiency levels, such as R and U values of envelope components, EERs of air conditioning equipment and the per unit wattage of lighting fixtures, on the drawings and submit completed COM*check*™ for every permit application will increase design compliance and will provide more assurance that the building will be constructed to the applicable standards; as the energy requirements will be clearly shown on the drawings for the use of purchasers, contractors, and code enforcement personnel.

A more detailed discussion of administrative compliance and findings from the code office visits is included in Appendix P.

Commercial code compliance was determined using an Excel tool developed specifically for this evaluation. This "Survey Tool" was the input mechanism used during plan and documentation review in code offices and in the field. The team endeavored to collect the necessary data to show compliance to both the ASHRAE 90.1 standards and the BECP Checklist. The Survey Tool contains all the ASHRAE 90.1-2007 and 2004 tables, the inputs for Trade-off calculations to be used in COM*check*™, and the BECP Checklist point calculations.

The Commercial buildings in the sample population were largely permitted under the ASHRAE 2007 Code; however, as expected, there were some (four) buildings permitted under earlier NYS Codes and used ASHRAE 2004 as the applicable baseline. In all cases building compliance was evaluated relative to the code that was in force at the time they were permitted. The team also analyzed compliance with the prescriptive requirements relative to the 2007 code for all buildings in the sample in order to ascertain potential issues with compliance for the building industry.

Table 5-1 summarizes the rates of compliance by method of compliance evaluation for the applicable baseline code and ASHRAE 90.1-2007 per Climate Zone and for the State. All aggregated results are based on area weighted averages of the sampled buildings.

Table 5-1. Summary Compliance Rates by Compliance Evaluation Method – Sample Commercial Buildings

Applicable Code (ASHRAE 90.1-2004 and 2007)		Climate Zone 4	Climate Zone 5	Climate Zone 6	Entire Sample
	Metric	**n=15**	**n=5**	**n=6**	**n=26**
Building Compliance					
	suggested BECP Protocol (Average score)	77%	85%	85%	83%
	suggested BECP Protocol (upper bound confidence range)	84%	88%	87%	**85%**
Buildings % Compliance (Pass/Fail Rate)					
	suggested BECP Protocol (Percent above 90%)	24%	22%	10%	21%
	Prescriptive/Trade-off (Percent pass)	33%	38%	46%	**36%**
Energy Cost Budget Relative to ASHRAE 90.1-2007					
Small	eQuest Composite Models			120%	
Medium			97%		
Large		99%			

The results of the evaluation using the suggested BECP Protocol on the limited sample of 26 buildings show that the New York State Score is 85% and, therefore, the state does not currently meet 90% compliance with ASHRAE 90.1-2007.

The Prescriptive/Trade-Off Method results show that an average of 36% of the buildings pass using a prescriptive and envelope trade-off analysis of the code to which they were designed. Percent compliance was calculated on a square foot basis.

The energy modeling score indicates that the composite medium and large buildings use less energy and have lower energy costs than the 100% code building, meaning they are in compliance using the Energy Cost Budget Method. The small buildings are not compliant, with higher energy consumption and costs than the code compliant small composite building.

When analyzing the conclusions that can be drawn from these evaluation methods, one must consider the details of each analysis method in order to understand the score. Looking at the Prescriptive/Trade-Off score in combination with the energy modeling shows that, although there are a relatively low number of buildings that comply using the Prescriptive/Trade-Off Method, the industry is focusing their compliance attention on the components that significantly affect the energy efficiency of the buildings. Energy modeling captures the net savings of interactive effects of a combination of above- and below-code components. Modeling is able to demonstrate that a small non-compliant item might not affect the overall score of the building where above-code components compensate for the energy penalty of the non-compliant component. As an example, one building failed to comply using the Prescriptive/Trade-off method because the smallest air handlers, serving 1% of the project cooling load, were 12% below code. On the same project, the largest air handlers serving 43% of the cooling load were found to be 47% more efficient than code required.

The comparison between the suggested BECP Protocol checklist and the Prescriptive/Trade-Off method also indicates what areas of the code are non-compliant. While the suggested BECP Protocols do not capture the interactive effects of various building components as building modeling is able to, the suggested BECP Protocols address project documentation, equipment labeling, and installation techniques, which are not captured in any other compliance methodology. The Prescriptive/Trade-Off approach, for example, only quantifies the nominal R-value installed for a given component, while the suggested BECP Protocol checklist quantifies not only the nominal R-value installed, but also whether or not the insulation was installed per manufacturer instructions. The Prescriptive/Trade-off Method and the suggested BECP Protocol both use a similar method to evaluate % component efficiency compliance; however, the suggested BECP Protocol generates a *score* for that component, whereas the Trade-off Method gives a *pass/fail*.

In summary, the findings of the commercial code compliance analysis indicate that current building practices in sampled buildings are achieving approximately 85% compliance to ASHRAE 90.1 2007. In order to reach or exceed 90% compliance, New York State must focus on improving compliance documentation, building envelope, HVAC and lighting efficiency across its new construction building stock as well as improve its scrutiny of the construction process to insure proper installation and documentation of every significant construction step of the project. In addition, the state needs to implement a means to inspect buildings for compliance periodically during construction. Reaching and even exceeding the 90% compliance goal by 2017 appears to be within reach with improved tools and increased training, inspection and enforcement as proposed in Sections 6 of this report.

5.2.3 Building Component Compliance Rates

In addition to the overall building compliance score, compliance of particular components of the sampled buildings needed to be analyzed in order to ascertain which areas New York State can focus their efforts to improving building compliance. Table 5-2 summarizes component level compliance results, as determined by the Prescriptive/Trade-Off Method and based on the plan reviews and site visits. Because of the variety of commercial construction techniques, the analysis is based on component type – envelope, HVAC and lighting with qualitative summary observations following the table.

Table 5-2. Commercial Building Component Compliance Rates to ASHRAE 90.1 2007 (Percent Pass)

Component	Sample Size	Buildings In Compliance	Percent Compliance (building sq ft)
Thermal Envelope			
Small	7	3	17%
Medium	11	8	77%
Large	8	8	100%
Mechanical Systems			
Small	7	6	87%
Medium	11	7	62%
Large	8	3	25%
Lighting Systems			
Small	7	4	64%
Medium	11	9	87%
Large	8	8	100%

The results in Table 5-2 above provide some insight into compliance trends in the sample population. The small buildings (<25,000 sq ft) seem to have the greatest trouble with compliance as none of the small buildings reached the minimum requirements for compliance under the suggested BECP Protocols or the Prescriptive/Trade-off method, especially for the envelope system. The medium sized buildings were closer to compliance and more consistent across the three building systems. The large buildings had compliant thermal envelope and lighting systems, but failed to comply with the mechanical systems. Some more specific findings are:

- Sixty-three percent of the medium buildings had packaged HVAC equipment with compliant efficiencies. The below-code equipment was only 5% less efficient than the standard.
- Only 25% of the large buildings had HVAC equipment including packaged air handling equipment and/or motors that were fully compliant with prescriptive code requirements, but large buildings were consistently designed to comply with the prescriptive envelope and lighting requirements. None of the buildings in the survey included chillers.
- Large buildings had many more of the design approaches that are captured in the suggested BECP Protocols and so were typically pursuing design strategies that incorporated higher levels of efficiency overall.
- In all three building sizes and all jurisdictions, there were gaps in submitted information making compliance verification at the plan review stage difficult.

- In medium and large buildings which required controls strategies, such as automatic lighting control, DHW recirculation control, demand control ventilation, etc. these were not typically implemented in accordance with code. These controls strategies were not captured in prescriptive compliance evaluations that found lighting to be compliant. They were captured in the suggested BECP Protocol and in the composite models.
- Continuous insulation is not consistently applied in small- and medium-sized commercial building construction.
- Window and door ratings are underspecified (i.e. not included in the project documents) and difficult to verify in the field due to lack of ratings on installed components.
- Documentation of compliance with lighting power density (LPD) requirements was found to be limited. Many COM*check*™ documents included a single line input for LPD which did not appear to provide adequate assurance that a detailed lighting analysis had been completed.

As mentioned in Section 2, there is a potential bias issue with the sample. In particular, the VEIC Team had difficulty recruiting large building participants. It is likely that there was self-selection bias that resulted in relatively higher efficiency in the large projects included in the sample. The large projects had reputable design teams and, as demonstrated by the composite model (described in Section 5.3), the overall efficiency of the HVAC systems in large buildings was high. On a prescriptive basis, however, the HVAC compliance appears low. This is because the prescriptive compliance method requires *all* HVAC component efficiency levels to be above-code in order to pass, no matter how small of the load these non-compliant components serve. The fact that the overall efficiency of the HVAC systems consumes less energy than the 100% code compliant building signifies that the non-compliant components of the HVAC systems served a small portion of the load. Large building heating equipment, for example, had a very high adoption rate of condensing boilers with efficiency ratings greater than 92%.

The medium buildings had the highest prescriptive compliance rate. They had the highest compliance overall with the prescriptive efficiency requirements of the code. Medium buildings had lighting power densities (LPDs) that ranged from about 130% less efficient than code allows to 60% better than code. Except for the non-compliant buildings, LPDs were generally found to be significantly better than code. The field inspection forms did not support LPD analysis based on field findings; however, the Team completed field lighting surveys to determine the installed LPD values. It would be beneficial to provide a mechanism for documenting and capturing the installed LPDs in the PNNL Checklists. Medium sized buildings did not tend to incorporate energy recovery or demand control ventilation strategies where they are required. In addition, deficiencies were found in the efficiency of mechanical equipment specified for medium sized buildings.

Small buildings have a limited impact on overall statewide compliance as the statewide score is area-weighted. These buildings tend to have small, simple mechanical systems. The high level of compliance for small building HVAC equipment may be a result of market penetration of efficient equipment supported through the NYSERDA's prescriptive rebate programs. The lighting had a relatively high compliance for small building LPDs. High efficiency fixtures with low wattage lamps were common in the small buildings surveyed. Small buildings also had the lowest compliance with building envelope requirements, including failing to install slab on grade insulation, failing to meet exterior wall requirements and failure to meet roof insulation values. Evaluation of small building fenestration was limited due to lack of information and could result in lower levels of compliance than found in this Study.

There are two areas for which the commercial code does not stipulate a numeric compliance value that were generally observed to have energy savings potential. Commercial building envelopes are not generally air sealed to a high level as indicated by the lack of continuous insulation and limited observations during site visits of the use of foam for air sealing. In addition, mechanical systems, including distribution fans, serving commercial buildings often appear to be oversized. Load calculations, though required by code, are not typically submitted and criteria for reviewing load calculations are not provided by ASHRAE 90.1.

5.2.4 Average Commercial Building Characteristics

This section reports on the sample population building characteristics found during the site visits and how those buildings may compare to the New York State commercial new construction market.

It should be recognized that the sample of buildings drawn does not represent a statistically valid sample of commercial new construction in New York. The Study sample size is only 26 buildings stratified into three size categories. Even were the sample to have contained the 44 sample sights required for the suggested BECP Protocol, it still would not have been usable as a representative sample of new buildings in the state. (The suggested BECP Protocol provides a means of selecting a sample of 44 commercial that can be used to meet their definition of 90% compliance, not one that can be used to represent a statistically valid sample of statewide commercial construction.)

Because there was insufficient budget to pull the full suggested BECP Protocol sample, the Study wanted to make sure that it got a cross-section of the kinds of buildings that are built in the state. Buildings were selected to represent different parts of the state, different sizes, and different end-uses. While not statistically valid, the collection of buildings does provide information on common building practices that are occurring in the NYS commercial new construction market. As noted in Section 2, recruiting challenges further impacted the Team's ability to collect an unbiased sample. The sample was selected based on size stratification as shown in Table 5-3 below:

Table 5-3. Commercial Building Size Stratification

Size (sq. ft.)	Market Share	Sample Share	Number in Sample
Small (<25,000)	16%	3%	n=7
Medium (25 - 60,000)	16%	26%	n=11
Large (>60,000)	68%	71%	n=8

Figure 5-2 below shows the distribution of compliance scores across the size strata.

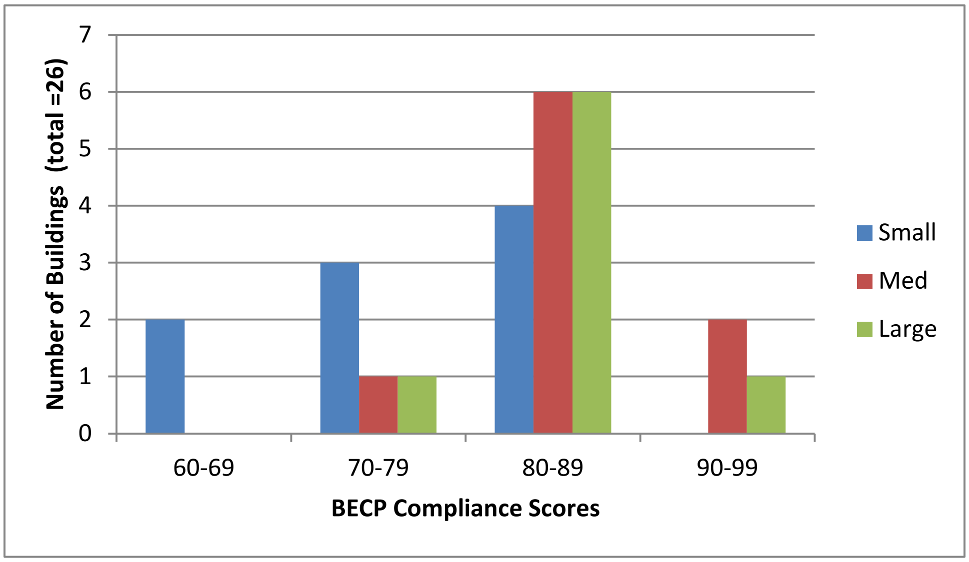

Figure 5-2. BECP Compliance Scores by Size – Commercial Building Sample

In general small buildings have lower compliance levels using all three rating systems – suggested BECP Protocol, Prescriptive/Trade-Off, and Energy Cost Budget modeling. These findings indicate that the overall results of the commercial portion of the Study are likely to overstate compliance for the state as a whole. Future evaluation and training efforts should include a particular focus on addressing barriers to compliance in the small commercial market sector.

<u>Building Component Findings</u>

The technical compliance of building components, using the Prescriptive/Trade-Off Method, was evaluated by building size. The small buildings in the sample all had HVAC equipment with energy efficiency ratings that met code. This was in contrast with the medium and large buildings, a significant number of which were found to have a portion of the installed HVAC equipment with efficiencies that fail to meet the minimum code requirement.

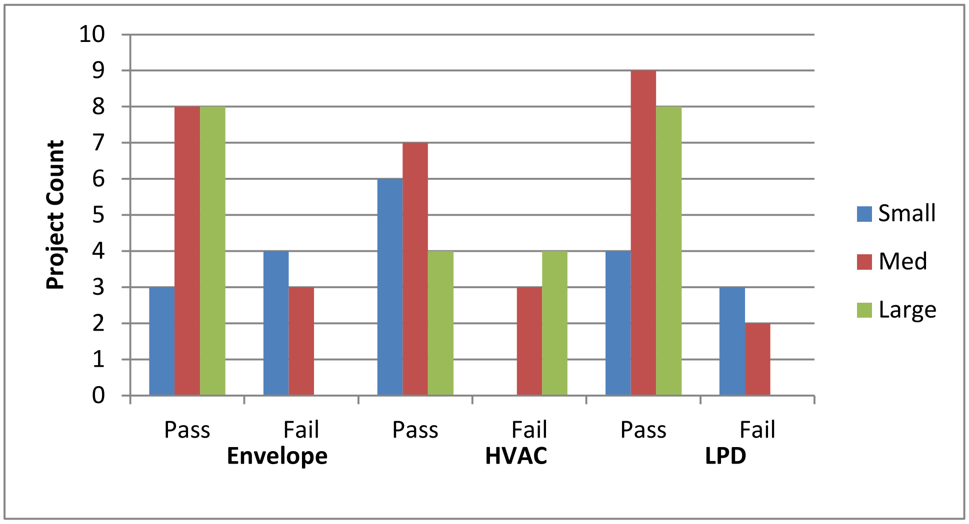

Figure 5-3. Compliance by Building Component

The large buildings were found to have envelope designs and installed lighting power densities that complied with the code. The greatest opportunities for improving code compliance in large buildings are in documentation, equipment sizing, increased controls and performance verification.

A significant portion of buildings had lighting power densities (LPD) that were more efficient than code. The area weighted average of the buildings had an overall LPD that is 13% more efficient than code requires. The opportunities for lighting efficiency include bringing non-compliant buildings up to code LPD levels, increased use of tandem wired ballasts and automated controls.

The Team classified buildings into three major type categories and compared them to the overall construction market over a two year period as shown in Table 5-4 below. Details of the market analysis are found in Appendix Q-6.

Table 5-4. New York State Market Share and Sample Distribution by Building Type

Building Type	NYS Market Share (% ft^2)	Sample Distribution (% ft^2)
Commercial	27%	10%
Dwelling	53%	46%
Institutional	20%	44%

The profile and scores of the buildings in the sample are shown in Table 5-5.

Table 5-5. Profile and Building Scores in Sample by Building Type

Building Types	Buildings in Sample	Square Footage	Percent of Sample	BECP Score
Commercial	9	162,362	10%	79%
Bank	1	3,848	0%	85%
Office	6	118,813	7%	77%
Retail	2	39,701	3%	83%
Dwelling	9	721,947	46%	85%
Dormitory	1	146,476	9.2%	88%
Hotel	2	110,134	6.9%	85%
Multi-family	6	465,337	29.4%	84%
Institutional	8	701,049	44%	84%
Education	2	301,163	19%	86%
Healthcare	2	81,220	5%	78%
Laboratory	1	41,964	3%	92%
Prison	1	255,271	16%	81%
Public Safety	2	21,431	1%	89%

The buildings that met the 90% requirement in the suggested BECP Protocol included two institutional facilities and a Federal office building. The seven buildings with the lowest checklist scores included five commercial type occupancies, one of which was a small government office, and two healthcare facilities. Compliance of the buildings with residential type occupancy is relatively consistent at approximately 85%. However, there may be additional opportunities in this occupancy class as the lighting loads in dwelling areas of multi-family housing are currently unregulated. In addition, code LPD allowances for dwelling areas in hotels and dormitories appears high relative to the installed lighting power densities found in new construction.

The compliance results were also analyzed per Climate Zone, but there was not a marked difference between compliance levels as they were all approximately 85% compliant.

5.3 ENERGY IMPACT OF NON-COMPLIANCE IN COMMERCIAL BUILDINGS

The VEIC Team modeled and analyzed the impact that non-compliant energy components have on the operating energy costs for commercial buildings, in addition to the impact on the electrical grid. Those results are presented below.

5.3.1 Energy Impact Calculation Methodology

The energy impact of non-compliance was analyzed by modeling composite commercial buildings in the DOE software program, eQuest. Three building models were constructed to represent "typical" small building construction (office – 9500 ft^2), medium building construction (mixed use building including retail, common areas and residential space of 38,700 ft^2) and large construction (multi-family housing with common areas of 131,000 ft^2). The composite buildings were developed using information from the sampled buildings including an amalgamation of the surveyed building construction and mechanical system types. The composite buildings contain a mix of the mechanical system types found in the field including central boilers, PTACs in dwelling units, central air handlers with DX, chillers, etc. The model construction is detailed in the "Methodology for Composite Building Development" document in Appendix Q-7.

Modeling was conducted to determine the following:

1. Baseline 100% code compliant composite building consumption and budget: this set all the components of the composite buildings to code levels and established the baseline consumption and energy budget of each of the composite buildings. Parameters for geometry, operating schedules, outside air intake, etc. reflected the buildings surveyed in the field and were held constant across all model iterations. These models estimate the energy consumption for buildings that meet the minimum requirements of ASHRAE 90.1 2007.

2. Composite design building consumption and budget: these models were developed to reflect the energy efficiency levels found in the surveyed buildings. The consumption and budgets for the composite building was compared to the baseline 100% code compliant building consumption and budget in order to ascertain the difference between energy use and cost in the composite model and the code compliant model.

3. Impact of component specific non-compliance: iterations of the most significant non-compliant components were modeled to determine the energy impacts of non-compliance of the "lost savings". This was accomplished by analyzing the specific components of the sampled buildings against the minimum level required by code and modeling the composite code building with the specific component set to the average of only the non-compliant buildings. For example: if 20% of square footage of the small sampled buildings had an average indoor lighting power density (LPD) that was 10% less efficient than code, then the composite code building was modeled to reflect the non-compliant LPD. This model was compared to the 100% code compliant model lighting energy use to determine the lost savings due to the higher LPD. This difference between the models

was then multiplied by 20% to reach the overall energy impact for non-compliance of the less efficient lighting. Separate lost savings models were constructed for small building lighting and envelope, medium building lighting, HVAC and envelope, and large building HVAC and air leakage.

Details of the modeling methodology can be found in Appendix P.

5.3.2 Non-Compliance Energy Impact

The composite models showed that the medium and large composite have higher aggregate levels of efficiency and lower energy costs than a baseline code compliant building. As noted above, the models captured the interactive effects of the efficiency associated with the better than code components as compared to the below code components. Un-calibrated building models are inherently inaccurate relative to the predicted building energy consumption; however, they are generally believed to do a good job at comparing the relative efficiency of different approaches.

The small composite building is the only one that showed energy consumption lower than code. However, opportunities to capture energy savings by increasing compliance with the energy codes exist in all three building sizes. The results of the composite building modeling relative to energy consumption per building size are summarized in Table 5-6.

Table 5-6. Results of Composite Building Modeling Relative to Energy Consumption Per Building Size

Building Size	Composite Building (MMBtu)	Code Compliant Building (MMBtu)	Difference (%)
Small	510	503	-1.4%
Medium	2,323	2,841	18%
Large	9,073	9,386	3%

While the model results give cause for optimism regarding the progress of commercial construction in New York State, there are areas for energy efficiency improvements based on the data collected in the field and the codes that were applicable at the time these buildings were permitted. As the stringency and extent of commercial building codes increases, the savings potential will also increase.

There are several caveats that the VEIC Team places on the results of this modeling exercise:

- Self-selection bias is likely a significant factor affecting the levels of efficiency in the composite buildings. As reported in Section 2, it was very difficult to recruit the sample of buildings in this evaluation. It was noticeable to the VEIC Team that made the recruitment calls, that owners who did agree to participate in this Study were ones who had confidence that their buildings were at least compliant with code. Owners who were not attentive to codes when their buildings were built, or owners who did not use design professionals accustomed to codes, were less likely to be receptive to scrutiny of their buildings for this Study. The eight owners who sought out the Study by proactively contacting the VEIC Team upon receipt of the recruitment letter were likely proud of their building construction. This means the findings of the building levels of efficiency are probably higher than the overall new construction market in New York State.

- In order to provide a representation of the system types found in the field, the models are based on an amalgamation of systems that would not be applied in any real world building. This could impact modeling results by driving system sizes down or by creating unexpected interactive effects.
- While the models reflect the findings in the surveyed buildings, they are not necessarily consistent with the VEIC Team's general experience working in the field of commercial building energy efficiency. The sampled buildings, for example, show a high percentage of LPD above code. It is the experience of the VEIC Team that buildings pursuing LEED certification often do not achieve installed lighting power densities as efficient as those found in the survey. Mechanical equipment sizing is another area where the modeling software assumes properly sized equipment and yet this Team's experience has been that most HVAC systems are oversized. This leads to fans, motors and pumps being oversized and the overall HVAC system consumes more energy than necessary.
- Because the level of inspection lacked the performance testing required to develop a truly accurate estimate of a commercial building's constructed levels of energy efficiency, the composite buildings are more representative of the design intent than of the actual performance of these buildings, particularly for the medium and large models. Performance monitoring through metering, too expensive and time consuming for an evaluation of code compliance, is the only industry-sanctioned method which truly represents the actual energy performance of a building. Examples are items such as variable speed drives that are set manually to one speed, economizers and demand control ventilation that are not controlled correctly, programmable thermostats that are manually set to one temperature, condensing boilers that do not operate correctly and therefore do not meet their efficiency ratings, to name but a few.
- Because the sample is relatively small and there are a number of different HVAC systems per building size in the medium and large buildings, the equipment efficiency levels modeled are based on a very small sample of systems.
- The VEIC Team has direct experience performing calibrated simulation modeling for commercial buildings and notes that *while these model results may be appealing, actual building energy performance for these buildings is likely to be substantially worse than the modeled performance*

for a variety of reasons. Further discussion of the modeling process and findings is provided in Appendix P.

5.3.3 Modeling Parameters per Building Size

Specific components were found to be non-compliant in the review of the sampled buildings. These individual components were aggregated on a weighted per sq ft average into three different composite buildings based on size. These composite building enabled us to calculate lost savings opportunities from non-compliance for each building size.

Small Buildings Composite

The main areas for improvement for all sizes of commercial buildings lie in proper HVAC sizing, code compliant exterior and interior lighting and lighting controls. Many small buildings showed opportunities for savings by bringing into compliance the windows and insulation – both for building slab and continuous wall insulation.

These building parameter deficiencies are not surprising for small buildings. The majority of buildings smaller than 25,000 sq ft are not designed by an architect and/or engineer. Most of these are designed by contractor design/build firms who size mechanical equipment and design lighting systems by long-standing 'rules of thumb.' ASHRAE 90.1 also does not mandate sizing calculations very clearly. It merely states "Heating and cooling system design loads for the purpose of sizing systems and equipment shall be determined in accordance with generally accepted engineering standards and handbooks acceptable to the adopting authority (for example, ASHRAE Handbook-Fundamentals)."

Engineers are leery of designing below these age-old standards because they often do not trust that buildings will be constructed as tight as the design specifies; they do not want to have problems with buildings not being able to meet their temperature set points or people complaining that there is not enough light. These particular areas – equipment efficiency, building envelope tightness, and lighting efficacy are areas that have seen great improvements, but some practitioners have not been convinced they can change their design methods. In order to influence a change in standard design practices, designers must be educated and the code compliance process must evaluate building mechanical system MMBtu/sq ft, lighting power density and air change rate. Mechanical equipment sizing calculations and air change rate could be required as an input in the COM*check*™ report. In addition, a blower door test could be required during construction and a post-construction check of LPD and equipment capacity could be required prior to an occupancy permit being issued. These actions would help enable the building designers and contractors to see that these new standards meet building performance requirements and would enable New York to have confidence that energy savings are being realized.

Medium Buildings Composite

The modeled medium building's overall building energy consumption was better than the code compliant building due to better-than-code components such as roof and wall insulation and mechanical equipment efficiency ratings. Where the sampled medium sized buildings fell short of suggested BECP Protocol code compliance was in the lack of energy recovery wheels, slab insulation and continuous wall insulation; the high LPD and low penetration of lighting and HVAC control. As many buildings did not have continuous wall or slab insulation, it is likely that air infiltration is significantly higher than necessary. Although it is not stipulated in ASHRAE 90.1, the evaluation performed in this Study has included an analysis of savings that can be realized by decreasing the air changes per hour of the composite building from 0.50ACH to 0.35ACH.

Large Buildings Composite

Large buildings performed better than code for this building sample. In general, these buildings are quite well designed by professional architects and engineers who are accustomed to building to code or beyond. The savings potential included in this analysis is comprised of improved HVAC equipment efficiency, improved HVAC controls, code compliant motors and tandem wiring for fluorescent light fixtures. While the LPD of the composite building was found to be better than code, the lack of tandem wiring imposes approximately a 3% penalty on the LPD. So, if the installed systems had more routinely included tandem wiring, the installed LPDs would have been even better. The use of tandem wiring in certain situations is required by code. The impacts of below-code air sealing were also calculated. This improvement relies on conscientious construction practices which are easily attainable without considerable increased material cost. Moreover, these practices will now be tested under the 2010 ECCC NYS requirements.

5.3.4 Energy Impact Results

Based on field data and modeling, there is an estimated annual "lost savings" of $0.10 per square foot of commercial new construction due to non-compliant design and construction or about 5% of the modeled code compliant building's annual energy cost. Over a twenty year period, the cumulative lost savings for a 50,000 sq ft building is estimated to be approximately $100,000 (in 2011 dollars). Assuming that the modeled buildings represent the average construction practices for all new commercial construction in New York, and adjusting for the 15% of new construction that participates in NYSERDA's New Construction Program, which are assumed to exceed code requirements, the lost savings for non-compliance of commercial new construction is estimated to be over $8.8 million annually. The cumulative 20-year savings for the 2,000 commercial buildings constructed annually in a five year period (average in NYS over 2008 and 2009) there is approximately $960 million of lost savings.

This $960 million is at the low end of the range. In all likelihood, the buildings in this sample represent a better than average new commercial construction in New York. Furthermore, the more challenging requirements of the ECCCNYS - 2010 will result in even greater non-compliance. Add to this the lost savings from all of the remodeling that is not being constructed to the energy code, and the results will be significantly more than reported above. Commercial building energy code non-compliance is a significant expense to New Yorkers. As this report discusses later, the high cost of lost savings justifies making some significant changes to the structure by which code compliance design and construction is enforced throughout the construction process.

The potential savings of the three building systems – HVAC (67%), Lighting (23%) and Envelope (10%) – lie in Figure 5-4.

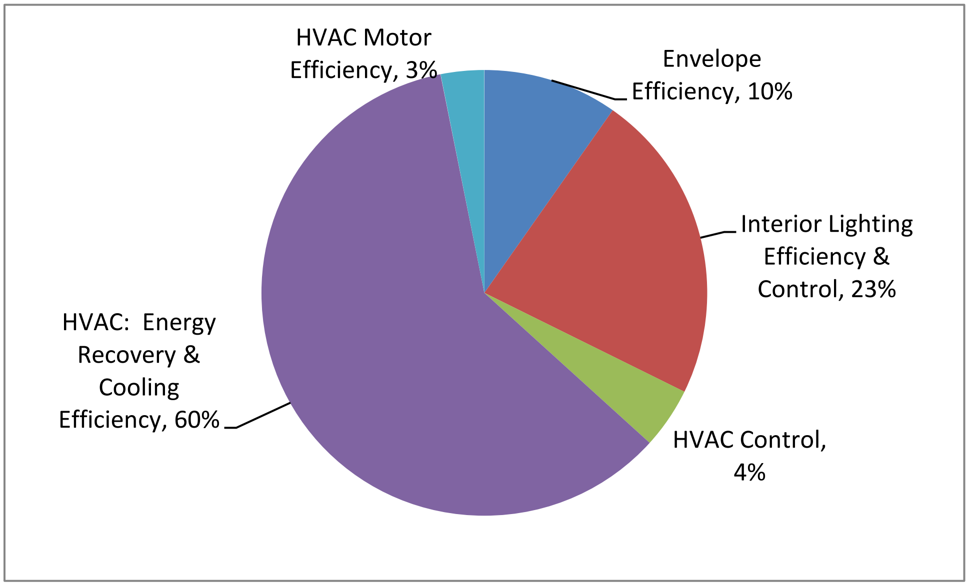

Figure 5-4. Potential Savings of Building Systems

The savings analysis examined the opportunities to save energy by bringing below code components and practices into compliance with ASHRAE 90.1-2007. Even though the large and medium composite models showed a lower energy use and budget than the code model, there are still significant savings opportunities in these buildings, even in areas such as lighting where the LPDs were consistently in compliance.

While the significant opportunities associated with HVAC control improvements were consistent with the Team's experience, the lack of code compliant motors in the inspected buildings was surprising. Given the regulation of motors under EPACT, the fact that a significant percentage of motors inspected in large commercial construction projects did not meet code was noteworthy. A relatively small percentage of packaged HVAC cooling equipment did not comply with minimum requirements. The estimated annual lost HVAC savings is $6.5 million. In addition, savings from over sizing of HVAC equipment, which is not quantitatively regulated by code, is an additional $1.8 million annually for the average square footage built in a year.

Lighting opportunities exist in three areas – lower lighting power density (interior and exterior), increased control and use of tandem wired ballasts for one and three lamp fixtures. The Team found little evidence of the use of tandem wired ballasts on site. This measure reduces energy consumption by one watt per ballast eliminated and if applied across the sector would have a considerable impact. While a significant percentage of spaces had occupancy sensors, the application of automatic lighting control strategies to all non-emergency lighting was not found. The value of lost lighting savings is approximately $2.2 million annually for the average square footage built in a year.

Building envelope compliance was difficult to inspect, as most buildings the Team used the design envelope information to determine compliance. This is likely to underestimate the savings associated with improving building envelope design and construction to the levels required by code. Validation of envelope installation and performance in commercial building can be done using a blower door in smaller faculties. No blower door testing was performed; however, based on field experience of the Team, there is an estimated $935,000 in envelope savings. Additional air sealing will likely generate at least another $2 million in lost savings. (These two savings calculations are included, with other components in the 10% category of Envelope Savings in Figure 5-4 above.)

The amount of new building square footage, per year, on which these savings are based come from the 2008-2009 new construction database. Buildings that participate in the NYSERDA New Construction Program have been deleted from this summary, as these buildings are assumed to meet or exceed the applicable codes.

Savings are considerable, even though compliance in this sample of buildings is already at 85%.

5.4 CASE STUDIES

The VEIC Team selected eight commercial buildings representative of new construction types and sizes throughout New York to probe for energy code issues. The Team conducted interviews with code officials, architects, engineers and contractors associated with the buildings listed in Table 5-7. Summary findings follow:

Table 5-7. Buildings Used as Case Study Candidates and their Energy Code Findings

Bldg #	Type	Size	Energy Code Findings of Significance
1	Correctional Facility	Large	BECP Score of 81%, non-compliant slab insulation, motor efficiencies below code, DHW efficiency below code.
2	Laboratory	Medium	BECP Score 92%, documentation was not compliant.
3	Motel/Hotel	Large	BECP Score 81%, domestic hot water system did not comply.
4	Retail	Small	BECP Score 79%, slab on grade insulation below code, required lighting and HVAC controls not installed.
5	Office Building	Small	BECP Score 67%, fiberglass insulation was installed on top of lay in ceiling, walls, doors, windows did not comply, required lighting controls not installed.
6	Nursing Home	Large	BECP 79%, windows don't comply, HVAC equipment efficiency level not to code
7	Retail	Medium	BECP Score 86%, required energy recovery and lighting controls not installed.
8	Apartment Building	Large	BECP Score 80%, non-continuous roof insulation, HVAC controls non-compliant.

5.4.1 General Findings from Case Studies

Interviews conducted of key players associated with the energy code compliance aspects of these selected case Study buildings revealed a general awareness and attempt to comply with the code. However, while there are some building code offices with adequate human resources and a sense of responsibility to ensure compliance with *all* codes, for most jurisdictions enforcing the energy code was at the bottom of the priority list. For most of these projects, only a cursory examination of energy code compliance was reported. Code officials relied on architects and engineers to design and specify energy code elements into their plans; as long as there was evidence of such, most code officials did little more than verify that energy code documentation was submitted. In the field, as with plan review, there was little emphasis or attention paid to verify all aspects of the energy code. Architects and engineers understood this responsibility to design in energy code compliance and reported a commitment to play that role. In most cases, contractors indicated that they believed they built what was on the plans and specifications and did not feel that it was their responsibility to do any more than what was in their contract. In a few cases, contractors faced with budget pressures made changes that may have altered the as-planned energy code elements. In none of these cases did anyone question or assess whether these changes violated the energy code.

5.4.2 Code Officials

Most officials rely on others to document and verify compliance with the energy code. A few who are fortunate enough to have the resources do the best they can with the staff and knowledge they have attempted to verify energy code compliance. In either case, it is clear that enforcing compliance with the energy code in commercial buildings is a challenge. It is also clear that as the code ramps up, the effort will more complex and these enforcement challenges are going to increase.

Time and again, code officials reported inadequate time to focus on energy code issues. When they were asked what they did focus on, they reported that for the plan review stage they verified that the architects had completed COM*check*™ or otherwise documented compliance. As long as the documentation was stamped "Passed," that was generally good enough for them. During the on-site visit, out of a dozen visits for some small to medium sized projects, code officials reported inspecting for energy once, and usually just for insulation. When probed on whether going forward they would verify and enforce other details of the new energy code in the field, including air and duct leakage, lighting power density and HVAC controls and settings, a typical response was "I don't know…"

There seems, at least, to be a general awareness to look for COM*check*™. If the architects and engineers are doing their jobs designing and inputting their buildings correctly, and the contractors are following the plans and specifications provided, then the results should be a code compliant structure. However, the field work indicated that COM*check*™ reports were available for only about one third of the sampled buildings. Furthermore, some submitted designs do not comply with code, demonstrating that a system that relies solely on self-certification by others without compliance verification has no assurance that the energy code is being met.

Code officials regularly report a lack of full understanding of the ECCCNYS - 2010. More trainings focusing on the new areas of code, providing both residential and commercial information (since most officials are responsible for both) held in convenient areas close by would be welcome.

Code officials appear open to using a third-party to assist with verification of compliance to the energy code, as long as it does not add another layer of government. In one jurisdiction the code official requested being present when the duct system is tested by the HVAC contractor or her/his subcontractor to verify tightness, per the code. In another jurisdiction, the electrical contractor's insurance underwriters require a third-party inspection to reduce their liability. The local code official relies on these inspections to document that the duct and electrical systems were built to code. While some code officials are hesitant about relinquishing control and responsibility, they generally seem open to exploring a third-party verification system that could assist on larger projects or with aspects of the code for which they do not have expertise, equipment to do the tests, or time required to ensure compliance. As "enough time" was the universal response when asked what aspect of the energy code is most challenging, finding a solution to this issue may be one way towards increasing compliance.

5.4.3 Architects

Architects play a key role in building energy code compliance. Code officials look to them as the experts, expect them to be up to speed on the details of the most current code, rely on them to specify the measures and details that the contractors need to build, and count on them to provide all the necessary documentation. Architects generally understand their role and responsibilities and seem to take them seriously. While most projects are just built to code and generally do not exceed it, architects are the single player with most influence on the project's outcome, including code level.

As one architect in the health field noted, the State Department of Health is downsizing; shedding its responsibility for policing building requirements. "The philosophy appears to be that the responsibility for code compliance falls back on the design professional." The current environment does not have much in the way of teeth; in that no enforcement exists to police submissions or to penalize those that knowingly or unknowingly submit plans that violate codes. The threat of losing a license because of an improper energy code submittal was deemed unlikely to happen by most stakeholders and an unreasonable consequence to one architect who thought those types of punishments should be reserved for violations threatening health or safety.

Despite the role they play in upholding the energy code, architects do not always see adequate attention paid to their efforts by code officials. As with the code officials interviewed, the architects also reported that as long as there was a passing COM*check*™ or documentation of prescriptive measures submitted, the energy code was considered done. Rarely was more than the bottom line reviewed and almost never did any of the interviewed architects report plans had been "tagged" for energy code non-compliance if they submitted a passing COM*check*™ or prescriptive checklists. From upstate New York, one architect reported that "very few of the energy code elements are being followed" for most of the residential projects being built, due to a lack of understanding of energy issues by local code officials.

Architects take on the role of ensuring code compliance due to potential liability issues. They acknowledged that if anyone were to question a building for deficiencies, they would be responsible, and, therefore, they need to ensure that all codes are followed. Architects note that while they and the supporting engineers may be required to sign-off on the energy code plan, they are not in position to be responsible for ensuring as-built complies with the energy code. As one architect noted, the quality of the construction determines if a building is actually compliant or not. No written submittal will ensure good quality construction. The typical fee structure does not permit architects or engineers to offer to guarantee construction quality for energy code components. The typical contract barely gets them enough funds to visit a site once or twice a week at most. Given this frequency, they cannot guarantee that every building component is built to energy code.

The architects had some recommendations that they thought would help them and code officials better succeed with the energy code compliance process, including the following:

- Provide a checklist that would require code officials to actually look at more than the bottom line and focus on the important energy elements that could be included on the checklist.
- Provide personnel to help interpret code, such as a "hotline" that has some authority and cuts across jurisdictions.
- Access to tools (e.g. COM*check*™ and RES*check*™) is critical; allow free access to tools that are to be used. A public code should have public tools.
- Provide regular and local training.

5.4.4 Engineers

Engineers play a similar role in supporting the energy code as architects. In fact, since in most instances engineers are a subcontractor to the architect, it is the engineers that may prepare the COM*check*™ or RES*check*™ files for the architect. Interviewed engineers reported that they typically bring new code issues to the code officers and end up educating them. They stated that it would help architects/engineers to justify doing it right if the code officers were better educated on all aspects of the code.

Engineers are now finding that they are required to put their stamp and signature on COM*check*™ plans submitted. This has put a lot of pressure on engineers to make sure plans do meet code. However, unless the engineer is also paid to provide construction phase services including equipment validation, the engineer does not have responsibility for verifying that the as-built systems are as planned and still meet code. One engineer said that only about 15% of the jobs he does include a post-inspection verification. The engineers also noted that their responsibility only extends to the base building and common areas, and not to any of the built-outs or tenant areas. This leaves a significant portion of the lighting, in particular, outside the engineers' or architects' responsibilities; and not covered in COM*check*™ plans.

An engineer noted that code officials in New York City do require that energy efficient boilers be installed and that stricter enforcement is tied to buildings designated as affordable in that owner has to install centralized heating systems meeting NYSERDA's standard of 85%+ efficiency. The stricter adherence and oversight for these affordable units is both a product of New York City code enforcement and requirements placed on building efficiency that are tied to funding from NYSERDA and other sources. New York City requires both a signed plan submittal and a signed post-construction signature. This firm uses a third-party to verify that code is met. The city is now employing similarly trained consultants to spot check code compliance.

A lighting engineer found problems with the code in that it does not allow for specialty needs in lighting applications. He noted that there needs to be provisions for theater with stage lighting or special medical applications such as sleep centers where incandescent lighting is needed.

For rural upstate projects, engineers are pulled in to adjust owner or builder designed plans and specifications to energy code levels and then run COM*check*™ in order to obtain a building permit. However, many of the smaller commercial, and most residential projects in these more rural jurisdictions do not have a knowledgeable code official overseeing them and may not involve and architect or engineer. Said one interviewed engineer, "Energy is given next to zero importance in New York State. I have never had a comment about insulation in 20 years."

Engineers play an important role in supporting architects in all aspects of code compliance, but may serve more of a back-office function than the architect who leads the project out front. With more training and support systems, engineers can continue educating code officials. But in the meantime, engineers are looking for more local training and opportunities to help upgrade the code official's and architect's knowledge base.

5.4.5 Contractors

General contractors on commercial projects are bound to follow the plans and specifications provided by the architect and therefore have very little leeway in conforming to the energy code. They assume that the architect has done their homework and has designed to meet the requirements of the energy code. As reported in the interviews, "We don't have a choice. We build what the architect designs. They are responsible for the code." The construction manager for a particularly large (three year build-out) project commented, "In my 40 years, I have never seen the inspectors look at insulation before they close up the wall; maybe in residential, but not on commercial jobs. They are concerned about egress, safety, but not inspecting insulation." Another contractor/owner noted that he did see the code official inspect the insulation, but not specifically with energy code aspects in mind.

5.5 COMMERCIAL CONCLUSIONS

The commercial sector has a ways to go before reaching 90% compliance with ASHRAE 90.1-2007. The VEIC investigation of compliance rates for the ASHRAE 90.1 2007 show approximately 80% of commercial buildings not participating in NYSERDA's New Construction Program do *not* comply with all minimum requirements of the 2007 code. With the more stringent NYS ECCC 2010 code recently put in place, the compliance gap is expected to increase. Compliance rates for individual building components vary across building sizes, but there are a number of areas that deserve particular focus as NYSERDA implements the CODE GREEN Training Program, to train design professionals and builders, guide code officials, and inform Energy Specialists (see below for more explanation). These problematic areas include slab insulation, interior foundation wall insulation, roof and wall insulation, lighting and HVAC efficiency and controls, air infiltration and duct leakage rates and cooling system sizing. The impact of these non-complying components results is about $8.8 million of annual lost energy savings and at least $880 million over a twenty year period. At higher IECC - 2009 code levels, this lost savings will be even greater.

New York has a significant opportunity to capture these lost savings. To close the gap, the State needs to take energy code compliance as seriously as it takes life-safety compliance. There are significant resources to be tapped in the commercial building market. These resources, coupled with full funding of code compliance efforts, will elevate practice relative to energy efficiency and assure that the State meets its code compliance goals.

Design professionals are a critical resource in achieving code compliance, and, as evidenced by the composite models, most are working to design to a reasonable standard of efficiency. Setting up a compliance verification system that increases design professional accountability through independent review of energy code documents is expected to have an immediate impact on compliance levels. Design professionals take pride in the standards that they achieve and seek to meet all aspects of the applicable codes. Unless there is a feedback loop that indicates they are failing to achieve the standard, they presume compliance. Introducing a consistent verification process will stimulate the market to increase its focus on the requirements for documenting code compliance which will likely increase the overall efficiency of the new construction and renovation projects submitted for review.

Setting up a mechanism to enforce code through a new third-party system of “Energy Specialists” who are equipped with the knowledge, testing tools and responsibility to review design compliance, evaluate construction compliance over the entire construction cycle for individual projects, support contractors in implementing required construction techniques, and assist code officials in verifying compliance and documenting deficiencies will be an effective means of improving New York’s code compliance rates.

Specific recommendations are provided in Section 6.

Section 6: **CONCLUSIONS AND RECOMMENDATIONS**

6.1 INTRODUCTION

This 2010-2011 investigation of New York statewide energy code compliance represents a substantive voluntary effort to assess current code compliance ahead of the ARRA mandated requirement that states achieve 90% compliance with energy codes by 2017. NYSERDA and the New York Department of State are to be commended for their early start toward this goal. Currently, the New York code enforcement infrastructure is decentralized with long-established locally-controlled procedures. Making major changes – such as this report suggests – to the statewide structure of code inspection and enforcement will take much time and effort.

Overall, New York State (NYS) is in an advantageous position relative to many other states. New York has a well-functioning tradition of building code enforcement, with local jurisdictions covering the entire state. Building codes have existed in New York since 1951 and energy requirements were added more than 30 years ago. The state has championed the development of a building performance industry that has led almost a quarter of all new housing units to achieve energy-efficiency levels well-above code requirements (New York ENERGY STAR® Homes). The state has also created a burgeoning Commercial New Construction Program that sets a high bar for the commercial sector.

The work performed by the Project Team will be valuable to NYSERDA, and secondarily to the U.S. Department of Energy (DOE), to accomplish two goals:

1. to streamline the process and improve the accuracy of computed results by which NYS will undergo sampling in future studies, and
2. to improve the compliance to the ECCCNYS - 2010 and IECC - 2009 in building and renovating more energy efficient buildings.

This report makes recommendations for significant changes to the enforcement of codes *during the process of construction*. New York City has recently implemented a pilot program to perform a similar progress inspection review. This coincidence validates the Team's recommendation to consider additional inspections, possibly undertaken by third-party specialists.

6.1.1 Study Approach and Objectives

This Study investigates the degree to which New York buildings comply with the building energy codes based on the protocol developed by DOE. The primary objectives of the Study were to:

1. Calculate the percent of compliance per the suggested BECP Protocol with:

- The code in effect at the time each studied building was permitted (Energy Conservation ECCNYS – 2007 for residential construction; ASHRAE 90.1-2004/2007 for commercial construction); and

- Future codes (implemented after the Study subject buildings were constructed) for residential construction using IECC - 2009 (on which the ECCCNYS - 2010 is based).

2. Calculate lost savings from non-compliance.

3. Create a roadmap for New York State to meet the 90% compliance rate by 2017.

The presented findings are a synthesis of information gathered by the VEIC Team in 2010 – 2011 through the application of the suggested BECP Protocol to plan review and on-site inspections of 44 homes and 26 commercial properties; survey or interviews with policy makers, active code officials (179), builders and contractors (61), architects (69), and homeowners who undertook renovations (20). The Team also interviewed owners, contractors, architects, engineers, and code officials associated with eight commercial case studies.

Most of these activities focused on the code to which the surveyed buildings were built, primarily the 2007 New York State Energy Conservation Construction Code (ECCCNYS - 2007)[7], rather than the current 2010 edition, based on the IECC - 2009. However, where possible, this report identifies the technical and compliance challenges that the ECCCNYS – 2010 represents to design professionals, builders, and code enforcement personnel.

[7] Four of 26 Commercial projects in the sample were permitted under and evaluated for compliance with the ASHRAE 90.1 – 2004.

6.2 LIMITATIONS AND CHALLENGES OF THE CURRENT PNNL CHECKLIST SUGGESTED APPROACH TO ASSESSING CODE COMPLIANCE

6.2.1 Potential High Costs of Code Compliance Evaluation under Current Suggested BECP Protocols

This Study was limited in its ability to follow the suggested BECP Protocol. Limitations of budget and therefore Scope of Work, as well as participant bias, are discussed below and have been identified previously in Section 2.

- The suggested BECP Protocol recommends that evaluators make *multiple* visits, preferably during construction, to each site to collect all of the data listed on the residential and commercial checklists. Since this Study was able to make only *one* visit, many of the energy code features were not verifiable, (e.g. slab insulation; quality of insulation installation; U-value of windows, etc.) Only one commercial and one residential site evaluated were under construction, while the remainder were evaluated post-construction.

- The Study was successful in recruiting only 26 commercial buildings, rather than the 44 in the suggested BECP Protocol.

- No on-site evaluations of residential or commercial *renovations* occurred.

Were a study to follow all of the suggested BECP Protocol's provisions, it is estimated that the implementation cost could be *more than $1 million.*

6.2.2 Sampling and Recruiting Challenges

The Study's attempt to follow strictly the sampling selection approach detailed in the suggested BECP Protocol was not fully successful for several reasons. There is no central database of all new construction and renovation activity in the State; the Dodge permit data required extensive cleaning, had missing and incorrect data, and did not reflect statewide activity; many of the randomly-selected code jurisdictions were unwilling to participate; and recruitment of buildings was difficult, with only a small fraction of properties having proper contact information and/or being willing to participate. Because it is likely that jurisdictions and property owners successfully enforcing and meeting the energy code were more prone to participate, the samples may represent higher code compliance than the whole set of New York buildings. Unless a means of more firmly requiring or incentivizing selected jurisdictions (code officials) and property owners to participate, self-selection bias will again significantly reduce the value of future code compliance studies.

6.2.3 Challenges of PNNL Checklist Still Under Development

For commercial buildings, the tools and guidance needed to support consistent determination of compliance with many of the suggested BECP Protocol checklist items were not readily available. Examples include: observed HVAC equipment did not list energy efficiency ratings on the equipment; and no quantitative standard existed to verify HVAC equipment testing. (This latter checklist item was thus set to “not reviewed” for all projects.) Increased guidance for inspection requirements for each checklist item is essential for consistent enforcement and compliance measurement. .

6.3 RECOMMENDATIONS

The following recommendations were created by the Team and influenced by input from the interviewed NYS and national code policy experts recommended by NYSERDA. The Team asserts that the potential energy savings valued at a minimum of $1.3+ billion over five years justifies implementation of the recommendations, despite the challenges posed by the required significant structural changes.

The Team finds that this Study’s assessment of actual buildings following the suggested BECP Protocol and the other supplementary evaluation activities produced valuable information for New York, despite the discovered challenge of creating a single, unbiased statewide compliance score consistent with the suggested BECP Protocol. Included are recommendations that would make the suggested BECP Protocol more efficient, less biased, and more accurate. The Study also presents recommendations for tools usable throughout the construction process to ensure that energy plans are incorporated into submitted documents and that as-built conditions reflect approved submissions.

The Team further believes that substantial efforts and resources dedicated to the period during which buildings are designed and constructed can help close the gap created after a permit is issued. Steps are needed to coordinate the proposed energy-related measures with the construction documents, and subsequently to verify the compliance of as-built conditions. For the process to work, NYS DOS, code officials, builders, architects, engineers and building owners must be more actively involved than the status quo.

The Team has four major recommendations:

1.) DOE and PNNL enhance COM*check*™ and RES*check*™ to migrate from a one-time design phase compliance tool to a tool that generates on-going, construction-based checklists useful for interim inspections and enforcement and building scoring in the suggested BECP Protocol.

2.) NYSERDA and DOS work collaboratively to establish the potential role and certification requirements of third-party Energy Specialists to perform on-site inspections at critical milestones during construction.

3.) DOS assume a more robust oversight role to: a.) maintain a central database of construction projects and filed documentation, and b.) verify the implementation and enforcement of same.

4.) NYSERDA performs periodic evaluations, including the development of compliance scores, as required by DOE, under a streamlined protocol.

These enhanced code compliance, enforcement and evaluation strategies will enable NYS to achieve its goal of 90% compliance with the ECCCNYS - 2010 by 2017.

6.3.1 Recommendations for DOE and PNNL

<u>Enhance Existing Code Compliance Software Tools</u>

The Team recommends that DOE consider: a.) revising COM*check*™ and RES*check*™ to include the important elements of the PNNL Checklists; and b.) producing checklists that facilitate the verification process during each phase of construction or renovation. This would create two benefits:

1.) facilitate measuring compliance scoring per the suggested BECP Protocol, and
2.) transform COM*check*™ and RES*check*™ into comprehensive compliance tools applicable over the duration of a project.

Enhancing the software platforms of COM*check*™ and RES*check*™ to provide the tools for design documentation and construction validation of energy code compliance is a compelling strategy because of the construction community's existing familiarity with the software. Three sets of checklists are recommended:

- **Design Documentation Checklist (DDC):** The software platforms would generate a mandatory list of code compliance documentation items, as well as an implementation schedule for field inspections to be included in the permit and construction documents and readily visible to contractors, inspectors, code officials and owners. The design professional or energy modeler (e.g., HERS rater) would continue to perform the role of analyzing the building design's code compliance using COM*check*™ or RES*check*™, assume responsibility for ensuring that the contract documents satisfy the checklists, and submit the signed compliance documentation and full Energy Code Compliance Plan (ECCP). The ECCP concept, discussed below, would combine all documents into one comprehensive energy plan.

- **Interim Construction Inspection Checklist (ICIC):** Each software platform would generate a comprehensive field inspection checklist and schedule following the requirements of the suggested PNNL Checklist. The software platforms would capture the submitted design values for components and equipment and populate the ICIC with the submitted values for field verification.

Field verification of the ICIC requirements would be performed by Energy Specialists at designated construction completion points. The number of required ICIC inspections and the construction milestones would be identified by the design professional in the DDC. In other words, larger commercial buildings would require approximately six field inspections, while small commercial and residential buildings would require three to four inspections.

- **Final Construction Inspection Checklist (FCIC):** The software platforms would generate an FCIC which the Energy Specialist would use to certify completion of all required inspections and compliance with the original COM*check*™ and RES*check* ™ submission. No Certificate of Occupancy would be issued without all required inspections and a completed FCIC. For construction varying from the submitted documents, the Owner would retain a design or energy professional to update the energy plan and certify compliance.

<u>Integrate the Enhanced Software Platforms with the Suggested BECP Compliance Protocols</u>

DOE has identified a variety of mechanisms available for *self-assessment compliance* prior to the mandated 2017 studies. To address the numerous barriers identified herein, the Team recommends integrating the various software tools developed to measure compliance with the enhanced COM*check*™ and RES*check* ™ suggested above.

<u>Provide Additional Evaluation Tools and Support Toward the 2017 90% Compliance Goal</u>

DOE can assist New York in improving the cost effectiveness and validity of periodic compliance assessments by:

1.) Encouraging and supporting the creation of a centralized database documenting all construction projects; and

2.) Enabling sampling of verified, electronic submissions to perform the 2017 compliance evaluation. DOE should require a QA/QC component within each Compliance Study. This may be spot-checking a small percentage of the total sample with site inspections, or other simplified approaches that are less labor-intensive and more statistically accurate.

6.3.2 Recommendations for New York State (DOS, NYSERDA and Other State Agencies or Stakeholders)

<u>Allocate the Required Resources to Transform NYS Design and Construction Practices</u>

As evidenced by this Study and documented in numerous state websites, NYS is committed to ensuring that at least 90% of residential and commercial buildings comply with ECCCNYS - 2010 by 2017. The recommendations in this report will require additional financial, technical and staffing resources. In order to demonstrate the State's commitment it will be essential to fully fund this market-changing effort.

The $3.6 million per year requested by NYSERDA as part of their Operating Plan for Technology and Market Development Programs proposal is one portion of the needed funding. Funds will also be needed for DOS and local jurisdictions to support the code enforcement enhancements recommended below.

<u>Develop a Third Party Energy Code Compliance System Using an "Energy Specialist".</u>

The Team urges New York to develop a third-party system of "Energy Specialists" (ES). A description of this approach follows and is presented in Tables 6-9 and 6-10.

Energy Specialists would provide most of the required plan review and field verification services needed to achieve 90% or better energy code compliance. ES would be professionals who are certified and possibly licensed by the DOS or its designated representative. The development and use of ES would leverage the existing market infrastructure of qualified professionals including: architects, engineers, HERS raters, BPI contractors, Progress Inspectors and other qualified inspectors. DOS could provide administration and oversight, including quality assurance and quality control (QA/QC), and qualify individuals, maintain a registry of inspectors, de-certify as necessary, maintain a database of all inspected buildings and their level of compliance, and report on status and progress.

ES' work would be paid directly by the owner, design professional or the builder of a project, based on market rates. Documentation of compliance would be required before issuance of a Certificate of Occupancy. Reduced fees for Energy Specialists could be offered through participation in the ENERGY STAR® Homes and NYSERDA's New Construction Programs.

For residential ES, QA/QC efforts could be coordinated with RESNET, which oversees the HERS Energy Rater infrastructure. With some additional training on the ECCCNYS, HERS Energy Raters would be well-suited for the ES role, since nearly one-quarter of new homes in the state are already ENERGY STAR® labeled annually. While there is not 100% overlap with the ECCCNYS, ENERGY STAR® Homes require verification of most of the energy code requirements. With training, tools and compensation, HERS Energy Raters would be well positioned to verify code compliance.

The potential pool of Commercial ES ranges from HERS Energy Raters for smaller buildings, to design and construction professionals trained in energy code compliance and verification for larger buildings. Significant additional training will likely be required to develop the needed inspection and testing capabilities necessary to elevate energy code compliance in the commercial market.

DOS would most likely be responsible for QA/QC of the ES efforts, which could include periodic ES surveys to obtain information on compliance verification practice; field checks of correct compliance assessment; documentation review to verify compliance, qualification criteria; and delisting protocols.

While licensing of these ES may be a long-term goal, the lack of an existing pre-licensing structure should not be a barrier to implementing this system in the near term.

The details of the roles and responsibilities of each design and construction professional at each phase of the construction process are delineated in Tables 6-9 through 6-10.

Increase Communication and Enforcement of Energy Code Compliance Responsibilities

Contractors, builders and owners, who are constantly under budget pressures and vulnerable to cost-overruns, are significant barriers to energy code compliance. Compliance levels will be improved most effectively through the use of a system that combines incentives and enforcement. A potential incentive could be to provide program incentives and reduced fees for code compliance verification and documentation to projects participating in the residential New York ENERGY STAR® Homes and commercial New Construction Programs, including requirements for mandated inspections or on-site testing. The strongest enforcement action could be withholding a Certificate of Occupancy until conformance is established.

Require all Permit Applications to Include a Signed Energy Code Compliance Plan (ECCP)

An ECCP will ensure that the submitted permit documents meet the existing administrative requirements of the ECCCNYS, as well new requirements to enable compliance verification at the time of submission and in the field. Elements of the ECCP discussed elsewhere in this document are repeated herein in order to provide a comprehensive understanding of recommended submission requirements.

- Code compliance certificate generated by COM*check*™ or RES*check*™. A design professional or energy modeler (e.g., HERS rater) would continue to perform the role of analyzing the proposed design using these software tools. These could generate the following compliance documents:
    - Design Documentation Checklist (DDC). New list of code compliance documentation items clearly identified in the permit and construction documents and readily visible to builders, code officials, and owners.
    - Interim Construction Inspection Checklist (ICIC). New set of inspection forms used to field verify that the building construction matches the submitted design.
    - Final Construction Inspection Checklist (FCIC). Inspection form used to verify completion of construction to the design.
- Schedule. Schedule for specific construction milestones identifying required inspections.
- Use of current COM*check*™ or RES*check*™ software. Confirmation that current DOE and PNNL-sponsored code compliance software tools are used.

Require Independent Verification of Documentation and ECCCNYS Compliance

To increase compliance, review of submitted project documents is essential. This can be performed by jurisdictions with the required resources and training or by the Energy Specialist (ES) engaged by the owner to verify compliance throughout the process - from permit submission to Certificate of Occupancy.

- The ES is responsible for reviewing the submitted project ECCP, signing the DDC at the time of submission, and certifying that the submitted documentation and proposed design are compliant.

- The ES uses the ICIC to perform on-site inspections at the designated construction milestones - approximately six for commercial buildings and three for small commercial and residential buildings. At each inspection milestone, the ES would file the checklist (pass or fail) to the owner and the code official. The code official would enforce compliance by requiring the violation to be rectified.

  For the ES to complete this checklist, he/she will be required to take several actions:

  1.) Record observable data, such as: quality of insulation installation, U-value of windows when installed and accompanying documentation is available; make and model of HVAC equipment; and confirmation of compliance. (Separate drop down menus on a computerized checklist would be required to, for example, provide efficiency information on more than 1,000 models of HVAC equipment commonly sold.)

  2.) Calculate complex numbers such as Lighting Power Density (LPD). (A spreadsheet behind the computerized checklist could support these calculations, including labeling of all necessary data inputs observed on site.)

  3.) Implement performance tests, such as blower door and duct blaster tests.

- At construction completion, the ES certifies that the as-built conditions match the compliant proposed design per Final Construction Inspection Checklist (FCIC). No Certificate of Occupancy would be issued without a passing inspection and a completed and signed FCIC.
- If construction cannot be certified to match the proposed design, a revised building ECCP must be provided by the design professional of record to document compliance. Approval of the updated and signed ECCP will result in issuance of the Certificate of Occupancy.
- The ES would advise all parties of the requirement for a revised ECCP. The code official would ensure that all necessary documentation is complete before issuing a Certificate of Occupancy. Ideally, the code official would electronically file the project compliance documents including the ECCP, ICICs and the FCIC into a centralized state database as discussed below.

Require Improved, Electronic Reporting System

Code officials or ES responsible for reporting progress and inspection status should be required to utilize an electronic database that is uploaded monthly to a central statewide DOS database ("Energy Code Tracking Database" or ECTD). Only when all forms have been completed and recorded should the Certificate of Occupancy be issued. Attention should be given to ensure that renovation projects are consistently tracked and recorded in this database.

Progress towards the 90% goal must be measured on an *on-going basis*. The suggested BECP Protocol is prone to sample bias and is expensive, due to the lack of a high-quality electronic database of permits and plans, and the suggestion make multiple trips to sites and code official offices. Costly delays associated with filing Freedom of Information Letters could be avoided. Ongoing monitoring should be done, if possible – i.e. if information is captured electronically on the ECTD for all buildings.

Establish DOS as the QA/QC Monitoring Body

DOS or its designated representative could audit the ES and assemble required compliance reporting by performing spot checks or by using the code officials to validate in progress and completed work. The cost of performing audits could be absorbed by slightly increased permit fees or other sources as determined by NYSERDA.

DOS should develop an oversight plan to monitor the progress in energy code enforcement and compliance. This plan will develop data collection and reporting protocols for the above proposed centralized database and establish clear and quantifiable metrics of performance for evaluation of jurisdictions.

DOS should focus its measurement of code compliance on direct measurement of code enforcement activities. Data should be collected on the number of: officials and jurisdictions receiving energy code trainings, jurisdictions requiring signed COM*check*™ plans, and drawings detailing code compliance and interim inspections. DOS should use the statewide database to monitor the number of site visits and post-installation activities by code officials. Data should be kept on ES and design professionals who have been identified as approving non-compliant buildings.

NYSERDA can support DOS by performing interim evaluations of the implemented changes and independent reviews of the compliance process, and by assisting DOS in undertaking surveys or other assessments and training targeted to jurisdictions identified as having low compliance levels.

Adoption of the above recommendations will enable NYSERDA to complete a 2017 compliance assessment using the independent code compliance assessments prepared by the ES and filed in the DOS database. A small percentage of the total sample should also receive QA/QC spot checking in the field.

6.4 COMPLIANCE RATES

For this report, the suggested BECP Protocol was used to measure building and average statewide energy code compliance rates. The suggested BECP Protocol recommends calculating individual building energy code compliance *based on the proportion of energy code requirements that have been met*; individual buildings receive a compliance score of 0-100%. Individual building scores are averaged to derive a statewide mean and standard deviation. The suggested BECP Protocol allows a state to claim 90% energy code compliance if the upper bound of the 95% confidence interval is above 90%, and values for compliance are presented showing this upper bound value. Other methods of measuring energy code compliance evaluate buildings on a pass/fail basis are discussed herein, although the suggested BECP Protocol is the primary focus of this Study.

The overall building compliance rate (as measured by the suggested BECP Protocol), with previous codes [ECCCNYS - 2007 (residential) and ASHRAE 90.1 – 2004/2007 (commercial)[8]] was below 90% for both the residential and commercial sector samples of investigated buildings. On the residential side, the upper bound of the confidence interval (BECP compliance rate) for new homes was 73%. For commercial buildings, the upper bound of the confidence interval was 85%.

Both sectors are even further below the 90% compliance rate when tested (residential) against the current 2009 IECC (on which ECCCNYS-2010 is based), as shown in Table 6-2 and ASHRAE 90.1 2007 (commercial). Since these codes are a.) more stringent on fundamental building structures (air sealing, building envelope, etc.) and b.) for the residential sector, eliminates equipment efficiency trade-off allowances, *a significant effort will be required for New York to meet the 90% compliance requirement.*

Table 6-1 reports the compliance rates for the residential and commercial samples as measured against the (previous) code in effect at the time of this Study. The suggested BECP Protocol Compliance Rate column reports the *percent of code requirements* that were found in compliance, on average, for each sector at the upper confidence bound. The last column reports the *percent of buildings* that were found to be in compliance with over 90% of the target code requirements. Two issues limit the extrapolation of sample results to a statistically valid statewide result: samples exclude higher performance buildings (New York ENERGY STAR® Homes, Commercial New Construction Program, and LEED-certified buildings); there is likely self-selection bias in the sample; and the commercial sample is relatively small (26 buildings).

[8] Code compliance is relevant to the code in effect at the time of permitting. Residential buildings are generally built within one to two years of permitting; for sample buildings the relevant code was ECCCNYS - 2007. However, given the multi-year lag between permitting and construction for commercial buildings, the Team used the NYS code in effect at the time of permitting – ASHRAE 90.1 – 2004 or ASHRAE 90.1 - 2007.

Table 6-1: Commercial and Residential New Construction Energy Code Compliance Rates of Sampled Buildings

Sector	Code Evaluated	Suggested BECP Protocol Compliance Rate – ***Percent of All Code Requirements in Compliance*** (Upper 95% Confidence Level)	RES*check*™ (Residential) and COM*check*™ (Commercial) ***Percent of Buildings that Pass the UA Pass/Fail test***
Residential	ECCCNYS - 2007	73%	61%
Commercial	ASHRAE 90.1 – 2004/2007	85%	36%

6.4.1 New Construction

The Team computed compliance for new construction using the suggested BECP Protocol methodology, and, because the Team was onsite and reviewing plans, used the allowed Trade-Off (e.g. RES*check*™ or COM*check*™) and Simulated Performance (modeling) methodologies. While the suggested BECP Protocol assesses and quantifies the energy code in its entirety, the latter methodologies assess only the *technical aspects of the code.* For example, a RES*check*™ analysis used to assess Trade-Off compliance only looks at the nominal R-value installed for each envelope *component*, whereas the PNNL Checklists[9] quantify the nominal R-value, as well as the *installation quality.* The PNNL Checklists also quantify code requirements not captured by the Trade-Off (e.g. RES*check*™) or Performance methods, such as construction documentation, HVAC sizing calculations, fenestration and recessed lighting infiltration, posted code certificates, etc.

The suggested BECP Protocol assumes that buildings are selected randomly. Because the Team required the cooperation of the code enforcement official and the building owner, it was not possible to fully randomly select samples. Samples likely represent a better-than-average set of buildings. (See Section 2 for a discussion of sampling bias and the Team's efforts to reduce this bias to the extent possible.)

[9] Note: the BECP Checklist has not been finalized, and is undergoing revisions by PNNL under the direction of DOE.

Residential

Current Code Baseline

For the (previous) code baseline (ECCCNYS – 2007), the residential new construction PNNL Checklist compliance rate was 73%: on average, 73% of all code requirements, averaged across all sampled buildings and then using the upper bound of the 95% confidence interval, are in compliance. While this calculation is based on strict adherence to the suggested BECP Protocol, it is an incomplete description of statewide compliance. In fact, ***no*** residential buildings were found to be compliant with over 90% of the ECCCNYS - 2007 code requirements.

Compliance with the ECCCNYS - 2007 using the Trade-Off method (e.g. RES*check*™) and Performance Paths (REM/Rate™) was between 61% and 64%, respectively. (RES*check*™ is used typically to demonstrate compliance, while REM/Rate™ is used primarily to evaluate ENERGY STAR® Homes programs.) In contrast to the PNNL Checklists which capture the energy code in its entirety, these two methods focus solely on the code requirements having a high energy impact. Table 6-2 illustrates the compliance rates for sampled residential buildings as evaluated by these different methodologies.

Table 6-2: Residential Energy Code Compliance Rates

Compliance Path	Compliance Rate
	ECCCNYS - 2007
Suggested BECP Protocol Compliance Rate – ***Percent of All Code Requirements in Compliance with ECCCNYS - 2007*** **(Upper 95% Confidence Level)**	73%
BECP / PNNL Checklists – ***Percent of Buildings with ≥ 90% compliance with all ECCCNYS - 2007***	0%
ECCCNYS - 2007 Trade-Off Path (e.g. RES*check*™)	61%
ECCCNYS - 2007 Performance Path (REM/Rate™)	64%

The high compliance rate using the suggested BECP Protocol reflects the fundamental differences in these methodologies. The suggested BECP Protocol evaluates the *proportion of all energy code requirements* that are in compliance. The Trade-off (RES*check*™) and Performance (REM/Rate™) methods evaluate the *proportion of buildings* that are in compliance. Because the suggested BECP Protocol assesses compliance with the energy code in its entirety, there are more code requirements to get right or wrong. Figure 6-1 demonstrates the proportion of energy code requirements, as weighted points in the PNNL Checklist that are captured by a RES*check*™ compliance certificate versus the remaining code requirements that are not captured by a RES*check*™ compliance certificate. Figure 6-2 shows the proportion of PNNL Checklist items that are designated high (Tier 1), medium (Tier 2) and low (Tier 3) energy impact. All of the code requirements captured by a RES*check*™ compliance certificate are designated as Tier 1 (high energy impact) by the PNNL Checklist. There are, however, many additional Tier 1 code requirements not directly captured by a RES*check*™ compliance certificate (e.g. quality of insulation installation, documentation of construction drawings detailing compliance etc.). These weightings have been thoughtfully considered by BECP and PNNL and, as Figure 6-1 demonstrates, provide more information about a building than does RES*check*™. However, the details behind Figure 6-2 are based on energy use weightings that the Team did not find fully accurate in their reviews.

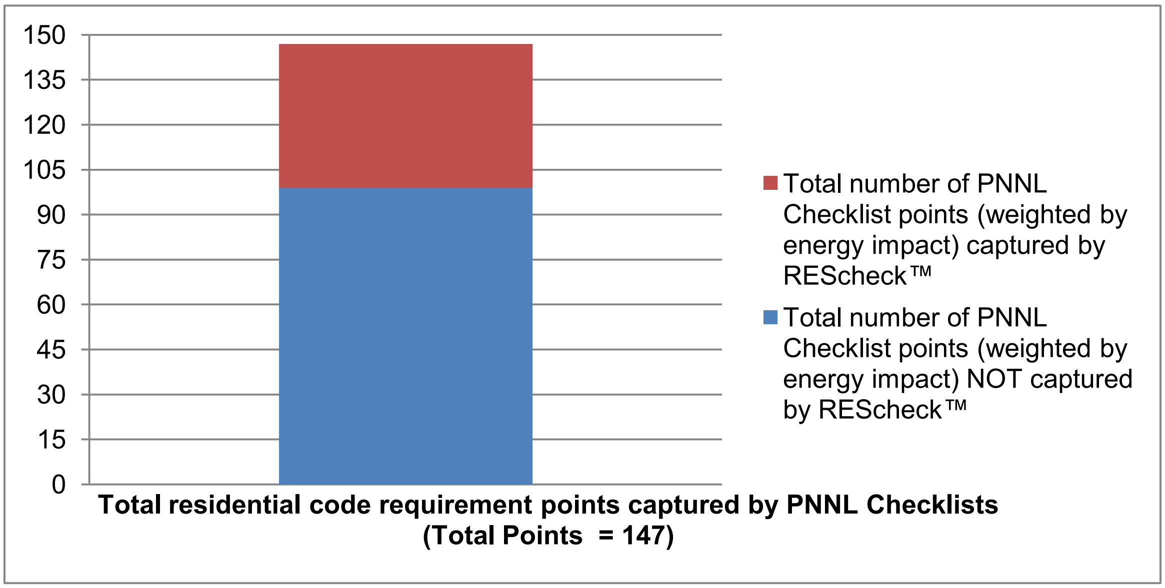

Figure 6-1: Proportion of Energy Code Requirements (PNNL Checklist Points) Captured by RES*check*™

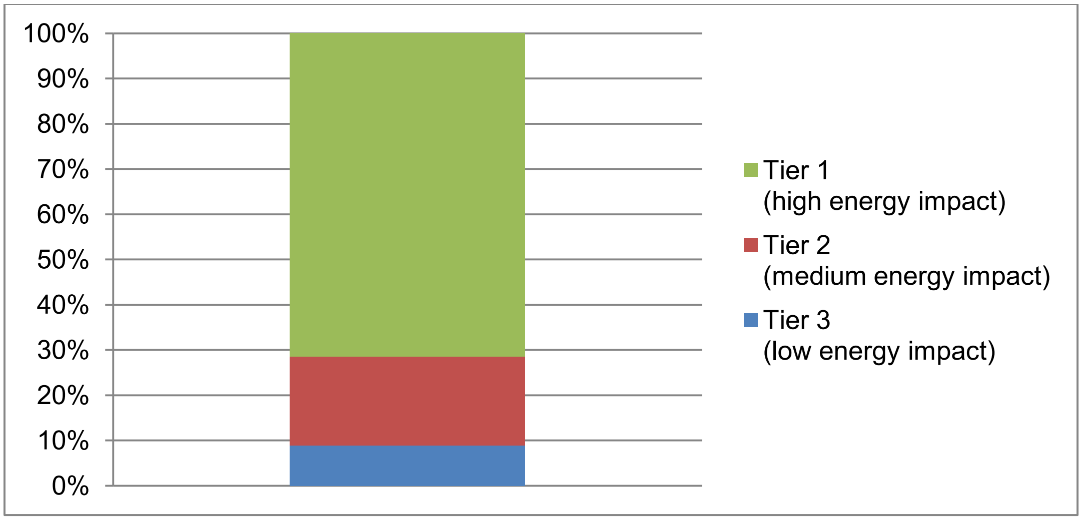

Figure 6-2: Proportion of PNNL Checklist Items by Energy Impact

Looking Forward

Residential compliance was also assessed using the PNNL Checklist based on the current IECC–2009/ ECCCNYS–2010. At 63%, Checklist compliance relative to this code was even lower. Technical compliance using the Trade-Off (e.g. RES*check*™) and Performance methods, 14% and 20%, respectively, was even lower. While this calculation is not a fair reflection of the compliance rate (IECC – 2009/ECCCNYS–2010 was not yet in effect), the measure indicates how much effort must be expended to bring homes into compliance by 2017. These results are summarized in Table 6-3 below.

Table 6-3: Residential Energy Code Compliance Rates – ECCCNYS-2007 vs IECC-2009

Compliance Path	Compliance Rate	
	ECCCNYS - 2007	IECC - 2009
PNNL Checklist (based on suggested BECP Protocol adjusted to ECCCNYS - 2007)	73%	63%
ECCCNYS - 2007 Trade-Off Path (e.g. RES*check*™)	61%	14%
ECCCNYS - 2007 Performance Path	64%	20%

Table 6-4 below summarizes compliance for those building elements that are both more often in compliance and those with lower compliance with both the past and future building codes.

Table 6-4: Compliance Rates of Residential Building Elements for ECCCNYS–2007 and IECC–2009 / ECCCNYS–2010

Higher Compliance	Lower Compliance
• Fenestration • Exterior foundation wall insulation • Duct leakage rates (Climate Zones 5 and 6) • Infiltration rates (Climate Zones 5 and 6) • Mechanical system efficiencies	• Slab insulation • Interior foundation wall insulation (Climate Zone 4) • Above grade wall insulation • Ceiling insulation (Climate Zones 4 and 6) • Insulation installation quality • Infiltration rates (Climate Zone 4) • Duct leakage rates (Climate Zone 4) • Mechanical system sizing • Efficient lighting

While previous codes have permitted relatively high mechanical efficiencies to trade-off against lower thermal envelope values, this is no longer permitted by IECC – 2009 / ECCCNYS – 2010. Thus, reaching 90% compliance will require significant improvement in the building thermal envelope, including the quality of fundamental construction practices.

Commercial

Current Baseline

For the (previous) code baseline for the commercial sector, as applicable to the time of permitting (typically ASHRAE 90.1-2007 or 90.1-2004), the PNNL Checklist compliance rate was 85%. The sampled projects were also evaluated on compliance with the prescriptive efficiency aspects of the applicable codes, including envelope trade-off allowances. The results are shown in Table 6-5.

Table 6-5: Commercial Energy Code Compliance Rates

Compliance Path	Compliance Rate ASHRAE 90.1 – 2004/2007	Compliance Method
PNNL Checklist (based on suggested BECP Protocol adjusted to ASHRAE 90.1 - 2004/2007)	85%	Upper Bound of Confidence Interval
ASHRAE 90.1 – 2004 or ASHRAE 90.1 – 2007 Prescriptive/Trade-Off Method (e.g. COMcheck™)	36%	Pass/Fail Rate

This commercial analysis found a pronounced difference between the use of the suggested BECP Protocol and the Prescriptive/Trade-off (Trade-off) method to evaluate compliance. The suggested BECP Protocol's numeric score includes loss of points for non-compliance with prescriptive and other code elements, while allowing points for both administrative and technical compliance. In contrast, the Trade-off method produces a pass/fail result, resulting in a much lower percentage of compliance. Other differences include the large number of additional commercial technical requirements that are not fully addressed in a prescriptive or trade-off evaluation, such as system control strategies, installation quality, and system testing. The compliance rates using the PNNL Checklist and the Trade-off method vary significantly, as shown in Figure 6-3.

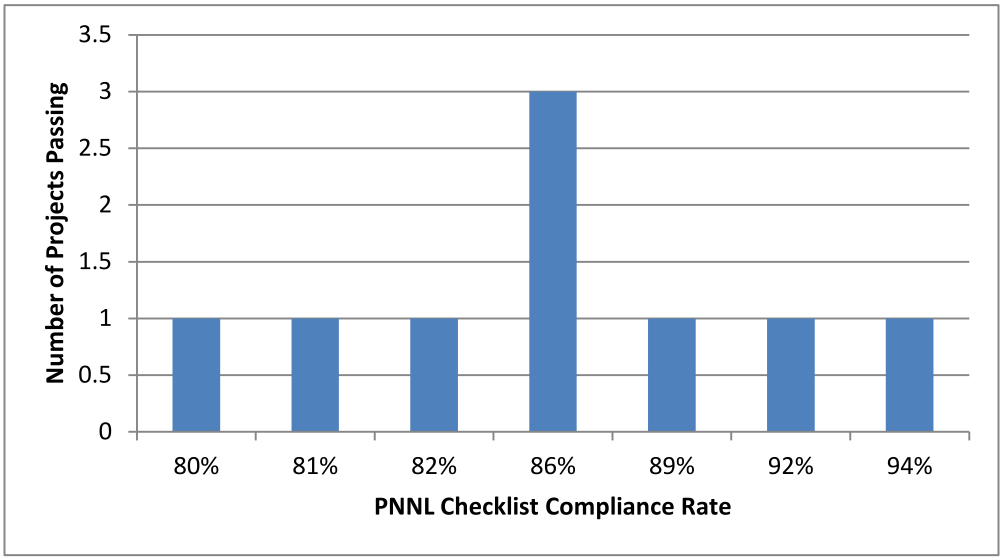

Figure 6-3: Compliance Rates for Projects that Passed under an Rx/Trade-off Analysis Method

Figure 6-4 shows the proportion of energy code requirements, as weighted in points by the PNNL Checklist, that are captured by a COM*check*™ compliance certificate versus the remaining code requirements that are not captured by a COM*check*™ compliance certificate. Figure 6-5 shows the proportion of PNNL Checklist items that are designated high (Tier 1), medium (Tier 2) and low (Tier 3) energy impact.

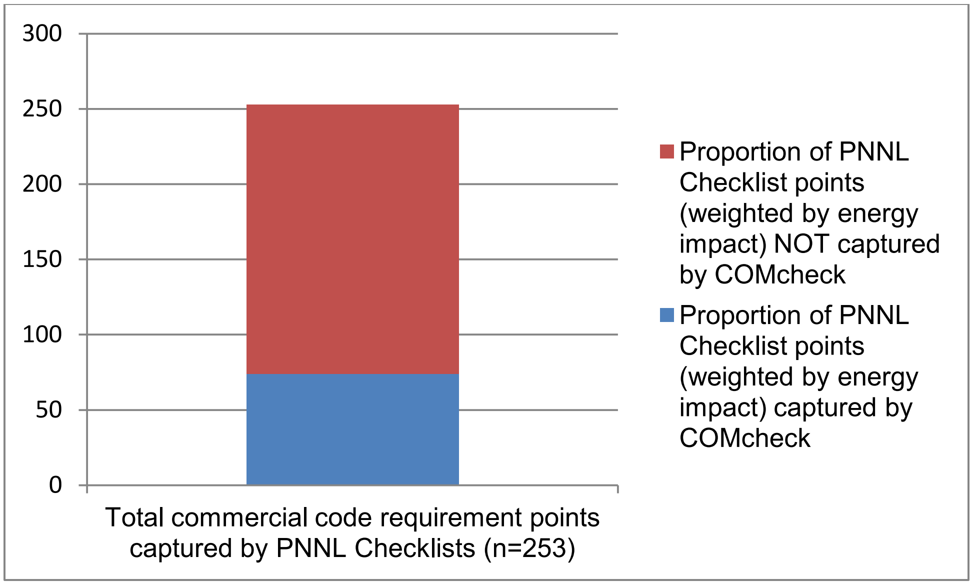

Figure 6-4: Commercial: Proportion of Code Requirements Captured by COM*check*™

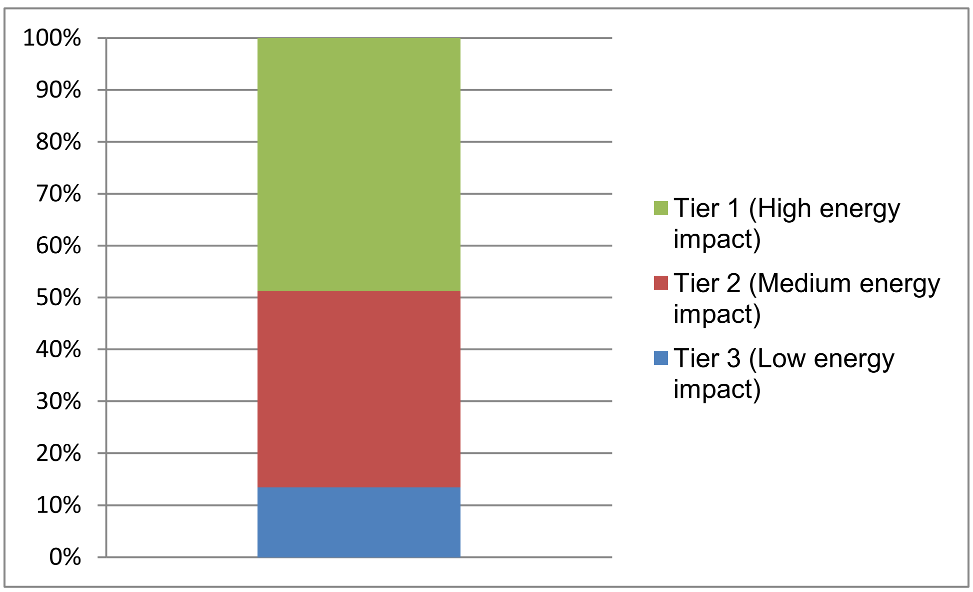

Figure 6-5 Commercial: Proportion of PNNL Checklist Items per Tier

<u>Compliance by Building Size</u>

The suggested BECP Protocol recommends that the sample of commercial buildings be distributed equally within the three main building size strata defined in Section 5.2 (small, medium, and large). The commercial building population for this Study included buildings from each stratum and analyzed the findings by building size as shown in Table 6-6. The small commercial buildings had the lowest compliance rates using the suggested BECP Protocol and Trade-off methods. This size building is often designed or constructed with limited involvement of design professionals who have a significant influence on building efficiency, thereby presenting a significant challenge in improving code compliance.

Table 6-6: Compliance by Commercial Building Size

	Compliance Rate		
	Small **<25k ft^2**	**Medium** **25-60k ft^2**	**Large** **>60k ft^2**
Suggested BECP Protocol	77%	85%	85%
Prescriptive/Trade-Off	0%	64%	39%

Performance Based/Energy Cost Budget Compliance Analysis

In addition to evaluating compliance of commercial buildings using the suggested BECP Protocol and the Trade-off method, the commercial performance evaluation included energy modeling of composite buildings developed to represent a "typical" commercial building in each size stratum using eQuest. [Actual code compliance using building modeling requires a comparison of the design building's estimated energy budget in dollars (not energy units, e.g., MMBtus) versus a code compliant reference building.]

As shown in Table 6-7, these models predict that the composite *small* building will use *more energy* than a code compliant building (the 83% compliance rate indicates that the small building would use 17% more energy than a code compliant building) while the composite *medium* and large buildings will use *less energy* than a code compliant building (shown with a compliance rate above 100%).

Table 6-7: Composite Energy Model Results

	Composite Model "Compliance Rate"[1]		
	Small **<25k sq ft**	**Medium** **25-60k sq ft**	**Large** **>60k sq ft**
Energy Cost Budget (relative to ASHRAE 90.1-2007)	83%	113%	101%

[1]This chart presents the design building energy cost budget divided by the code building energy cost budget

These modeling results differ from the PNNL Checklist and the Trade-off results because modeling does not account for failure to comply with the code's administrative elements, such as submitting required documentation. These results do, however, capture the above code levels of efficiency found in the field. For instance, 55% of the boilers in large commercial buildings were condensing boilers rated above 94% efficiency, while code-required boiler efficiency was 82% or lower. Below-code cooling equipment in large buildings typically served a small fraction of the building load, while the majority of the load was served by equipment that was rated significantly better than the code minimum. Energy modeling is the only means to capture the overall efficiency levels achieved by buildings with efficiencies ranging from 12% worse than code to 68% better than code.

The modeling results indicate that design professionals for medium and large buildings in the survey population are including above-code minimum energy efficiency aspects. There remain, however, significant opportunities to increase code compliance and energy efficiency in buildings of all sizes, as indicated by the PNNL Checklist compliance rates and the failure to incorporate prescriptive code requirements across all building sizes.

6.4.2 Residential Renovations

The 2017 90% compliance requirements also apply to residential renovations. Given the almost total lack of current compliance, achieving 90% compliance for renovations will be a major challenge. Although required, shockingly few projects involving renovations, additions, and installing heating or cooling systems, submit permit applications. As of December 2010, the "50% Rule" that waived compliance requirements if 50% or less of a system was replaced has been eliminated. ECCCNYS - 2010 requires that all components covered by the code that are "touched" by the project meet the energy code.

According to code officials interviewed for this Study, the number of permit-required renovations done each year in New York exceeds the number of new homes constructed. Yet renovation permits constituted just *six percent* of all of the residential permits in the applicable Dodge data set. Where permits for residential renovation are filed, it does not appear that any energy code plan review or enforcement occurs. Via phone interviews, the Team surveyed the few (20) reachable homeowners doing renovations who filed permits; none reported any interaction with code officials regarding energy code requirements***. Reaching 90% compliance for this sector will require more rigorous enforcement of the requirement to submit permit applications and stricter enforcement of the energy code.***

6.4.3 Commercial Renovations

The tracking and enforcement of energy codes in commercial renovations is higher than the residential renovation sector, although the Study did not investigate commercial renovation. In the commercial Dodge data set, commercial renovations comprise 50% of the permits, although these projects are not necessarily accurately tracked. Two of the buildings in the commercial "new construction" sample were in fact renovations; where energy efficiency was addressed, it was only for new equipment, and not for equipment or building envelope elements affected by the renovation. Interviews indicate that many jurisdictions use the same process to review commercial renovations and new construction. The level of compliance with these requirements is not known.

6.5 LOST ENERGY SAVINGS FROM NON-COMPLIANCE

For both sectors, energy modeling was performed to quantify the savings that are lost due to non-compliance with the energy code. Although there are many challenges in accurately predicting savings in all sectors statewide, the lifetime lost energy savings over a five-year building cycle are estimated at a minimum of $1.3 billion, and, depending on a wide range of assumptions, could easily be more. The scale of these estimated savings justifies the recommendations included herein, although developing cost estimates of the recommendations was not included in the project scope. The Team's approximation of a quantification of savings each sector follows.

6.5.1 Residential

<u>Residential Overall Lost Savings</u>

The estimated "lost savings" opportunity for all 44 non-compliant homes visited is approximately 18.6 MMBtus per home: 15.2 MMBtu from below code component efficiency levels, and 3.4 MMBtu due to improper insulation installation. At 2010 fuel prices, this represents an average of $373 of annual lost energy savings per non-compliant home, 8% of the home's total annual energy costs, and, specifically, 14% of the heating and cooling costs. Over the average non-compliant home's 50-year lifetime, this is a cumulative lost savings of more than $18,000 (2011 dollars). Assuming these homes represent the stateside average, and adjusting for the percentage of new homes that are out of compliance (27% to 39%, depending on the evaluation methodology) and the 23% of homes qualified as New York ENERGY STAR® Homes and assumed to be code compliant, this translates into total lost energy savings of approximately $1.2 million annually. Over the 50-year life[10] of the 12,250 single-family and low rise multi-family new homes built annually (average in NYS over the past three years), this totals approximately $58 million cumulative lost savings for each construction year. Assuming similar levels of construction activity and a similar amount of lost savings per home over five years, the 50-year cumulative lost savings from five years of new residential construction would be approximately $300 million.

$300 million is a conservative minimum savings estimate, since it is likely that the homes included in this sample represent a better than average home in New York. Furthermore, absent aggressive efforts to improve compliance, the more challenging requirements of ECCCNYS – 2010 will likely result in even greater non-compliance. Adding the lost savings from all of the renovation not constructed to the energy

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[10] For these calculations, the Team assumed that extensive renovations of the highest residential energy component – the building envelope - occurs approximately every 50 years; for commercial buildings, change-out of some of the highest energy components (including lighting, HVAC, energy recovery and cooling) was assumed to occur every 20 years.

code, the results will be significantly more than the estimated $300 million. The high cost of lost savings justifies the Study's proposed administrative and enforcement changes from design through construction.

<u>Residential Component Lost Savings (New Construction Only)</u>

On a building component level, basement walls, slabs, floors and above grade walls provide the greatest opportunity for reclaiming lost savings. The insulation installation quality analysis also demonstrates the significant savings available simply by ensuring proper installation of insulation materials. While non-compliant basement walls show the greatest opportunity for savings, overall, about 78% of foundation walls are found to be compliant. The largest single category of lost savings – low or no basement wall insulation – occurred most often in Climate Zone 4. This climate zone includes the metropolitan New York City region, where warmer climates and more affluent homeowners have traditionally paid less attention to energy efficiency. After basement walls, the components with the highest lost energy savings are: above-grade exterior walls, frame floors and slab edges. While these provide similar levels of savings, exterior walls are the most critical. The distribution of lost energy savings opportunity by building component is displayed below in Figure 6-6.

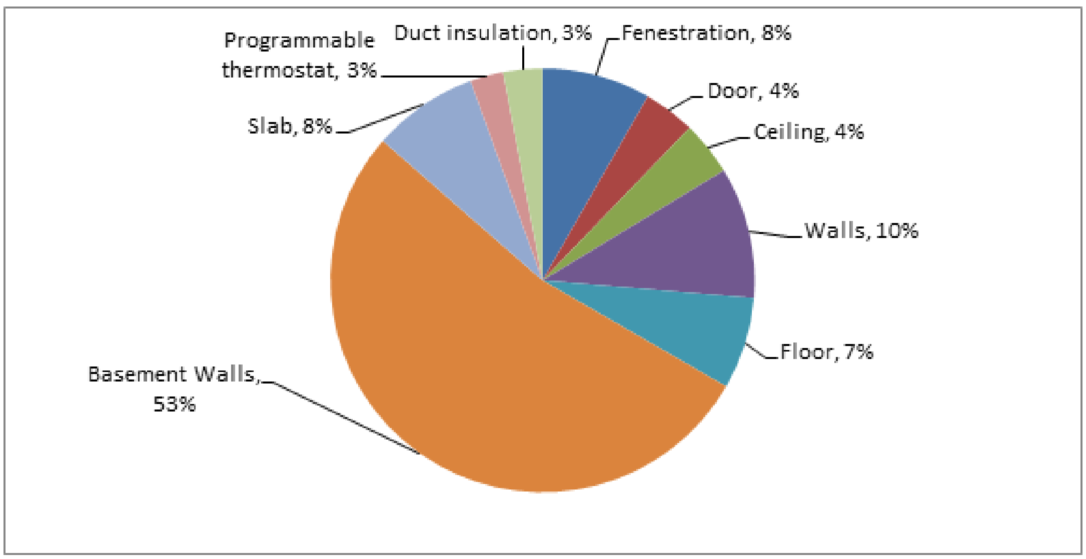

Figure 6-6: Lost Energy Savings Opportunities by Residential Building Component

In addition to the lost energy savings, oversized cooling systems in residential buildings, sized on average for 1.5 tons, could impose an increase in peak demand of more than 7 MWs on the New York electrical grid.

6.5.2 Commercial

Commercial Overall Lost Savings (New Construction Only)

Based on field data and modeling, there is an estimated annual lost savings of $0.10 per square foot in commercial new construction due to non-compliant design and construction. This represents approximately 5% of the annual energy cost of the modeled code compliant building. Over 20 years, the cumulative lost savings for a 50,000 square foot building is estimated to be approximately $100,000 (2011 dollars). Assuming that the modeled buildings reflect average construction practices for all new commercial construction, and adjusting for the 15% of new construction participating in NYSERDA's New Construction Program which is assumed to exceed minimum code requirements, the lost savings for non-compliance of commercial new construction is estimated at over $9.6 million annually. The cumulative 20-year savings for the 2,000 commercial buildings constructed annually (average in NYS for 2008 and 2009) is approximately $960 million.

This $960 million is a conservative (low) estimate and the actual cost to New Yorkers is even greater. Sampled buildings likely represent better-than-average new commercial construction; the more challenging requirements of the ECCCNYS - 2010 will result in even greater non-compliance; and there is an un-quantified amount of renovation work that has not been captured by the Dodge data set.

Commercial Lost Savings by Building System

Commercial building lost savings opportunities occur across the code. Figure 6-7 below shows the relative savings by building component – HVAC (67%), Interior Lighting (23%), and Envelope Efficiency (10%).

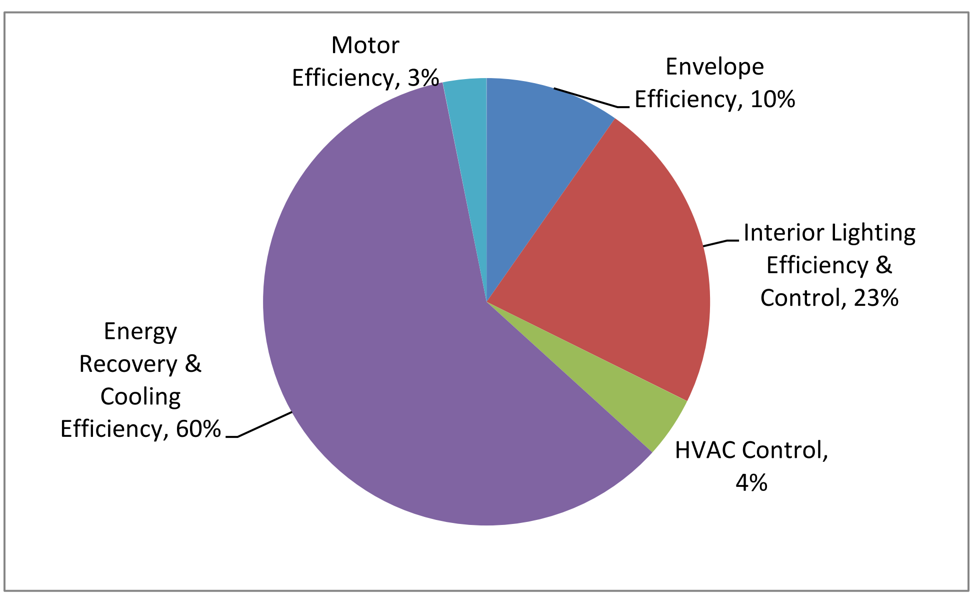

Figure 6-7: Commercial New Construction Lost Savings by End Use

While non-compliance of HVAC control improvements was consistent with the Team's experience, the significant percentage of motors in large commercial construction projects that were not code compliant was surprising, in particular given the regulation of motors under EPACT. In contrast, only a relatively small percentage of packaged HVAC cooling equipment were not compliant. The estimated annual cost of lost HVAC savings is $6.5 million. In addition, savings from over sizing of HVAC equipment, which is not quantitatively regulated by code, is an additional $1.8 million annually

Lighting opportunities exist in three areas – lower lighting power density (interior and exterior), increased control, and use of tandem wired ballasts for one and three lamp fixtures. The Team found little evidence of the use of tandem wired ballasts on site. This measure can reduce energy consumption by one watt for each ballast eliminated and, if applied across the full commercial sector, would have a significant impact. While a significant percentage of spaces had occupancy sensors, the use of code-required automatic lighting control strategies to non-emergency lighting was not found. The value of lost lighting savings is approximately $2.2 million annually.

Because building envelope compliance was difficult to inspect, for most buildings the Team used the design envelope information to determine compliance. This approach likely underestimates the savings associated with improving building envelope design and construction. No blower door testing was performed (a test most appropriate to only smaller facilities). However, based on field experience of the Team, there is an estimated $.94 million in annual lost savings associated with the building envelope and air sealing,

All of the lost savings identified above combine to a 20-yr cumulative sum of approximately $960 million. Twenty years was used because these lost savings, driven primarily by HVAC, lighting systems and building components – the greatest determinants of energy use – have a useful life of 20 years.

<u>Total Savings: Residential plus Commercial,</u>

The Team estimates a total minimum of approximately $1.3 billion in savings ($300+ residential; $960+ million commercial), as shown in Table 6-8. The high cost of lost savings justifies the Study's proposed administrative and enforcement changes from design through construction.

Table 6-8: Lost Savings from New Construction Buildings

	Annual lost savings per building	# New buildings built annually	Annual lost savings for all buildings	Useful life	Cumulative lost savings over 5-year construction cycle
Residential	$373	12,250[1]	$1.2 M	50 years[3]	$300 M
Commercial		2,000[2]	$9.6 M	20 years[4]	$960 M
Total					$1,300 M

[1]Excluding New York ENERGY STAR® Homes
[2]Excluding Commercial New Construction Plan projects
[3]Building envelope is largest determinant of energy use; 50 years
[4]Building components (HVAC, etc.) are largest determinant of energy use; 20 years

6.6 ENFORCEMENT OF CODE COMPLIANCE

Energy requirements are given less attention when compared with other requirements of New York codes – in particular those associated with fire, health and safety, which are considered to have priority. Per discussions with code officials and review of project files, currently available tools and training levels do not support enforcement and are considered by many as beyond code officials' core focus. As energy codes become more complex and demanding through the adoption of new requirements (e.g., blower door and duct leakage testing), code officials' ability to understand and implement these requirements decreases. NYS is addressing the identified need for training through various code-specific programs administered by NYSERDA. The Team emphasizes that surveys reflect this need and recommends that training focus on specific building components noted herein.

In almost all jurisdictions, commercial code enforcement is largely dependent on design professionals representing compliance through submission of stamped drawings as part of permit applications. While COM*check*™ is one of the more common code paths for documenting compliance, COM*check*™ documentation was filed for less than one-third of the sampled commercial buildings. Since New York's energy requirements exceed the elements captured in COM*check*™; proper review in fact includes evaluation of the COM*check*™ documents and plans and specifications.

Neither building specifications nor evidence of review of COM*check*™ or plan submissions were found in code offices. The code administration and enforcement system is even further undermined: design professionals' responsibility for compliance often does not extend beyond the permit submission stage. (Many surveyed design professionals opined that the lack of inspection during construction is one of the largest contributors to non-compliant buildings and that additional auditing of their work would be beneficial.) Enforcement is further diminished through contractors' substitutions for code requirements (e.g. lighting and wall assembly components), often with little or no code coordination since few jurisdictions perform field inspections to match as-built characteristics with approved energy features.

New York City is an excellent example of a jurisdiction that, in fall 2010, moved to tie the plan submission to as-built results by requiring additional information, inspections and certifications through the adoption of local laws that enhance the ECCCNYS-2010 [New York City's energy code, which includes local laws, is the NYC Energy Conservation Code (NYCECC)]. Submitted permit documents for commercial buildings must explicitly document conformance of all specified materials, construction techniques, systems and controls; and identify specific "Progress Inspections" to enable contractors to budget for and schedule these inspections. The requirements for Approved Progress Inspection Agencies, and the role of the "progress inspector" to perform construction phase inspections and certify that the completed building complies with the final submitted building energy analysis, are defined. If the completed building differs from the designed and approved conditions, a design professional must submit a revised energy analysis and certify compliance with the NYCECC.

An evaluation of NYC's initial effort will be completed in mid-2011. NYSERDA and DOS should review the findings from this Study to inform proposed changes to statewide energy code compliance efforts.

Many small commercial, and most residential, buildings lack the involvement of a design professional who can verify code compliance. This absence places a responsibility on code officials to ensure that the energy code is followed. While field checking of residential buildings is increasing (in particular of wall insulation), newer requirements such as air sealing and duct leakage rates are not field verified through performance testing using blower door or duct blaster tests. The complexity of the ECCCNYS – 2010 makes it unlikely that code officials will be able to provide the necessary assistance and verification. Many parties interviewed see a role for third-party verification for all buildings.

If New York elects to rely on design professionals and/or third-party verifiers to determine and document code compliance, local jurisdictions and DOS must provide oversight and enforcement. At a time of funding cuts and shrinking municipal budgets, additional financial support will be needed to support this function.

6.7 FEEDBACK FROM STAKEHOLDERS

With few exceptions, the role of the homeowner in promoting energy efficiency is minimal due to a low knowledge base and their minimal interaction with code officials. The commercial case studies and policy interviews indicate that commercial owners are often only marginally aware of the new energy code requirements. Commercial owners appear to allow their project teams to design and build to a minimum level that often reflects long-standing practices which do not incorporate air and duct sealing, the criticality of insulation at the slab, and, for insulation, required performance or installation protocols.

Many stakeholders indicated that owners do not recognize the value of life-cycle cost assessment, instead focusing on first cost. Most commercial developers will not own the building after it is built, and the "split incentive" issue between developers and condo owners or residential tenants and commercial lessees has not yet been solved by the marketplace. Builders are not motivated to pay strict attention to the energy code because they experience lax enforcement. Only 65% of builders believed that the code official checked the original plans, and 50% believed that the code official conducted on-site inspection of energy-related elements. Only 44% had discussed an energy code concern with a code official. Per evidence discussed in Sections 3, 4 and 5, builders do pay attention to the specific measures that code officials are most likely to focus on.

This Study did not look at the sector of new construction that builds energy efficient buildings, including builders distinguished by participation in the residential New York ENERGY STAR® Homes, NYSERDA's Commercial New Construction Programs, or LEED certification.

Architects requested greater training of all stakeholders, including their own profession. Many architects' assumption that training for builders is uncommon is confirmed by evaluating the targeted audience of NYSERDA's recent energy code trainings (2010, presented by Newport Ventures). Of these programs, 140 sessions were planned for code officials, 25 for contractors and 20 for builders. NYSERDA's experience is that it is difficult to entice contractors and builders to attend trainings. However, without their active participation, projects will continue to be constructed with using outdated and non-compliant construction methods.

Code officials face numerous impediments to performing their enforcement role, including lack of staff and time. Code officials report spending less than 12% of their time on energy code plan review and inspection – a percentage that may be over reported based on findings of the commercial case studies. New York has dedicated an admirable amount of resources to training of code officials, builders, and design professionals. However, the Team is concerned that as energy code requirements continue to increase in complexity and require performance testing, limitations on code officials' time, available tools, and training will limit their enforcement ability without support from outside parties.

6.7.1 Energy Code Policy Expert Interviews

Following completion of the draft study, the Team interviewed the following code experts identified by NYSERDA to gauge their reactions to the Study:

- Deborah Taylor, AIA, LEED AP from New York City Department of Buildings
- Ron Piester, AIA, Director of the Division of Code Enforcement and Administration, New York State Department of State
- Joseph Hill, RA. Assistant Director for Energy Services, Education, and Information Technology, Codes Division New York State Department of State
- Ian Graham, Associate Principal from Viridian Energy & Environmental
- Liza Bowles, President of Newport Ventures, Inc.
- Ed Farrell, Executive Director of the New York State American Institute of Architects
- Mike DeWein, Technical Director from the Building Codes Assistance Project
- Linda Connell, Mark Halverson, and Diana Shankle, Pacific Northwest National Laboratory

Questions asked of these experts covered barriers to code compliance, ideas for increasing compliance rates, differences between residential and commercial construction, design and field issues and opportunities, training, third-party compliance, building ownership vs. rental impacts, local vs. national ownership impacts, economic issues, and carrots versus stick approaches to energy code compliance. These discussions informed the Team's final recommendations.

Among the more salient comments made by interviewees were the following:

- Barriers:
  - Much is driven by the scope of the building project and the construction timeframe.
  - Energy is not a key issue for most builders, with all they have going on in a house.
  - Barriers are different for residential / small commercial (single zone with one lighting system, two stories or less in height) and larger buildings. Also different is whether a building is owner-occupied or has a national-owner. National owners focus on doing a good job. Developer interests are different.
  - Resources are tight. If they are not now inspecting for code, where will resources come from to add separate energy inspections? State budget cuts are reducing number of code officials. Those remaining have more to do without adding additional energy code work. It is improbable that without additional funds, jurisdictions will do the extra work required to meet energy code compliance. Energy is not health and safety and is not a priority for code officials. This is a challenge due to resource constraints.
  - Most jurisdictions, particularly the smaller ones, are totally reliant on architects and engineers to comply with code. Small municipalities tend to have part-time inspectors.

Design professionals should continue to be responsible for covering energy, relieving the jurisdictions from having to acquire the expertise and additional code officials that would be needed if jurisdictions assumed responsibility for energy code enforcement. On the residential side, the code officials seem to be more attuned to existing energy code requirements. While they do not devote the full amount of time needed to ensure every home is in full compliance, the code officials are better able to understand code requirements for residential buildings. Larger municipalities have better ability to understand commercial codes. Small ones will never get there on commercial.

 - These issues are pervasive. There aren't examples of success out there.
 - Biggest barrier is a lack of compliance on renovations since no permits are pulled, typically. Renovations are completely disregarded. Even in NYC, renovations are overlooked. Commercial renovations should be everything given the low new construction rates.
 - Lack of resources for code officials (training, on-the ground training, consumer education and outreach to build demand from consumers, outreach to code officials, building inhabitants) are also barriers.

- Reasons for non-compliance:
  - Code enforcement officials haven't been given the necessary resources, training, time or inclination to go to bat on energy code provisions because they would rather take the builder to task on larger code issues (e.g., egress, electrical, sprinkler, etc.)
  - Combination of knowledge and resources. Code is complicated: unvented attics; open vs. closed cell foams; R-values of foam; how is code official going to 1) understand and 2) inspect for these? These are just examples of some issues. How are they going to inspect cathedral ceilings and know what the R-value of the foam is?
  - From builder standpoint, there are many subcontractors to manage and they may not know all the code pieces. So many interactions and pieces that this becomes challenging.
  - Electrical is hard. HVAC contractors are more likely to know code requirements than other trades so they may know the code better.

- Design/In-Field Relationship:
  - On the design side, there is a disconnect between the design and what happens in the field. A lack of code compliance can be due to construction quality, i.e. when all the pieces comply with the code, but they aren't put together well. Education is a key piece to resolve this.
  - The design professional's responsibility for code compliance normally ends with a signed set of plans. A builder assumes responsibility at that point, using drawings that are

typically not directly connected to energy code submission. New York City now requires that submitted drawings tie directly to plan submission, with every code requirement being explicitly shown on signed drawings.

- New York City requires a design professional/engineer verify that elements included in code plan are installed as planned. If elements are changed, a new energy code plan must be filed. A design professional/engineer must also sign off that all aspects of the code were incorporated in final construction. New York City conducts QA/QC to keep the process honest.

- How to address /removing barriers:
  - Funding: Additional financial resources are needed to enable code officials to be empowered to go after non-compliant contractors.
  - For commercial, reliance on architects and engineers remains the only way to enforce compliance. Making the process more official by requiring signed submission of plans, drawings, and verified installation is suggested.
  - Realizing that there are limited resources for residential projects, the State should provide checklists that prioritize what is really critical to inspect, and Inspectors need to be given a sense of importance of energy code elements.
  - Continual outreach and training of code officials and builder users to build demand. Everyone needs to be engaged.
- Role of third-party verification of energy code compliance:
  - New York's Local Rule laws make it difficult to develop a statewide mandatory process. Creation of a bureaucracy that oversees third-party verifiers will be expensive and unlikely to be legislated. Encouraging local jurisdictions to adopt required sign-offs for drawings and verification of code elements is likely means for encouraging greater compliance.
  - The use of third-party verification should be encouraged, although this may take different forms across state if legislation is not passed. .
  - In Fairfax County, VA a building owner can hire architectural firm that is not the primary design firm. Ways to get the architect/engineer/builder first party to be responsible for energy code, with oversight over them,
  - Code officials will move more towards requiring some third part tests.

- Some parties interviewed strongly support the recommendation to adopt third party verifiers. “This is exactly what needs to happen.” “Code officials just can’t keep up. Without state or municipal money to support code enforcement, it won’t get done. Regardless of how much we train, this won’t get done.”
- The HERS raters are trained and able to spend the time it takes to verify homes. HERS raters are a logical choice for being third-party verifiers.
- Issues exist as to how such an effort could be best integrated with the current code enforcement structure.
- Other interviewees were less enthusiastic about third party verifiers. New York State is considering doing away with third party electrical inspectors due to corruption and other issues. Some feel that other alternatives should be considered, but recognize that budget limitations may be a major stumbling block. Assessing another fee on builders/owners will be very controversial. So will other funding options such as use of SBC funds. In the commercial sector, third party inspection is very important, including commissioning.

- Need to ensure QA system to oversee third parties. Need to keep an eye out for those who cut corners in order to align with what the market is paying.
- Compliance enhancement ideas:
    - Need decent penalties in place to encourage compliance as a less expensive option. Set up some tough enforcement officers to go around the State and shut down projects that do not comply. Withholding occupancy permit is a major stick that can be wielded.
    - The best way to affect the developer or building owner (who is speculatively building the building) would be to produce a monthly report of top 10 and bottom 10 builders. Post with pictures and on public website monthly. Go after the building owner or developer. Pictures and details with top 10 “bone-heads” of the week. Peer pressure can work wonders.
    - If code officials are to continue enforcement, then well-developed simple checklists that line up with key items would help. “Example: if you are in there at this stage of construction, look for X. At this point in the process, look for Y.” Some of these are out there, but aren’t simple enough. Make it more practical based on what’s happening in the field, not from a code perspective.
    - An alternative would be a NYSERDA-funded circuit rider personnel to help code officials.

- Reaction to compliance rate findings:
    - Surprised that compliance came out where it did; thought it would be lower.
- Trainings in New York State on codes:
    - NY has done 150 trainings of 4-5000 attendees. This is going quite well, but code officials have a varying level of interest.
    - The trainings overwhelm code officials with too much information.
    - Inspection training would be useful; train on checklists so they know what to look for.
    - Code officials still need to know about the energy code, even if a third party is involved. They still need knowledge base on what to look for. Not as much "here are the new code requirements," but "here is what's going on in field, this is what to look for at each inspection. When in the field looking at electrical, look for…"
    - On-going training, outreach, coordination with business allies.

6.8 ROADMAP FOR NYSERDA TO ACHIEVE DOE-MANDATED 90% COMPLIANCE BY 2017

NYSERDA plays a critical role in supporting the energy code compliance activities of the DOS, and must continue to collaborate with DOE and PNNL in the development of tools appropriate to New York's needs. In addition, NYSERDA leads the code training and evaluation efforts for all members of the design and construction industry.

The Team has specific recommendations for NYSERDA to ensure achieving the stated goal of 90% by 2017:

1.) Work with DOE and PNNL to define the functionality and mechanics of enhanced COM*check*™ and RES*check*™ software tools. NYSERDA should help define the required checklists, the electronic formats for reporting, the use of electronic signatures and other means for streamlining documentation and reporting that will make these new tools easy to integrate with stakeholder software and databases.

2.) Work with the DOS and stakeholders to establish a third-party market of Energy Specialists (ES)

a.) Develop ES certification procedures, including minimum qualifications, testing requirements, listing and delisting process;

b.) Perform outreach, recruitment, training and testing of ES as needed by DOS;

c.) Develop communications tools for introducing new code enforcement practices to the market and include these in code training; and

d.) Perform stakeholder outreach and obtain input on planned market and enforcement changes.

3.) Work with the DOS to define QA/QC and data tracking systems; identify and garner the necessary resources, and support their implementation. These systems may include:

a.) A centralized database which maintains a project record, complete with all permit filing and energy compliance checklists;

b.) A process to spot-check the success and enforcement of this new protocol through sampling of the records; and

c.) A QA/QC mechanism to ensure the quality and independence of ES.

4.) Integrate the new ES mechanism into the energy efficiency programs serving the new construction market to minimize costs and increase consistency across the market.

5.) Perform interim compliance assessments in partnership with the DOS as outlined in DOE's *Measuring State Energy Code Compliance.* The recommended procedure would rely heavily on electronic record sampling, but also provide for spot-checking by on-site inspections for a small percentage of the sample.

Prior to full implementation of the recommended changes, these assessments can help raise code officials' focus on energy code enforcement requirement and could include:

a.) Surveys of selected jurisdictions to identify rate of COM*check*™ and RES*check*™ document submission at the time of permitting;

b.) Requiring a select segment of code officials to perform spot checking of mid-construction compliance of commercial buildings (given the lengthy construction timeframe of these buildings). NYSERDA should initiate a compliance study by January 2016 to allow for two years (before the end of 2017) to measure commercial compliance.

As this new structure is implemented, NYSERDA should take an active role in developing interim feedback loops. These might include:

a.) Develop surveys to track variables critical to success such as the availability of ES in rural jurisdictions, barriers to ES use, etc.

b.) In cooperation with DOS, set up a means to periodically review database submissions, specifically:

- compare database submissions to other records of construction activity such as the Dodge Database permit filings;
- identify areas of non-conformance for potential additional training and support in non-compliant jurisdictions; and
- perform in-field spot-check QA/QC on electronic sampling for % code compliance.

NYSERDA's active encouragement of the adoption of as many as possible of the above recommendations will result in a cost-effective and accurate roadmap.

Tables 6-9 to 6-10 present the Team's recommended approach to code compliance in New York State. The similarities with the recently launched approach of the New York City Department of Buildings validate the approach and provide the opportunity for greater collaboration. While the state's current administrative and enforcement process would not require significant change, implementing the recommendations would result in at least two new players in the process: the ES and a Statewide QA Code Oversight entity.

Table 6-9: Commercial: NY State Energy Code Roadmap: Proposed Roles & Responsibilities for Players by Building Phase

Player	Role & Responsibilities	Phase		
		Design Phase / Construction Permit	**Interim Construction Inspections**	**Final Inspection**
Commercial [1]				
Design Professional	• Responsible party for all energy code compliance design and compliance documentation	• Completes the ECCP which is stamped and includes plans that address all energy code elements and DDC • Reviews plans and DDC with ES • Submits plans and DDC to Local Code Official	• Responds to findings and questions from ES and others during construction	• If the building design changes during construction, the Design Professional prepares and submits a revised ECCP to document final compliance of building construction with the energy code.
Energy Specialist (ES)	• Hired agent for to verify that energy code design elements are installed • Reports all findings to Owner and Local Code Official • Maintains credentials with State Energy Code QA Entity	• Certifies compliance of ECCP on the DDC • Enrolls project in ECTD	• Completes periodic in-field inspections as required to confirm code compliance • Completes ICIC during construction • Files results to Owner and Local Code Official	• Inspects, tests and prepares FCIC • Files results to Owner and Local Code Official • Uploads final data to ECTD
Local Code Official	• Enforces Energy Code	• Verifies that ECCP documentation has been submitted and signed by Design Professional and ES • Issues building permit	• Flags any energy code issues to ES while on site for other code inspections • Supports ES by enforcing compliance with code items identified on ICICs as non-compliant	• Verifies that the signed FCIC indicates the building is constructed as designed. • Requires, verifies, files updated ECCP if FCIC indicates the building is not as submitted • Issues Certificate of Occupancy • Uploads verification information to ECTD
State Energy Code QA Entity	• Credentialing, oversight, disciplinary actions of ES • Maintenance of ECTD • Reporting and statewide compliance tracking	• Reviews all projects enrolled in ECTD to draw inspection sample • Reviews a sample of DDCs to ensure accuracy	• Performs inspections on sampled projects, comparing ICIC to the project • Reports findings in ECTD	• Performs final inspections on a sample of projects • Reports findings in ECTD

[1] A limited amount of commercial construction, such as projects using prefabricated construction, do not always include a design professions. In these cases, the ES can be retained by the Owner to prepare and submit the ECCP.

Table 6-10: Residential: NY State Energy Code Roadmap: Proposed Roles & Responsibilities for Players by Building Phase

Player	Role & Responsibilities	Phase: Design Phase / Construction Permit	Phase: Interim Construction Inspections	Phase: Final Inspection
Residential				
Builder	Responsible party for all energy code design and compliance documentation	• Reviews plans and DDC (prepared by ES) with ES to prepare for in-field inspections • Submits plans and DDC to Local Code Official	• Responds to findings and questions from ES and others during construction	
Energy Specialist (ES)	• Hired agent for builder to verify that energy code design elements are installed • Must be independent from builder • (Likely to be HERS energy rater) • Reports all findings to Builder and Local Code Official • Maintains credentials with State Energy Code QA Entity	• Reviews building plans and specs • Performs any necessary modeling and/or completion of DDC • Enrolls project in ECTD	• Completes periodic in-field inspections as required to confirm code compliance • Completes ICIC during construction • Files results to Builder and Local Code Official	• Inspects, tests and prepares FCIC • Files results to Builder and Local Code Official • Uploads final data to ECTD
Local Code Official	• Enforces Energy Code	• Verifies that DDC meets energy code requirements • Issues building permit	• Flags any energy code issues to ES while on site for other code inspections	• Verifies that the signed FCIC indicates the building is constructed to code. • Issues CO • Uploads verification information to ECTD
State Energy Code QA Entity	• Credentialing, oversight, and any necessary disciplinary actions of ES • Maintenance ECTD • Reporting and statewide compliance tracking	• Reviews all projects enrolled in ECTD to draw inspection sample • Reviews a sample of DDCs to ensure accuracy	• Performs inspections on a sample of projects, while comparing ICIC to the project • Reports findings in ECTD	• Performs final inspections on a sample of projects • Reports findings in ECTD

Table 6-11: Roadmap Acronyms

Acronym	Description	Notes
ES	Energy Specialist	Separate credentials and certifications for residential and commercial
DDC	Design Documentation Checklist	Differs for residential and commercial: combination of COM*check*/PNNL Commercial Compliance Checklist for commercial and RES*check*/PNNL Residential Compliance Checklist for residential. Software vendors (for EQuest, REM/Rate, TREAT, etc.) may incorporate DDC, ICIC and FCIC checklists with software to make use easier for Energy Specialists.
ICIC	Interim Construction Inspection Checklist	Differs for residential and commercial
FCIC	Final Construction Inspection Checklist	Differs for residential and commercial
ECTD	Energy Code Tracking Database	Statewide web-based tool accessible by ES and Local Code Officials maintained by Statewide Energy Code QA Entity
ECCP	Energy Code Compliance Plan	A complete building permit submissions including plans, specifications, COM or RES*check*, the DDC, ICIC and FCIC for the project with signatures and stamps by the responsible professional.

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APPENDIX A: FINAL RESIDENTIAL SAMPLE

County	Place Name	1-Fam	2-unit	3/4-unit	5+ units	Total	Number of Sites	Dodge Site	Dodge County
Albany County	Colonie town	150	0	0	1	151	1	Y	
Bronx County 1	Bronx borough	223	89	111	102	525	1	Y	
Broome County	Vestal town	120	0	0	1	121	1	N	N
Clinton County	Au Sable town	170	2	4	0	176	1	N	N
Dutchess County	Fishkill town	278	0	0	4	282	2	N	Y
Erie County	West Seneca town	261	0	0	6	267	2	N	Y
Erie County	Boston town	23	0	0	0	23	1	N	Y
Erie County	Lancaster town	270	2	0	0	272	1	Y	
Erie County	Orchard Park town	94	0	0	4	98	1	Y	
Jefferson County	Jefferson County Part Unincorporated Area	631	1	0	0	632	1	N	N
Kings County 1	Brooklyn borough	1	234	198	485	918	1	Y	
Madison County	Canastota village	30	0	0	0	30	1	N	N
Monroe County	Chili town	118	0	18	15	151	1	N	Y
Monroe County	Greece town	238	0	0	0	238	1	Y	
Monroe County	Pittsford town	54	0	0	0	54	1	Y	
Monroe County	Webster village	79	8	17	0	104	1	Y	
Oneida County	Ava town	200	0	2	0	202	1	N	N
Oneida County	New Hartford town	201	3	3	0	207	1	N	N
Onondaga County	Lysander town	123	0	0	7	130	1	Y	
Onondaga County	Van Buren town	76	0	0	0	76	1	N	Y
Orange County	Kiryas Joel village	5	1	4	27	37	1	N	Y
Orange County	Montgomery town	9	2	0	0	11	1	Y	
Oswego County	Constantia town	11	0	0	0	11	1	N	N
Queens County Total 3	Queens borough	264	500	171	230	1165	3	Y	
Richmond County	Staten Island borough	315	282	2	39	638	2	Y	
Rockland County	Ramapo town	190	2	0	2	194	1	N	Y
Saratoga County	Clifton Park town	87	0	0	0	87	1	Y	
Saratoga County	Halfmoon town	254	0	1	14	269	1	Y	
Steuben County	Addison village	78	1	0	0	79	1	N	N
Steuben County	West Union town	85	0	0	0	85	1	N	N
Suffolk County	Brookhaven town	329	0	0	0	329	2	Y	
Suffolk County	Huntington town	148	0	0	0	148	2	Y	
Suffolk County	Smithtown town	110	0	0	13	123	1	Y	
Sullivan County	Fallsburg town	168	23	2	0	193	1	N	N
Ulster County	Wawarsing town	58	10	0	1	69	1	N	N
Warren County	Warren County Part Unincorporated Area	248	1	4	0	253	1	Y	
Washington County	Washington County Part Unincorporated Area	206	1	0	0	207	1	N	N
Total							44		

APPENDIC B: RESIDENTIAL RECRUITMENT LETTER

January, 2011

Dear Homeowner:

The New York State Energy Research and Development Authority (NYSERDA) is conducting an evaluation of energy efficiency of homes constructed throughout New York State over the past three years. Your home has been randomly selected from a small qualifying list for this evaluation and we would *greatly appreciate your participation* in this important research study. NYSERDA is offering **$100.00** to homeowners who participate in the study. We will provide you this $100 in the form of an American Express gift card at the completion of the research visit.

This evaluation is being conducted to fulfill a portion of the American Recovery and Reinvestment Act (ARRA) requiring the State of New York to meet high standards of energy efficiency for new construction building practices by the year 2017. To meet this future milestone, NYSERDA is gathering information on the level of energy efficiency of recently built homes and major renovation projects. NYSERDA will use the information collected at your home to support the design and construction industries' efforts in energy efficiency improvements.

NYSERDA has contracted with a team of independent research firms to complete this evaluation, which will include an on–site inspection of your home. **A representative from the company of Conservation Services Group (CSG) will contact you soon to schedule a site visit at your convenience. Alternatively, to originate your participation in this program, you may call CSG at 1-877-741-4312. There are limited appointments available to you on a first come first serve basis so call CSG soon to schedule your appointment.**

Information collected from your home will be confidential. Only summary data will be used and no specific homes or owners will be identified. The information collected at your home will be used solely to assess the energy efficiency of your home when constructed; no individuals or firms will be evaluated. We look forward to working with you on this important research effort. Thank you in advance for your interest and cooperation.

Sincerely,

Marilyn E. Kaplan, RA, FAPT
NYSERDA Project Manager

APPENDIX C: COMMERCIAL RECRUITMENT LETTERS AND RECRUITMENT SCRIPT

<Month, Day, Year>

<Participant Name and Address>

Dear <Name of Participant>:

The New York State Energy Research and Development Authority (NYSERDA) is conducting an evaluation of the energy efficiency of new construction projects throughout New York State over the past three years. The <Project Name> project for <"your company"> has been randomly selected for this evaluation, and we would greatly appreciate your participation in this important study. NYSERDA is offering a $150.00 for companies that participate in this research.

The study is being conducted to fulfill the American Recovery and Reinvestment Act (ARRA) funding prerequisite that the State of New York must meet energy efficiency requirements of new construction building practices by the year 2017. NYSERDA is gathering information on the current levels of energy efficiency to support the design and construction industries' efforts in meeting this future milestone.

NYSERDA has contracted with Cx Associates, an independent research firm, to complete this evaluation. The evaluation work will include one time, on–site inspections of the selected buildings and interviews with design firms practicing in New York State. An engineer from Cx Associates will be contacting you shortly to schedule a site visit at your convenience.

NYSERDA and Cx Associates will keep your project information private. *We are not evaluating individuals, buildings or firms.* The information collected will be used solely to assess the current state of energy efficiency in the market, with project findings used only in summary data.

Should you have any questions about this study or would like to schedule this site visit, please contact Eveline Killian of Cx Associates at 1-802-861-2715 x-15 or Eveline@cx-assoc.com. If you prefer to speak with a NYSERDA representative, feel free to contact me at 518-862-1090 x3298 or mek@nyserda.org.

We look forward to working with you on this important research effort. Thank you, in advance, for your interest and cooperation.

Sincerely,
Marilyn Kaplan
NYSERDA Project Manager

Dear Code Official:

In order to comply with the American Recovery and Reinvestment Act (ARRA) funding building energy efficiency prerequisite, the New York State Energy Research and Development Authority (NYSERDA) is conducting an evaluation of the energy efficiency of new construction projects throughout New York State over the past three years. A few projects in your jurisdiction have been randomly selected for this evaluation, and we would greatly appreciate your support in this important study.

This is not an evaluation of individuals, buildings or firms. The information collected will be used solely to assess the current state of energy efficiency in the market, with project findings used only in summary data. Information gathered from these building will form a database of information to create an "average" building across the commercial sector. No persons, firms or specific buildings will be individually evaluated on code compliance. This evaluation is to support the design and construction industries' efforts in meeting the ARRA funding prerequisite that the State of New York meet energy efficiency requirements of new construction building practices by the year 2017. Building data will not be used to identify individual deficiencies to be corrected by the owner.

NYSERDA has contracted with Cx Associates and Buro Happold, two independent research firms, to complete this evaluation. The evaluation work will include a one time, on–site inspection of the selected buildings and a review of the plans submitted to your office. An engineer from Cx Associates or Buro Happold will be contacting you shortly to schedule an office visit at your convenience.

NYSERDA, Cx Associates and Buro Happold will keep your project information private. Again, *this is not an evaluation of individuals, buildings or firms.* The information collected will be used only in summary of state-wide data intended to improve the state's support of New York State building codes, standards and construction.

Should you have any questions about this study or would like to schedule this office visit, please contact Eveline Killian of Cx Associates at 1-802-861-2715 x-15 or Eveline@cx-assoc.com. If you prefer to speak with a NYSERDA representative, feel free to contact Marilyn Kaplan at 518-862-1090 x3298 or mek@nyserda.org.

Thank you, in advance, for your interest and cooperation.

Sincerely,

Department of State – Energy Services

NEW YORK STATE CODE COMPLIANCE VERIFICATION OUTREACH INTRODUCTION

nterviewer Name and Firm:

Participant Name:

Firm Name:

Outreach Date:

Phone Number:

Project Name:

Project Number:

Hello, my name is ____________________ and I'm calling from ___________ on behalf of the New York State Energy Research and Development Authority (NYSERDA).

Our firm is conducting research for NYSERDA on the efficiency levels of new construction and to improve services to the new construction market. The [Project Name] project for [Owner Name] is one of a small group of projects that has been selected for this evaluation and we would greatly appreciate your participation in this important study. NYSERDA sent you a letter recently telling you that we would be calling and explaining the research we are doing.

As an independent research firm, __________ will not report your responses in any way that would reveal your identity or the identity of your organization. The research will be used solely to assess the current state of the market in general and will in no way be used to evaluate the practices of any individual firms in the state. The project findings will use only summary data and will not identify individual projects or firms

I have you listed as the contact for the new construction project at **[Project name and location].**

1. Are you the most appropriate person to talk to about this project?

   - ☐ YES ➔ proceed
   - ☐ NO ➔ "May I ask who would be the best person to talk to?" **[Obtain title, name, phone number, email address]**

     ____

     Title *Name* *Phone* *Email*

   - ☐ DOES NOT REMEMBER PROJECT ➔ "Is there someone else there who may be able to provide information regarding this project?" **[Obtain title, name, phone number, email address]**

     ____

     Title *Name* *Phone* *Email*

2. Has this building been sold, or is it tenant occupied?

   - ☐ YES ➔ **[Obtain information on the appropriate contacts and constraints. For buildings that have been sold we have to talk with the new owner to obtain access. For tenanted buildings there are a variety of conditions with which the review engineers will have to contend.]**
   - ☐ **[Obtain title, name, phone number, email address for additional contacts]**

     ____

     Title *Name* *Phone* *Email*

   - ☐ **[Obtain title, name, phone number, email address for additional contacts]**

____

Title *Name* *Phone* *Email*

☐ **[Obtain title, name, phone number, email address for additional contacts]**

____

Title *Name* *Phone* *Email*

3. A sitevisit will take approximately 3-4 hours in which we would like access to the mechanical and electrical rooms, but which otherwise can be unsupervised if it is your preference. Can we schedule a time when we may come out and walk through your building?

☐ YES ➔ **[Date:_____________________ Time: ____________________]**

☐ NO ➔ **[Next Steps:____]**

4. Who is the person we should meet at the site?

Name: ____

Email: ____

Telephone: ______________________________________

Thank you very much for your time in talking with me today. We look forward to meeting you/your staff and we thank you for your participation in this study.

[If they express hesitation, use an appropriate combination of the following.]

Security. All information obtained in this evaluation will be strictly confidential.

Sales concern. I am not selling anything. I simply want to understand the energy efficiency levels of your building.

Contact. If you would like to talk with someone from NYSERDA about this effort, you can call

NYSERDA Project Manager: Marilyn Kaplan 518-862-1090

[Please document contacts and save hard and/or electronic copies of outreach results. Log in contacts database as appropriate.]

APPENDIX D: RECRUITMENT EMAIL FOR CODE OFFICIAL SURVEY

March 1, 2011

ALERT: ACTION REQUIRED – please click the link to complete the survey identified below.

Dear Code Enforcement Official:

The New York State Energy Research and Development Authority (NYSERDA), in conjunction with the New York State Department of State, is in the final stages of conducting an evaluation survey of the energy efficiency of construction projects throughout the state of New York, in order to establish a baseline compliance level for the past three years. The federal American Recovery and Reinvestment Act of 2009 (ARRA) requires NYS to develop a plan to achieve compliance with the newly adopted Energy Conservation Construction Code of New York State-2010 (ECCCNYS) in at least 90% of new construction and renovation projects by the year 2017. ARRA and recent changes in the New York State Energy Law oblige of municipalities to participate in compliance with ARRA and the required evaluations. Specifically, § 11-110 of the Energy Law requires municipalities to report, cooperate, and assist the Secretary of State as deemed necessary.

As part of this last project phase, we are asking that code officials take part in an on-line survey regarding permitting and energy efficiency of residential projects in your jurisdiction. ***This is not an evaluation of individuals, buildings or firms and data will not be used to identify individual or project deficiencies to be corrected, and all information will be kept confidential.*** The survey information collected will be used solely to assess the current level of energy efficiency in the state, with project findings used only in summary data. Collected information will form a database to create an "average" building across the residential sector and to support the state's efforts to increase the energy efficiency of construction projects.

The survey will take approximately 15 minutes to complete and we greatly appreciate your participation and support in this effort. If you have questions regarding the evaluation process, please contact Joseph Hill at Department of State (518-474-4073; Joseph.Hill@dos.state.ny.us) .

Thank you in advance for your interest and cooperation.

Sincerely:

Ronald E. Piester, AIA, Director
Division of Code Enforcement and Administration

APPENDIX E: CODE OFFICIAL WEB SURVEY

NYSERDA Code Official Email Survey
The New York State Energy Research and Development Authority (NYSERDA) is conducting a study regarding New York State codes. NYSERDA is interested in receiving feedback from code officials about current and future code inspection and compliance issues and interaction with builders and other trade allies. Your input is important. Please complete the following survey to the fullest, your responses will be kept strictly confidential and will be used for analytical purposes only. This survey should require approximately 12 to 15 minutes of your time to complete. We appreciate your participation, as it is critical to NY State continuing to receive Federal funding. Remember; this anonymous survey will be aggregated into a summary of general feedback to the New York State Energy Research and Development Authority (NYSERDA). This survey is not intended to be an evaluation of any individual's performance, and no information provided by any one individual will be reported to either NYSERDA or NY State Administration.

Are you currently active in energy code enforcement services for a municipality or other code jurisdiction within New York State?
Yes
No

If no, could you please provide the name and e-mail contact of the professional who currently has this responsibility
Name
E-mail contact

In which of the following energy code activities do you personally participate?
Manage or supervise staff who do Plan Check/Reviews
Residential Building Plan Check/Reviews
Commercial Building Plan Check/Reviews
Manage or supervise Field Inspection Staff
Conducting Residential Field Inspections
Conducting Commercial Field Inspections
None of the above

In what jurisdiction do you provide services? {If more than one applies, please identify the jurisdiction where you are most actively involved}

For your jurisdiction, who conducts plan reviews for energy code compliance? {Please choose all the answers that apply to your jurisdiction}
Me
Other in-house staff
Outside consultants or company
Other jurisdictions or government agencies
Not done
Don't know

For your jurisdiction who conducts field inspections for energy code compliance? {Please choose all of the answers that apply to your jurisdiction}
Me
Other in-house staff
Outside consultants or company
Other jurisdictions or government agencies
Not done
Don't know

Which of the following best describes the level of training you have received for reviewing building plans and enforcing energy codes?

I have professional certification by NY Department of State, ICC or similar credentialing and I receive annual training on the energy code.
I attend periodic training on the energy code (1 time approximately every two years)
I have on-the-job training on the energy code but little or no formal training
I have neither formal energy codes training nor on-the-job training
Don't Know

Have you attended any training focused on the new 2010 New York State Energy Code?
Yes
No
Don't Know

Please respond to the following as it pertains to any staff you might have.
Which of the following best describes the level of training your staff has received for reviewing and enforcing energy codes? {Please choose the one response that best describes your staff's level of training}
Professional certification by NY Department of State, ICC or similar credentialing and they receive annual training on the energy code
They attend periodic training on the energy code (1 time every other year)
They have on-the-job training on the energy code but little to no formal training
There have neither formal energy codes training now on-the-job training
Don't know
Don't have any staff other than me

Has your staff attended any training specifically focused on the new 2010 New York State Energy Code?
Yes
No
Don't know

You indicated that you serve both residential and commercial properties. In order to shorten the survey for you, we ask you to choose the sector that you deal with most often. Do you primarily focus on residential or commercial properties?
Residential - For the rest of this survey, we will only be asking you the questions about residential buildings you work on.
Commercial - For the rest of this survey, we will only be asking you the questions about commercial buildings you work on.
Both the same - For the rest of this survey, we will only be asking you the questions about commercial buildings you work on.
Don't know - For the rest of this survey, we will only be asking you the questions about commercial buildings you work on.

For a typical residential building built in your jurisdiction, how much time in hours is devoted to the average plan review including energy and all other code requirements?
Less than 1/2 hour
1/2 to 1 hour
1 hour to 2 hours
3 hours to 4 hours
5 to 8 hours
9 to 16 hours
More than 16 hours
Don't know

For a typical residential building in your jurisdiction, what percentage of the time doing plan review is spent on energy code requirements?
Less than 5%
5-9%
10-14%

15-19%
20-24%
25-29%
More than 29%
Don't know

To document energy code compliance in residential buildings, over the last 2 years in your jurisdiction, what percentage of the time do builders use a prescriptive approach, what percentage of the time do builders use a trade-off approach including REScheck, and what percentage of the time do they use a performance approach?
Prescriptive
Trade-Off
Performance
Don't know
Total

For the typical residential building in your jurisdiction, how much time in hours is devoted to the average field inspection, including all inspections by all your staff and outside contractors?
Less than 1/2 hour
1/2 to 1 hour
1 to 2 hours
3 to 4 hours
5 to 8 hours
9 to 16 hours
More than 16 hours
Don't know
Refused

For the typical residential building in your jurisdiction, what percentage of the time doing field inspection is spent on energy code requirements?
Less than 5%
5-9%
10-14%
15-19%
20-24%
24-29%
More than 29%
Don't know
Refused

For the typical commercial building in your jurisdiction, how much time in hours is devoted to the average plan review by your staff and outside contractors?
Less than 1/2 hour
1/2 to 1 hour
1 to 2 hours
3 to 4 hours
5 to 8 hours
9 to 16 hours
17 to 24 hours
25 to 32 hours
More than 4 days
Don't know

For a typical commercial building in your jurisdiction, what percentage of the time doing plan review is spent on energy code requirements?
Less than 5%

5-9%
10-14%
15-19%
20-24%
25-29%
More than 29%
Don't know

To document energy code compliance in commercial buildings, over the last 2 years in your jurisdiction, what percentage of the time do builders use a prescriptive approach, what percentage of the time do builders use a trade-off approach including COMcheck, and what percentage of the time do they use a performance approach?
Prescriptive
Trade-off
Performance
Don't know
Total

For the typical commercial building in your jurisdiction, how much time in hours is devoted to the average field inspection including staff and outside contractors?
Less than 1/2 hour
1/2 hour to 1 hour
1 hour to 2 hours
3 hours to 4 hours
5 hours to 8 hours
9 hours to 16 hours
17 hours to 24 hours
25 hours to 32 hours
More than 4 days
Don't know

For the typical commercial building in your jurisdiction, what percentage of the time doing field inspection is spent on energy code requirements?
Less than 5%
5 - 9%
10 - 14%
15 - 19%
20 - 24%
24 - 29%
More than 29%
Don't know

What major issues impede your ability to enforce the energy code in residential buildings?

What major issues impede your ability to enforce the energy code in commercial buildings?

For residential buildings, in what percentage of units:
Do you conduct field inspections during rough-in or when insulation is visible?
Does your agency and its representatives check whether the envelope sealing (infiltration) meets the energy code?
Does your agency check whether the fenestration specification meets the energy code?
Does your agency do field tests to check whether the duct sealing meets the energy code?
Does your agency check whether the duct insulation meets the energy code?
Does your agency check whether the pipe insulation meets the energy code?
Does your agency check whether the lighting fixtures meet the energy code?
Does your agency check whether the mechanical system efficiencies meet the energy code?
Does your agency check whether the HVAC heat load calculations meet the energy code?

For the homes you verify, how regularly does your plan review and/or field inspection uncover non-compliance for the following:

Envelope Insulation Levels or Quality of Insulation Installation
Envelope Sealing (infiltration)
Fenestration Specification
Duct Sealing
Duct Insulation
Pipe Insulation
Lighting Fixtures
Mechanical System Efficiencies
HVAC Heat Load Calculations

For commercial buildings in what percentage of buildings does your agency check whether the following meets energy code?

Envelope and fenestration details
Mechanical System Components and Heat Load Calculations
Piping and Duct Sealing and Insulation
Hot Water System Efficiencies
Heat Load Calculations
Lighting LPD Calculations
Lighting Fixtures and Controls
Exterior Lighting Specifications
Infiltration Requirements

For commercial buildings, how regularly does your plan review and/or field inspection uncover non-compliance for the following:

Envelope and fenestration details in the buildings you verify?
Mechanical system components and heat load calculations in the buildings you verify?
Piping and duct sealing and insulation in the buildings you verify?
Hot water system efficiencies in the buildings you verify?
Heat load calculations in the buildings you verify?
Lighting LPD calculations in the buildings you verify?
Lighting fixtures and controls in the buildings you verify?
Exterior lighting specifications in the buildings you verify?
Infiltration requirements in the buildings you verify?

APPENDIX F: BUILDER TELEPHONE SURVEY

NYSERDA Code Telephone Survey Instrument

Hello, my name is ________________________. I am calling from CSG, on behalf of the New York State Energy Research and Development Authority (NYSERDA). This is not a sales call. We are conducting a study regarding New York State design and construction practices. We are interested in receiving feedback from contractors about their construction practices and interaction with code officials.

Are you the appropriate person to discuss issues related to the energy efficiency decisions and equipment made on projects you company has been involved in within New York State?
[IF YES CONTINUE]
[IF NO] Can you provide me with a contact name and phone number for a person who can speak to energy-efficiency design and equipment issues at your organization? [*SEE SPACE BELOW FOR NAME AND NUMBER]*
[ONCE CORRECT PERSON IS ON THE LINE, REINTRODUCE AND CONTINUE.]

a) YES – *CONTINUE WITH RESPONDENT*
b) NO – *NEW RESPONDENT COMING TO PHONE [REINTRODUCE YOURSELF]*
c) NO – *RESPONDENT NOT AVAILABLE [SCHEDULE CALLBACK]*
d) REFUSED **[***THANK AND TERMINATE***]**

Screener

S1. I am calling to ask questions about energy codes and how they affect the buildings you build. Has your firm built any new residential or non-residential buildings in New York State in the last two years?

a) Yes *CONTINUE*
b) No *THANK AND TERMINATE*
c) Don't know *THANK AND TERMINATE*
d) Refused *THANK AND TERMINATE*

S2. What type of buildings have you built *[Read list, Accept multiple answers]*

a) Single family detached or attached buildings *[If only 1 response set Res/nonres to "res" and Hometype to 'single-family']*
b) Multi-family buildings (5 or more units) *[If only 1 response set Res/nonres to "nonres" and Hometype to 'multi-family']*
c) Non-residential commercial, industrial, or governmental buildings *[If only 1 response set Res/nonres to "nonres" and Hometype to 'non-residential']*
d) No activity *THANK AND TERMINATE*
e) Don't know *[ask to pick one and if not THANK AND TERMINATE]*
f) Refused *THANK AND TERMINATE*

[If multiple answers to S2 ask]
S3. In the last two years in New York State, which type of building has your firm built most often? [Select only 1 answer]

a) Single family detached or attached buildings *[set Res/nonres to "res" and Hometype to 'single-family']*
b) Multi-family buildings (5 or more units) *[set Res/nonres to "nonres" and Hometype to 'multi-family']*
c) Non-residential commercial, industrial, or governmental buildings *[set Res/nonres to "nonres" and Hometype to 'non-residential']*
d) Don't know *[ask to pick one]*

[If Res/nonres= 'res' ask, otherwise skip to S4a]
S4. If you know, in the last two years, have you participated in NYSERDA's or LIPA's New York ENERGY STAR Labeled Homes Program?

a) Yes
b) No
c) Don't know
d) Refused

[If Res/nonres= 'nonres' ask, otherwise skip to S5]
S4a. If you know, in the last two years, have you participated in LIPA's or NYSERDA's Non-Residential New Construction Program?

a) Yes
b) No
c) Don't know
d) Refused

General Questions

S5. For the next set of questions please think of all of the [Housetype] buildings you have built in New York in the last two years. How many [Housetype] projects did you build or are in the process of building?

a) Record number
b) Don't know
c) Refused

S6. In what jurisdiction or jurisdictions have you had the most activity building [HouseType] buildings?

a) Record number
b) Don't know
c) Refused

S7. Over the last two years have you built [Housetype] buildings under the [if res/nonres =res say "NY2004"; if res/nonres = nonres say "ASHRAE 90.1 2003"] energy code?

a) Yes
b) No
c) Don't know
d) Refused

[if res/nonres =res ask]
S8. Over the last two years have you built [Housetype] buildings under the NY2007 energy code?

a) Yes
b) No
c) Don't know
d) Refused

S9. Over the last two years have you built [Housetype] buildings under the new energy code [if res/nonres =res say "NY2010"; if res/nonres = nonres say "ASHRAE 90.1 2007"]?

a) Yes
b) No
c) Don't know
d) Refused

Interaction with Code Officials

I1. Thinking again of all the [Housetype] buildings you have built in New York over the last two years. When you submitted your plans to your permitting agency, did they discuss with you any of the building elements covered by the relevant energy code?

a) Yes
b) No
c) Don't know
d) Refused

There are different ways that you may have dealt with code officials over the last two years. Thinking of your interaction with code officials, please tell us how often such an interaction occurred.

I2. Had building permit checked for energy code compliance.
I3. Was required to change plan by permitting agency to comply with energy code

I4. Had a visit from energy code official to inspect insulation prior to covering it up

I5. Had a code official check the installed HVAC equipment to see that the efficiency matched filed plan

I6. ["non-res" only] Had a code official check the installed system control strategy to see that it matched filed plan

a) Every time
b) Most of the time
c) Occasionally
d) Never
e) Don't know
f) Refused

[If I3 = a, b, or c ask]

I7. What elements of your buildings were you required to change to comply with energy code?

a) Record verbatim
b) Don't know
c) Refused

I8. In your experience with code officials from plan approval through inspections, approximately what percentage of their time is devoted to energy-related issues as opposed to health, safety, and other concerns?

a) Record verbatim
b) Don't know
c) Refused

I9. In your opinion, how well informed are code officials on energy code issues and building science in general?

a) Extremely knowledgeable
b) Somewhat knowledgeable
c) Somewhat uninformed
d) Extremely uniformed
e) Don't know
f) Refused

I10. Have you and your staff attended any training sessions that deal with the specific requirements of the new energy code [if res/nonres =res say "NY2010"; if res/nonres = nonres say "ASHRAE 90.1 20079"]?

a) Yes
b) No
c) Don't know
d) Refused

[If I10 = a ask, otherwise skip to IC1]

I11. What specific training courses have you attended? If possible please supply course name, sponsor, and approximate date and location.

a) Record verbatim
b) Don’t know
c) Refused

I12. Did you find that the training fully prepared you to handle the new energy code?
a) Yes
b) No
c) Don’t know
d) Refused

[If I12 = b, or -96 ask]

I13. In what ways could the training have better prepared you to handle the new codes?
a) Record verbatim
b) Don’t know
c) Refused

Non-res buildings

[if res/nonres = nonres ask, otherwise skip to R1]

IC1. What areas of the existing code (ASHRAE 90.1 2001-2003) gave you the most compliance issues?
a) Record verbatim
b) Don’t know
c) Refused

There are a number of new requirements in the new energy code (ASHRAE 90.1-2007) that may or not now be part of your construction practices. For each of the following please state whether this measure is already a part of every building you constructed under the old energy code, is something that you will be able to add to all new buildings built under the new code, or is something that you may have difficulty always meeting in new buildings you build?
a) This measure is already a part of every building we constructed under the old energy code,
b) This measure is something that we will be able to add to all new buildings built under the new code,
c) This measure is something that we may have difficulty always meeting in new buildings we build?
d) Don’t know
e) Refused

IC2. Temperature setpoint deadbands between heating and cooling are within allowed tolerances?

IC3. Above-deck roof insulation is R-20 or higher

IC4. Maximum voltage drops on feeder conductors are less than 2% and branch conductors are less than 3%

IC5. Occupancy sensors are installed in all classrooms, meeting rooms, and lunch rooms

IC6. Lighting power densities (lpd) are provided as part of the design drawings

IC7. When building spaces are larger than 5000 square feet, you install Demand-Controlled Ventilation (DCV) systems

IC8. Detailed control schematics for lighting and mechanical systems are submitted

IC9. Fan/pump motor horsepower is not oversized?

In thinking about the jurisdictions that you deal with how likely is it that code officials will stringently check your submitted plans to see if the following components are at new code required levels?

a) Extremely likely
b) Somewhat likely
c) Somewhat unlikely
d) Extremely unlikely
e) Don't know
f) Refused

IC12. Temperature setpoint deadbands between heating and cooling are within allowed tolerances?

IC13. Above-deck roof insulation is R-20 or higher

IC14. Maximum voltage drops on feeder conductors are less than 2% and branch conductors are less than 3%

IC15. Occupancy sensors are installed in all classrooms, meeting rooms, and lunch rooms

IC16. Lighting power densities (lpd) are provided as part of the design drawings

IC17. When building spaces are larger than 5000 square feet, you install Demand-Controlled Ventilation (DCV) systems

IC18. Detailed control schematics for lighting and mechanical systems are submitted

IC19. Fan/pump motor horsepower is not oversized?

Residential Buildings

[ask if res/nonres = 'res', otherwise skip to D1]

R1. Did you use a checklist approach to air-seal this building?
a) Always
b) Some times
c) Never
d) Don't know
e) Refused

R2. Did you use a blower door at this home to guide air sealing?
a) Always
b) Some times
c) Never
d) Don't know
e) Refused

R3. Did you use a blower door at this home to confirm the results of air sealing?
a) Always
b) Some times
c) Never
d) Don't know
e) Refused

R4. Thinking about the way you did jobs three years ago and those you do now, what percentage of jobs did you do the following

Measure	3 years ago	Now
a. Manual J load calculation		
b. Manual D for duct installation		

j. Conduct a room pressure balance test		
k. Duct leakage testing		
l. Blower door test		
m. Location of all ducts within the building thermal envelope		

R5. What areas of the existing NY2007 code gave you the most compliance issues?

a) Record verbatim
b) Don't know
c) Refused

R6. Were there any areas of the NY2007 where you regularly exceeded code?

a) Record verbatim
b) Don't know
c) Refused

[If S4 = a ask,]

R7. You noted previously, that you do build homes that meet the stricter energy requirements of the New York Energy Star Labeled Homes program. When building one of these homes, do code officials accept the ESH label as documentation of code compliance or do you still have to go through the same inspections and documentation?

a) Code officials always accept ESH label as sign of code compliance
b) Code officials sometimes accept ESH label as sign of code compliance
c) Code officials never accept ESH label as sign of code compliance
d) Code officials sometimes accept ESH label, but then also want to do supplementary compliance verification
e) Don't know
f) Refused

Residential New Code

R8. What compliance approach do you think you will most likely use most of the time for future homes you build?

a) Prescriptive
b) REScheck
c) Manual UA Tradeoff
d) Performance (Home Energy Rating System (HERS) or similar calculation)
e) Other:______________________
f) Don't know
g) Refused

R9. There are a number of new requirements in the NY2010 energy code that may or not now be part of your construction practices. For each of the following please state whether this measure is already a part of every building you constructed under the old energy code, is something that you will be able to add to all new buildings built under the NY2010 code, or is something that is a difficult step that you may have difficulty always meeting in new buildings you build?

a) this measure is already a part of every building we constructed under the old energy code,
b) this measure is something that we will be able to add to all new buildings built under the NY2010 code,
c) This measure is something that we may have difficulty always meeting in new buildings we build?
d) Don't know
e) Refused

R10. Installation of high-efficacy (efficient) (i.e. fluorescent) lamps in a minimum of 50% of the permanently installed lighting fixtures.

R11. Blower door testing for house air leakage

R12. Duct blaster testing to measure duct tightness

R13. Requirement that any home addition, alteration, renovation or repair conform with the provisions of the new code requirements

R14. How many hours per home do you and your staff spend interacting with code officials on energy-related issues?

a) Record verbatim
b) Don't know
c) Refused

R.15 For non New York ENERGY STAR Homes, how do you comply with (or plan to comply with) the house air sealing requirements:

a) Checklist approach
b) Blower door testing with equipment owned by the builder
c) Blower door testing by subcontractor who provides testing as part of another subcontracting service (e.g. insulation contractor)
d) Third-party contractor hired just to perform blower door test

R.16 For non New York ENERGY STAR Homes, how do you comply with (or plan to comply with) the duct leakage testing requirements:

a) Install all ducts within building thermal envelope
b) Duct leakage testing with equipment owned by the builder
c) Duct leakage testing by subcontractor who provides testing as part of another subcontracting service (e.g. HVAC contractor)
d) Third-party contractor hired just to perform duct leakage test

R.17 As energy codes move towards more stringent standards that incorporate increased performance testing (e.g. blower door tests, duct blaster tests, infrared thermography, room-to-room air flow tests, etc.), we will need trained and certified professionals to conduct these tests and verify code compliance. Please rank the following professionals to indicate who you feel would be best suited to provide this type of code compliance testing:

a) Code officials
b) Home Energy Rating System (HERS) raters
c) Architects
d) Engineers
e) Building Performance Institute (BPI) certified contractors
f) Another independent contractor
g) Self-testing
h) Other: ______________

Company Info

D1. How many years has your company been building in New York?

a) Record verbatim
b) Don't know
c) Refused

D2. How many employees work for your business in New York State?

a) Record verbatim

b) Don’t know
c) Refused

That is all the questions I have. Thank you for your time.

APPENDIX G: RESIDENTIAL RENOVATORS TELEPHONE SURVEY

NYSERDA Renovation Telephone Survey Instrument

Hello, my name is _______________________. I am calling from CSG, on behalf of the New York State Energy Research and Development Authority (NYSERDA). We are conducting a study regarding New York State energy codes. We are interested in receiving feedback from homeowners who have recently undergone home renovations. We are interested in finding out your experience in having your home renovated and what if any interactions you or your contractor had with local code officials.

S1. Our records indicate that a home at [ADDRESS] applied for a permit to renovate or remodel the residence. Are you the owner of the home at [ADDRESS]?

a) Yes *CONTINUE*
b) No *THANK AND TERMINATE*

S2. What is the status of the renovation at this address?

a) The renovation is completed
b) The renovation is underway
c) The renovation has not yet started *THANK AND TERMINATE*
d) The renovation is not being done *THANK AND TERMINATE*
e) Don't know *THANK AND TERMINATE*
f) Refused *THANK AND TERMINATE*

S3. Are you familiar with the renovation that was completed or is in the process of being completed at this location?

a) Yes *CONTINUE*
b) No *CONTINUE*

[If S3 = b ask]

S3. Is there someone else that we can speak to who is knowledgeable of the renovation at this address?

a) Yes *Get name and contact if not available*
b) No *THANK AND TERMINATE*

S4. What kind of renovation did you perform at this home? [READ LIST, SELECT ALL THAT APPLY]

a) Add a room or rooms
b) Enlarge existing room or rooms
c) Finish off basement
d) Convert sunroom or porch to heated space
e) Gut existing space and remodel
f) Other, specify
e) Don't know
g) Refused

General Questions

A1. Who was responsible for filing the permit to renovate this home?

a) Myself
b) Other owner or family member
c) Contractor
d) Architect
e) Other, specify
f) Don't know
g) Refused

[If A1=a ask, otherwise skip to A5]

A2. When you or your representative applied for the permit, did the permitting agency require you to change any of the elements of your plan to conform with the current building code?

a) Yes
b) No
c) Don't know
d) Refused

[If A2=a ask, otherwise skip to A5]

A3. Were any of the required changes related to energy use or energy efficiency?

a) Yes
b) No
c) Don't know
d) Refused

A4. What energy-related changes did the permitting agency require you to change? Did any of the required changes relate to energy use or energy efficiency? [READ LIST ACCEPT ALL THAT APPLY]
a) Ceiling insulation levels
b) Wall insulation levels
c) Foundation insulation levels
d) Insulation installation details
e) Building air sealing/infiltration
f) Window specifications
g) Duct sealing
h) Duct insulation
i) Pipe insulation
j) Lighting fixtures
k) Heating systems efficiency
l) Cooling system efficiency
m) Building heat loss calculations for HVAC sizing
n) Thermostats
o) Other:________
p) Don't know
q) Refused

A5. How many visits to your home did building code inspector make to inspect the renovation work?
a) None
b) 1
c) 2
d) 3
e) 4
f) More than 4
g) Don't know
h) Refused

[If A5>0 ask, otherwise skip to B1]
A6. Did the permitting agency require you to change any component of the renovation?
a) Yes
b) No
c) Don't know
d) Refused

[If A6=a ask, otherwise skip to B1]
A7. Did the field inspector require any changes in any energy use or energy efficiency component of your building?
a) Yes
b) No
c) Don't know
d) Refused

[If A7=a and A2 not equal to a ask, otherwise skip to B1]
A8. What energy-related changes did the permitting agency require you to change? Did any of the required changes relate to energy use or energy efficiency? [READ LIST ACCEPT ALL THAT APPLY]
a) Ceiling insulation levels
b) Wall insulation levels
c) Foundation insulation levels
d) Insulation installation details
e) Building air sealing/infiltration
f) Window specifications
g) Duct sealing
h) Duct insulation
i) Pipe insulation
j) Lighting fixtures

k) Heating systems efficiency
l) Cooling system efficiency
m) Building heat loss calculations for HVAC sizing
n) Thermostats
o) Other:________
p) Don't know
q) Refused
r) Don't know
s) Refused

B1. As part of your renovation, did you add walls or gut walls to bare frame?
a) Yes
b) No
c) Don't know
d) Refused

[If B1=a ask, otherwise skip to B6]
B2. What type of insulation did you add to the walls? [READ LIST, CHOOSE ALL THAT APPLY]
a) Fiberglass batts
b) Fiberglass batts and foam board
c) Foam board
d) Blown in cellulose
e) Blown in foam
f) Blown in fiberglass
g) Other: __
h) Don't know
i) Refused

B3. Do you know the total R value of the insulation you installed in the walls?
a) Yes
b) No
c) Don't know
d) Refused

[If B3=a ask, otherwise skip to B5]
B4. What is the R value of the walls insulation you installed?
Record verbatim

[If B3 not equal a ask]
B5. How many inches of insulation did you install?
Record verbatim

B6. In you renovated area what material did you use to seal the home for air leakage?
a) Caulk
b) Spray foam
c) Gaskets
d) Tape
e) Plastic sheeting
f) Air barrier
g) Membranes
h) Tyvek
i) Other
j) Don't know
k) 97 Refused

B7. Did your contractor or anyone else use a blower door and/or an infrared camera to detect leakage?
a) Blower door
b) Infrared gun
c) Both a blower door and an infrared camera
d) Neither
e) Don't know
f) Refused

B8. Was any heating or cooling equipment installed as part of this renovation?
a) Heating
b) Cooling
c) Both heating and cooling
d) None
e) Don't know
f) Refused

B9. Was ductwork installed or replaced as part of your renovation?
a) Yes
b) No
c) Don't know
d) Refused

[If B9=a ask]
B10. How was the duct work sealed? [READ LIST, CHOOSE ALL THAT APPLY]
a) Conventional duct tape
b) Approved duct tape
c) Mastic
d) Spray foam
e) Caulking
f) Other, specify
g) Duct work was not sealed

[If B8= a or c ask, otherwise skip to B13]
B11. What type of heating system did you install?
a) Furnace (i.e. with ducts)
b) Boiler (i.e. with hot water pipes and radiation)
c) air source heat pump
d) Ductless mini-split heat pump or other wall/unit heaters
e) ground source/geothermal heat pump
f) wood or coal stove
g) Other: __
h) Don't know
i) Refused

[If B11 = a, b, or c ask]
B12. What was the efficiency of the heating system?
Record verbatim

[If B8= b or c ask, otherwise skip to B15]
B13. What type of cooling system did you install?
a) Central air with ductwork
b) Air-source heat pump
c) Ductless mini-split system
d) Window AC
e) ground source/geothermal heat pump
f) Don't know
g) Refused

[If B9 = a, b, or c ask, otherwise skip to B15]
B14. What was the efficiency of the cooling system?
Record verbatim

B14a. In what units was last answer?
a) EER
b) SEER
c) COP
d) Other, specify
e) Don't know
f) Refused

B15. For this renovation, did you use a contractor or did you complete the work yourself?

a) Contractor
b) Myself
c) Don't know
d) Refused

[If B15 = a ask]

B16. Was your contractor certified by the Building Performance Institute (BPI)?

a) Yes
b) No
c) Don't know
d) Refused

[If B15 = b ask]

B17. Are you certified by the Building Performance Institute (BPI)?

a) Yes
b) No
c) Don't know
d) Refused

B18. Did you use an energy consultant to help make your renovation energy efficient?

a) Yes
b) No
c) Don't know
d) Refused

[If B18 =a ask, otherwise skip to B21]

B19. Was the consultant BPI certified?

a) Yes
b) No
c) Don't know
d) Refused

[If B17 =a or B18 =a or B19=a ask]

B.20 Was a Home Energy Rating (HERS) rating calculated for your renovation project?

a) Yes
b) No
c) Don't know
d) Refused

B21. Did you participate in any NYSERDA or utility program to get free technical assistance or incentives for this renovation?

a) Yes
b) No
c) Don't know
d) Refused

[If B21=a ask]

B22. What programs or programs did you participate in?
Record verbatim

B23. When doing the renovation were you required by code officials to upgrade to code any energy-related features of the rest of your home that were not part of the renovation project?

a) Yes
b) No
c) Don't know
d) Refused

[If B23=a ask]

B24. Please describe the energy-related features that were not part of the renovation that you were required to upgrade?
Record verbatim

B25. Approximately, how much did you spend in total on your renovation?
Record verbatim

B26. Approximately how much extra did you spend to make the more energy efficient?
Record verbatim

That is all the questions I have. Thank you for your time.

NYSERDA Energy Code Compliance Architects E-mail Survey 4/7/11

1. In what (approximate) size communities are most of your projects?
   a. New York City (5 boroughs)
   b. Large cities (population 60,000 – 300,000 (ex., Buffalo, Rochester, Yonkers, Syracuse, Albany, New Rochelle, Mt. Vernon, Schenectady, etc.)
   c. Smaller cities and town (< 60,000)
   d. Villages and Towns (< 10,000)
   e. Mixed

2. In which sector is the **dominant** portion of your work?
   a. Residential (1-4 units)
   b. Small Commercial (including > 4 units residential)
   c. Medium/Large Commercial

For the following questions, please provide answers relative to the sector in which you perform the dominant share of your work.

3. With respect to the requirements of the NYS Energy Code,
   a. What do you think contributes most to the gap between <u>code requirements</u> and <u>buildings as designed</u>?

   b. What would help close that gap?

4. With respect to the NYS Energy Code requirements,
   a. What do you consider to be the largest gap(s) relative to how <u>buildings are designed</u> versus <u>buildings as</u> <u>constructed</u>?

   b. What would help close that gap?

5. What architectural or system measures <u>not</u> currently required would be most effective for increasing the energy efficiency of new and existing buildings?

   a. What would you anticipate to be the greatest hindrance to adoption or incorporation of these?

   You are almost finished! One more question to go.

   Thank you greatly for your time. Your responses will provide valuable input to future energy code guidelines and training in New York State.

6. What future and additional efforts should NYS and NYSERDA support in order to reduce energy use in buildings throughout the state?

APPENDIX I: RESIDENTIAL DETAILED METHODOLOGY AND ANALYSIS

The following sections include the summary results, analysis and discussion from what was included in the main body of Section 4 above, plus additional detail, results, data, analysis and discussion.

The VEIC Team conducted on-site assessments of 44 single- and two-family non-ENERGY STAR® residential homes across New York to determine compliance rates with the residential energy code requirements of the 2007 NYS ECCC. A compliance assessment was also made against the IECC 2009 and guided the conclusions and recommendations section of this report. The details of the sampling design and recruitment methodology are described in detail in Section 2. The results of the compliance analysis and the energy impacts of non-compliance are presented in this section.

I.1 Compliance Results

The VEIC Team examined multiple compliance approaches to address the question "what is the energy code compliance rate of new homes in New York State?" Compliance rates ranged from 61% to 73%, with the U.S. Department of Energy's (DOE) Building Energy Codes Program (BECP) protocol coming in at the high end of 73%. This would indicate that 27% of new (non-ENERGY STAR®) homes did *not* achieve 100% compliance with the New York State 2007 Energy Conservation Construction Code (2007 NYS ECCC), as measured using DOE's methodology. However, the ARRA requirement is that buildings are 90% compliant with the energy code, so New York State buildings on average are 17% under-compliant (90% compliance required – 73% compliant = 17% under-compliant). Given the issues with sampling discussed in Section 2, it is not known for sure how the sampled buildings match the population. The only thing we are able to state with certainty is that the residential sector is not above the 90% goal.

I.1.1 Compliance Calculation Methodology

There are multiple approaches to energy code compliance. New York State has basic code requirements that are mandatory for all buildings. These basic requirements are either compliant or non-compliant. Compliance with the remaining code requirements, such as insulation and window requirements, can be shown using the following four approaches:

1. The **Prescriptive Package Approach** allows builders to choose from packages of insulation and window requirement developed for each Climate Zone.

2. The **Trade-Off Worksheet Approach** enables builders to trade-off insulation and window efficiency levels throughout the building.

3. The **Software Approach** is a Trade-Off compliance path that automates insulation and window components by trade-off calculations through the use of approved software (REScheck™). This approach also allows heating equipment efficiencies to be traded off with building envelope components.

4. The **Simulated Performance Alternative** may be demonstrated with an approved Home Energy Rating Software (HERS) energy modeling software. This approach requires the total annual energy cost of the modeled design home be less than or equal to the total annual energy cost of the standard reference design.

As there are multiple approaches to *demonstrate* energy code compliance, there are also multiple approaches to *evaluating* energy code compliance. The three methods discussed in this residential section of this report include:

1. **"BECP Protocol,"** developed by the Pacific Northwest National Lab (PNNL) for the U.S. DOE's Building Energy Codes Program (BECP) to demonstrate 90% compliance;

2. **"Trade-Off (e.g. REScheck™),"** used to evaluate overall UA compliance. (The sum of U-factor times assembly area for the sample home must be less than or equal to that calculated for the code reference home); and

3. **"Simulated Performance,"** used to evaluate the overall energy performance of the home, (The annual energy cost of the sample home must be less than or equal to the annual energy cost of the reference code home).

The BECP Protocol evaluates compliance quite differently than either the Trade-Off (e.g. REScheck™), or Simulated Performance methods. The BECP Protocol calls for the evaluation and quantification of all energy code requirements, with the exception of a few items that are either purely administrative or have no energy impact. The PNNL Checklist is the tool created by PNNL to calculate compliance by the BECP Protocol methodology. The PNNL Checklist, specific to each Climate Zone, lists each code requirement as a separate item and evaluates each item as compliant or not compliant. Energy code requirements are weighted so that code items with a high energy impact receive a higher score (three points) when in compliance, and items with little or no direct energy impact receive a lower score (one point) when in compliance. For example, foundation wall insulation R-values, depth and quality of installation checklist items are all worth three points, while exposed foundation insulation protection is worth two points. Code requirements with a low energy impact, such as fenestration leakage rates, receive only one point. An overall compliance percentage "score" is calculated for each home by dividing the total received points by the total possible points. In cases where a given code requirement is not applicable to the home being assessed (e.g. on-grade slab insulation where no on-grade slab exists), or a code requirement cannot be assessed because it is not visible (e.g. the quality of insulation installation), these checklist items are not scored and thus do not affect the overall compliance percentage score of the home. The compliance percentage scores of each home are then averaged to produce an average compliance rate for the state.

The PNNL checklists were originally designed to assess compliance rates with IECC 2009. VEIC adapted the checklists to the 2007 NYS ECCC so that a compliance rate with the code in effect at the time of this study could be generated. Compliance rates with both 2007 NYS ECCC and IECC 2009 are reported here. The BECP Protocols are the only method to quantitatively score each requirement of the code and thus are the focus of this study in determining the energy code compliance rate of homes in New York State.

The Trade-Off (e.g. REScheck™) and Simulated Performance methods of compliance evaluation differ from the BECP Protocol in two ways. The first difference is that, the Trade-Off (e.g. REScheck™) and Simulated Performance methods evaluate a home as either compliant or not compliant; whereas the BECP Protocol provides a compliance percentage score (i.e. the home is 80% compliant with all the requirements of the code). The second difference is that, as stated above, the BECP Protocol quantifies *all* requirements of the energy code, whereas the other two methods do not. The Trade-Off (e.g. REScheck™) method evaluates and quantifies compliance with the insulation and window requirements of the code, and when applicable, the heating equipment efficiency levels (i.e. the Overall UA of the sample home is X% more or less than the Overall UA of the reference code home). The Simulated Performance method evaluates and quantifies the overall energy performance of the home (i.e. the annual energy costs of the sample home are X% more or less than the annual energy costs of the reference code home). Some basic code requirements (such as duct insulation and overall fenestration UA) are evaluated distinctly and built into the final compliance check produced by the software. This means that even if the home meets the overall UA (Trade-Off (e.g. REScheck™)) or annual energy cost (Simulated Performance) requirement, if it does not also meet the basic code requirements, it is not compliant with the Trade-off or Simulated Performance approach. Many code requirements, however, are either included only as a manual checklist but not quantified, or not included at all. The Trade-Off (e.g. REScheck™) and Simulated Performance methods only quantify about 25% of the code requirements quantified by the BECP Protocol. This is discussed in more detail below and in Appendix I.

This study reports the compliance rates resulting from each of these three compliance evaluation methods. The BECP Protocol compliance rate is expressed as "percent in compliance," i.e. the average percentage of all code requirements that are in compliance for each home. The Trade-Off (e.g. REScheck™) and Simulated Performance compliance rates are expressed as "percent pass," the total number of homes that are fully compliant with the requirements of the evaluation method. Appendix I also reports compliance rates with the Trade-Off (e.g. REScheck™) and Simulated Performance methods with and without inclusion of the distinct basic code requirement check. This allows insight into whether homes are not in compliance due to the Overall UA requirement (Trade-Off (e.g. REScheck™)) or annual energy cost requirement (Simulated Performance), or due to the basic requirements of the code.

I.1.2 Compliance Results Summary

<u>Overall Building Compliance Summary</u>

The VEIC Team field inspectors collected or reviewed at the code offices the code documentation for most of the 44 homes. REScheck™ certificates were found in the code offices for 30 homes, or 68% of the total sample. An additional six homes had construction documents (i.e. stamped plan-inspection reports) on file demonstrating compliance. The remaining eight homes had no documentation demonstrating energy code compliance. No prescriptive package or trade-off worksheet documentation was found during the code office visits. There was also no documentation found showing that the simulated performance approach was taken. (This is not surprising as the study did not include homes that had participated in the ENERGY STAR® programs offered by NYSERDA and LIPA). A more detailed discussion of administrative compliance and findings from the code office visits is included in the administrative compliance sub-section, below and in this Appendix.

Table I-1summarizes the rates of compliance by method of compliance evaluation for 2007 NYS ECCC and for IECC 2009 by Climate Zone and for the State. Compliance rates by the Trade-Off (e.g. REScheck™) and Performance methods are shown with and without assessment of the mandatory, or basic, code requirements as modeled by REM/Rate™. The Home Energy Rating System (HERS) energy rating Score (where 100 is best) and Index (where 0 is best) are also reported.

Table I-1: Summary compliance rates by compliance evaluation method

	Metric	Climate Zone 4	Climate Zone 5	Climate Zone 6	Statewide
		n=9	n=26	n=9	n=44
2007 NYS ECCC					
Trade-Off (e.g. REScheck™) (With basic requirements)	Percent Pass	11%	81%	56%	61%
Trade-Off (e.g. REScheck™) (Overall UA only)	Percent Pass	44%	100%	67%	82%
Performance (With basic requirements)	Percent Pass	22%	81%	56%	64%
Performance (Energy cost only)	Percent Pass	56%	96%	78%	84%
BECP Protocol	Percent In Compliance	59%	81%	66%	73%
IECC 2009					
Trade-Off (e.g. REScheck™) (With basic requirements)	Percent Pass	11%	27%	11%	20%
Trade-Off (e.g. REScheck™) (Overall UA only)	Percent Pass	33%	31%	33%	32%
Performance (With basic requirements)	Percent Pass	11%	15%	11%	14%

Performance (Energy cost only)	Percent Pass	11%	19%	33%	20%
BECP Protocol	Percent In Compliance	53%	69%	62%	63%
HERS					
NY Score	HERS Score	83	84	84	84
HERS Index	HERS Index	86	79	81	81

The results in **Table I-1** are evaluated considering the following points.

1. The "Percent Pass" metric shows the total percentage of buildings that passed as a whole. The "Percent In Compliance" metric shows the average compliance percentage of all buildings calculated per the BECP Protocols methodology.

2. When evaluating compliance via "Trade-Off (e.g. REScheck™)" or "Performance" method, mandatory requirements such as duct insulation and overall fenestration UA were analyzed separately. Separating these mandatory features provides additional clarity as to whether homes are failing due to the overall UA or simulated performance requirements, or to the additional mandatory requirements of the code.

3. Trade-off compliance with 2007 NYS ECCC was evaluated by reviewing REScheck™ reports when they were documented or by evaluating VEIC Team REM/Rate™ models when no REScheck™ report existed. One home with no REScheck™ report was in compliance with 2007 NYS ECCC Prescriptive Table 402.1(1) and is included in the Trade-Off (e.g. REScheck™) compliance rate.

4. Trade-off compliance with IECC 2009 was evaluated using VEIC Team REM/Rate™ models.

5. When Trade-Off (e.g. REScheck™) compliance was evaluated using REM/Rate™, all insulation was (unrealistically) set to Grade I to more closely simulate a REScheck™ analysis. Calculation of U-Factors differs between REM/Rate™ and REScheck™ and so these compliance rates are approximations of what might be found using REScheck™.

6. Performance compliance rates for both 2007 NYS ECCC and IECC 2009 were analyzed using the VEIC Team REM/Rate™ models.

7. HERS Scores and Indices are presented with unadjusted insulation grades as reported from the field by CSG HERS Raters.

8. BECP Protocol compliance for IECC 2009 is much higher than either Overall UA or Performance compliance. There are two primary reasons for this. The first is that there are no mechanical system trade-off allowances under IECC 2009. Therefore, individual component R-values must be much closer to the prescriptive table insulation requirements for IECC 2009 than what is allowable using a system trade-off

approach under 2007 NYS ECCC. The second reason is that the BECP Protocols quantify all aspects of the code, whereas the Trade-Off (e.g. REScheck™) approach only quantifies the insulation and window requirements. The Performance approach quantifies these as well as mechanical system efficiencies and building envelope tightness. The Trade-Off (e.g. REScheck™) and Performance approaches to compliance evaluation account for only about 25% of what is quantified by the BECP Protocol checklists.

9. While results are presented by Climate Zone, given the small sample sizes in each, the results have no precision. The only result we can definitively state is that none of the sectors is above 90% compliance. Given the sampling issues (discussed in Section 2), we are not sure how well the buildings match the population. Whether this is a function of the Climate Zone or the sample as it was drawn is not known, but if the issues identified and discussed below are characteristic of the Climate Zone (especially Climate Zone 4), then it has major implications. Because the sample was not drawn in a truly random fashion, it is not clear if issues identified are true measures of the home characteristics or an inherent bias in the selection process.

The code compliance data from the above table can also be presented graphically. Figure I-1shows the average compliance rates by approach for each Climate Zone. The average compliance rates presented here for the Trade-Off (e.g. REScheck™) and Performance methods reflect the compliance rates that include the basic code requirements.

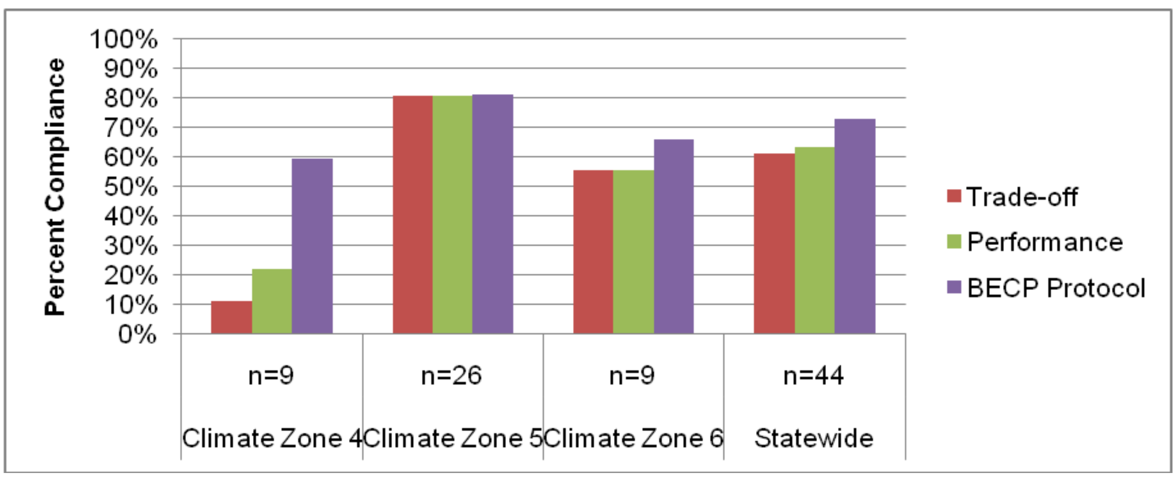


Figure I-1: Percent Compliance with 2007 Code by Evaluation Method

Statewide, overall compliance with the 2007 code ranged from 61% to 73% depending on the evaluation method. Evaluation by the Trade-Off (e.g. REScheck™) and Performance methods results in slightly lower compliance rates than the BECP Protocols statewide, but in general **Figure I-1** shows that compliance rates for the 2007 Code are comparable for each of the three approaches evaluated with the exception of Climate Zone 4. Compliance rates in Climate Zone 4 evaluated using the BECP Protocol are over twice that of the Trade-Off (e.g. REScheck™) and Performance approaches. With only nine homes in the sample for Climate Zone 4 (located in the greater New York

City metropolitan area), less than one-half of the homes in Climate Zone 4 had REScheck™ reports, and one of these was found to have energy features that did not match the REScheck™ report. Of the remaining homes evaluated by the REM/Rate™ models, only one was found to have a building envelope in compliance, but it failed a basic requirement of the code. Why the compliance rate is so much higher when evaluated using the BECP Protocol is similar to the reasons stated in note number eight to **Table I-1**, the Trade-Off (e.g. REScheck™) approach only quantifies about 25% of what the BECP Protocols do. Therefore, there are more code requirements to "get right" (or wrong) using the BECP Protocol method. For example, the Trade-Off (e.g. REScheck™) approach only quantifies the nominal R-value installed for a given component, whereas the BECP Protocol checklist quantifies not only the nominal R-value installed, but also whether or not the insulation was installed per manufacturer instructions. Additionally, the BECP Protocols quantify construction documentation, HVAC sizing calculations, fenestration and recessed lighting infiltration, posted code certificates etc.

In general, the reasons for this low compliance rate for Climate Zone 4 versus the other two climates could be attributed to a number of factors (including a lack of emphasis on energy issues in this warmer Climate Zone, less skilled or under-trained subcontractors, code compliance oversights, self-certification policy, etc.). It's possible (although the Team has no direct evidence) that the larger homes in Zone 4 were built with more complex designs and high attention to aesthetic details, rather than the wealthier homeowners being focused on energy costs. However, with only nine homes in the sample, it would be unreasonable to draw any firm conclusions without further investigation.

Climate Zone 5 shows the highest compliance at 81%. When the basic requirements of the code are not considered and only looking at overall UA or energy performance, the Trade-Off (e.g. REScheck™) and Performance methods show greater than 95% compliance. At the same time, Climate Zone 4 shows compliance levels as low as 11% under the same methods. Looking at compliance rates without considering the basic code requirements provides insight into the percentage of homes that are failing solely due to the basic code requirements vs. the insulation and window requirements. Trade-Off (e.g. REScheck™) and Performance compliances reach over 80% when the basic requirements are not considered. While this is not typical relative to other code compliance studies conducted for other states, it still does not meet the 90% target.

When analyzing compliance rates against IECC 2009, it is clear that builders have a long way to go to reach 90%; full compliance rates with IECC 2009 range from 14% to 63%. Some of the reasons that these compliance rates are so low for IECC 2009 are not only the more stringent overall insulation and performance requirements, but also the inability to trade off more efficient mechanical equipment again lower envelope R-values. Specifically, ceiling and wall insulation show relatively high compliance under the 2007 code due to the ability to trade-off the higher insulation requirements with high heating system efficiency, infiltration or duct leakage rates. Homes in Climate Zone 4 will also need to significantly improve infiltration and duct leakage rates to meet the new code.

I.1.3 Detailed Compliance Results

I.1.3.1 Overall Building Compliance Detail

BECP Protocol Compliance

The Compliance Checklists developed by PNNL for BECP to evaluate 90% compliance represent a new approach to energy code compliance evaluation. Past methods of compliance evaluation assessed building thermal envelope components based on a nominal R-value. Other requirements of the code, such as insulation quality and additional mandatory requirements have been relegated to a “Yes or No” style check box. The BECP Protocol Compliance Checklists attempt to quantify all aspects of the energy code. Given that the purpose of the code is to build energy efficient buildings, code requirements directly related to energy performance are weighted higher than more administrative requirements. For example, foundation wall insulation R-values, depth and quality of installation checklist items are all worth three points, while exposed foundation insulation protection is worth two points. Code requirements with a low energy impact, such as fenestration leakage rates, receive only one point. The compliance rate for each home is calculated as the sum of all points received divided by the sum of all total possible points for a percentage of 100% compliance. A statewide compliance rate is obtained by taking the average of all individual home scores.

The BECP Protocol 90% compliance methodology has two advantages over other compliance evaluation approaches:

1. On a per home compliance basis, the measurement quantifies all requirements of the code, not just the thermal envelope

2. On a statewide compliance basis, the measurement is looking for *each home* to be at least 90% in compliance, rather than for 90% of *all homes* to be 100% in compliance.

The 90% Compliance Checklist was originally developed for use during the code inspection process as homes were being built. This study, which post-construction inspections, found some issues completing the Checklist. For instance, wall insulation installation quality and some duct sealing could not be viewed since they were enclosed behind drywall. The BECP Protocol provides **Equation IV- 1** in order to calculate the upper bound confidence level of compliance. The values that result from the adjustment to the mean compliance rate, is the final compliance rate to be reported by each state.

Equation IV- 1: Upper Confidence Bound Calculation

$$\bar{x} + 1.645 \text{ x} \frac{s}{\sqrt{n}}$$

where:

$\bar{x}$ = the mean

s = Standard deviation
n = sample size

Table I- 2 shows the mean, standard deviation and upper confidence bound results for both 2007 NYS ECCC and IECC 2009 compliance using the BECP 90% methodology.

Table I- 2: BECP 90% Compliance Results for 2007 NYS ECCC and IECC 2009

	Climate Zone 4	Climate Zone 5	Climate Zone 6	Statewide
Sample Size	**n=9**	**n=26**	**n=9**	**n=44**
2007 NYS ECCC				
Mean	50%	79%	58%	69%
Standard Deviation	18%	7%	16%	17%
Upper Confidence Bound	59%	81%	66%	73%
IECC 2009				
Mean	42%	66%	54%	59%
Standard Deviation	19%	10%	14%	16%
Upper Confidence Bound	53%	69%	62%	63%

New York State's compliance rate with 2007 NYS ECCC is 73%, which is 27% less than is needed to meet the ARRA 90% compliance requirement. Meeting 90% compliance of the new IECC 2009 code is at only 63%. **Figure I- 2** shows the distribution of compliance rates with 2007 NYS ECCC (under which the homes in this study were built). The lowest compliance rate found was 23%, and the highest was 87%. The highest number of homes in any given bin was eight; these were between 80 and 85% in compliance.

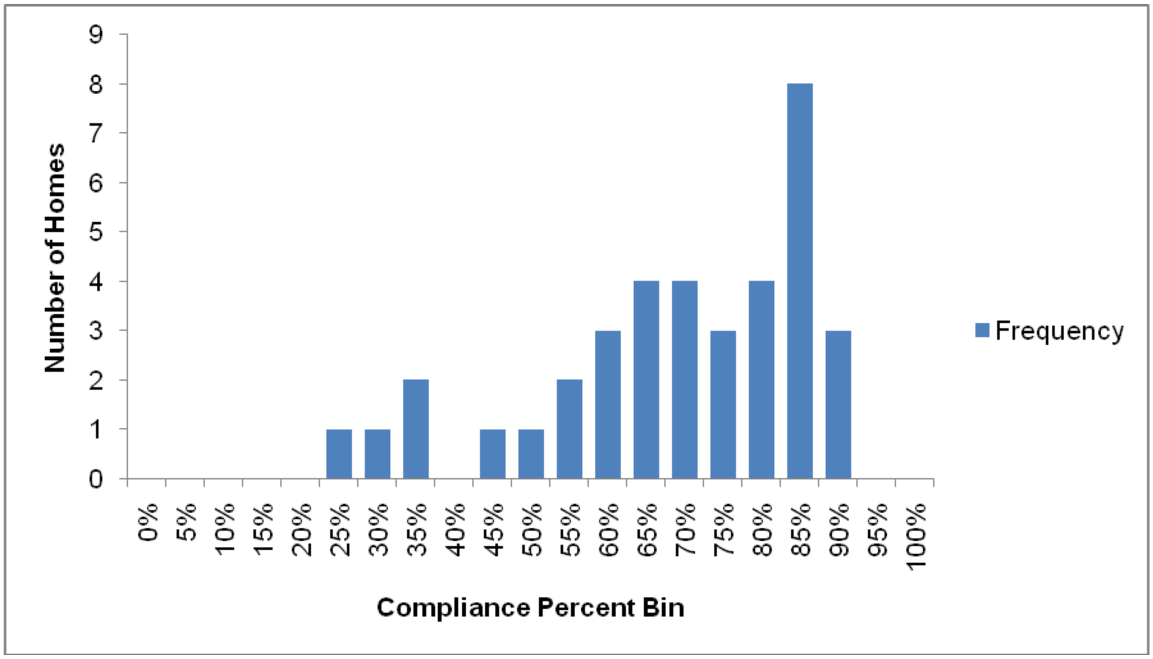


Figure I- 2: Distribution of BECP Protocol Compliance Rates with ECCC NYS 2007

There is an argument to be made that because these checklists were being used for a post-construction study, a large number of checklist items would not contribute to the score because they were not observable (e.g. labels, insulation quality etc.) An informal test was conducted changing all 'Not Observed' responses to 'Yes'. Assuming all "Not Observed" code requirements were in compliance is a very conservative, and unlikely, scenario. Even so, modifying the checklist responses in this way resulted in a statewide compliance increase of 7%. The modified upper confidence bound was 80%. Given this small increase in compliance under a very conservative scenario, it is unlikely that the number of "Not Observed" checklist items had a very large impact on the overall compliance rate for New York State.

The average BECP Protocol compliance scores statewide between 2007 NYS ECCC and IECC 2009 (73% vs.63%) are not that different, whereas the difference in average statewide "Trade-Off (e.g. REScheck™)" and "Performance" compliance is considerable. This is due in large part to how the BECP Protocol checklist calculates compliance. By assessing and quantifying all aspects of the code, there are a greater number of code requirements to get right, or wrong. A trade-off methodology such as REScheck™ is only quantifying compliance of the building thermal envelope by assessing nominal installed R-values. Those same requirements (insulation and fenestration requirements) only account for about 25% of the total BECP Protocol checklist items. Of those, about half saw a 'Not Applicable' (N/A) response all or most of the time (i.e. crawl space R-value, skylight U-factors). By removing 'N/A' checklist items, code requirements quantitatively assessed by REScheck™ or an Overall UA prescriptive approach account for only about 15% of the BECP Protocol checklist items. Of the code requirements other than insulation and fenestration requirements, New York State homes scored very similarly for 2007 NYS ECCC and IECC 20009.

2. Trade-Off (e.g. REScheck™) Compliance

Homes in New York State can show compliance using a prescriptive approach or by trading off envelope components with one another or another building system (e.g. heating efficiency, duct leakage or infiltration rates). For this report, homes were not evaluated against all of the various prescriptive packages (numbering from 15 to 28 options depending on Climate Zone and housing type), but only against prescriptive table 402.1(1) of the 2007 NYS ECCC. When a REScheck™ report was found at the code office, observed component efficiency levels were evaluated against the REScheck™ report. Thirty homes fit this category. These homes were not further analyzed to verify whether they met the specific prescriptive requirements. In cases where no REScheck™ report was found, the VEIC Team evaluated the REM/Rate™ models for Overall UA compliance. Of the 14 homes, out of the total sample of 44, with no REScheck™ report, only one met the specific prescriptive requirements of table 402.1(1) of the 2007 NYS ECCC. This one home is included in the Trade-Off (e.g. REScheck™) compliance rate discussion below.

Statewide, 68% of homes had REScheck™ documentation. The highest percentage, 88%, was in Climate Zone 5. One home had no documentation on file at the code office, but the homeowner had a copy of the REScheck™ certificate. Of the homes with REScheck™ reports, three were found to have observed featured that did not match what was shown on the report. Only one of these did not meet the Overall UA requirements when evaluated in REM/Rate™. Three homes (of the 68% with REScheck™ reports) were found to have REScheck™ reports that were run against codes other than ECCC NYS 2007. No data was obtained to inform why the alternate codes (earlier versions of the IECC) were evaluated. Two of these homes were verified to meet overall UA compliance in REM/Rate™. One home had a high efficiency heating system which is not accounted for as a trade-off in REM/Rate™. This home was run against the correct code in REScheck™ to verify compliance. All three of these homes were found to be in compliance with the overall UA requirement.

To show whether homes with REScheck™ reports were meeting compliance with the overall insulation and fenestration requirements as well as the basic requirements of the code, these two items were analyzed separately. **Table I- 3** shows the percent of homes that met the overall UA requirements as well as the percent of homes that met the overall UA requirements and other basic requirements such as duct insulation and overall fenestration UA. Compliance rates are also differentiated by the compliance evaluation method. Note that the statewide compliance rate with ECCC NYS 2007 by REScheck™ report (66%) does not match the total percent of homes with REScheck™ reports (68%). This difference is due to the one home that had observed features not matching the report, and the observed features were not in compliance.

Table I- 3: Overall UA Compliance by Evaluation Method

	Climate Zone 4	Climate Zone 5	Climate Zone 6	Statewide
	n=9	n=26	n=9	n=44
2007 NYS ECCC				
REScheck™ Report	33%	88%	33%	66%
REM/Rate™ Overall UA	11%	12%	33%	16%
Total Overall UA Compliance	44%	100%	67%	82%
Total Overall UA Compliance with Mandatory Requirements	11%	81%	56%	61%
IECC 2009				
REM/Rate™ Overall UA Compliance	33%	31%	33%	32%
Overall UA Compliance with Mandatory Requirements	11%	27%	11%	20%

For 2007 NYS ECCC in Climate Zones 4 and 6, duct insulation was the failing mandatory requirement 100% of the time. In Climate Zone 5, the failing mandatory requirements were both duct insulation and overall fenestration UA at about the same rate. Because IECC 2009 has less restrictive duct insulation in all Climate Zones and overall fenestration UA requirements for Climate Zones 4 and 5, the primary reasons for failed compliance were due to duct leakage and infiltration requirements. It should be noted that the mandatory requirements listed here are only those reported by REM/Rate™. 2007 NYS ECCC includes other basic requirements including vapor retarders, air sealing.

The BECP Protocol Checklists modified for 2007 NYS ECCC were used to track whether compliance included one of the optional trade-off approaches. **Table I- 4** shows which optional compliance approach was used most frequently. Documentation was not always available to demonstrate that the builder *intended* to use one of these approaches.

Table I- 4: Optional Compliance Approaches Utilized

Optional Trade-Off (e.g. REScheck™) Compliance Path	Climate Zone 4	Climate Zone 5	Climate Zone 6	Statewide
	n=9	n=26	n=9	n=44
Infiltration	22%	35%	11%	27%
Duct Leakage	-	8%	11%	7%
Heating Efficiency	22%	35%	22%	30%
Any Optional Approach	44%	78%	44%	64%

High efficiency heating equipment and infiltration rates were most commonly used to meet the optional compliance requirements. The heating efficiency trade-off approach is the only one of the three evaluated by. Overall, 64% of homes used one of the three optional compliance paths available. This should be considered when reviewing component compliance rates. Where ceilings and walls may have high compliance rates against 2007 NYS ECCC, this will change significantly when system trade-offs are no longer allowable under IECC 2009. While REScheck™ does evaluate infiltration or duct leakage rates when setting the target UA, it does allow for high efficiency heating system trade-offs and adjusts the target UA accordingly. The effects of not allowing this mechanical system trade-off approach can be seen in the difference in Trade-Off (e.g. REScheck™) compliance rates between 2007 NYS ECCC and IECC 2009 reported in **Table I- 3**. Statewide, there is about a 50% difference (82% vs. 32%) in Overall UA compliance (without accounting for the additional basic requirements). With a few exceptions, the fenestration and insulation requirements listed in section 402.1 of both codes are very similar. The removal of alternative insulation requirements will mean that builders will need to meet the prescriptive or overall UA insulation and fenestration requirements.

Performance Compliance

All homes visited for this study were modeled in REM/Rate™. This allowed the opportunity to not only evaluate homes for energy code compliance by the BECP Protocol and Trade-Off (e.g. REScheck™) methodologies, but also by the Simulated Performance Alternative. The Simulated Performance Alternative requires that the modeled energy cost of the design home be less than or equal to the modeled energy costs of the code reference home. Like the Trade-Off (e.g. REScheck™) approach, full compliance with the Simulated Performance Alternative requires the mandatory requirements of the code be met in addition to the total energy cost requirement.

While no homes in the sample had documentation indicating that a Performance approach was used to meet compliance, a Performance evaluation does provide an indication of how homes in New York State are actually performing on an energy consumption basis. The performance approach, as defined in section 404 of the code, requires the energy cost of the As Built home be less than the energy cost of the standard reference design home. REM/Rate™ models also produced a HERS Score and Index. At the time these homes were evaluated, New York State used the HERS scoring method (where 100 is a zero energy home) rather than the HERS Index (where 0 is a zero energy home) to determine program compliance. **Table I- 5** shows the percentage of homes in compliance under the performance approach for ECCC NYS 2007 and IECC 2009. Compliance rates are shown for meeting only the total energy cost requirement of the Simulated Performance Alternative, as well as the energy cost and mandatory requirements. HERS Score and Index are also reported.

Table I- 5: Simluated Performance Alternative Compliance Rates and HERS Scores

	Climate Zone 4	Climate Zone 5	Climate Zone 6	Statewide
	n=9	n=26	n=9	n=44
ECCC NYS 2007				
Performance only	56%	96%	78%	84%
Performance with Mandatory Requirements	22%	81%	56%	64%
IECC 2009				
Performance only	11%	19%	33%	20%
Performance with Mandatory Requirements	11%	15%	11%	14%
HERS Rating				
HERS Score	83	84	84	84
HERS Index	86	79	81	81

As with Trade-Off (e.g. REScheck™) compliance, failed mandatory requirements for 2007 NYS ECCC were primarily due to duct insulation in Climate Zones 4 and 6. Climate Zone 5 had instances of both failed duct insulation and overall fenestration. For IECC 2009, the primary non-compliant mandatory requirement was duct leakage, and to a lesser degree, duct insulation. It is interesting to note that statewide, homes received an average HERS Score of 84, the 2006/2007 New York ENERGY STAR® requirement. Buildings were not evaluated for additional ENERGY STAR® requirements.

The challenge builders will encounter when moving from ECC NYS 2007 to IECC 2009 is clearly demonstrated here where there is a drop in compliance rates of between 40% and 70% between the two codes. This achievement gap will need to be filled with builder education and a focus on compliance issues if there is a chance of closing it.

I.1.3.2 Component Compliance Summary

In addition to overall compliance, individual components were also analyzed for compliance. **Table I-6** and **Table I- 7** summarize individual component compliance statewide and by Climate Zone, as well as the average installed efficiency values observed from the on-site visits.

Table I-6: Average Statewide Building Compliance Rates

Component	Sample Size	Unit	Verified Value	Percent in Compliance
Building Thermal Envelope				
Doors	44	U-Factor	0.29	93%
Windows	44	U-Factor	0.35	82%
Ceiling, attic	44	R-Value	36	82%
Ceiling, vaulted		R-Value	32	
Above-Grade Walls	44	R-Value	18	86%
Frame Floor	24	R-Value	25	75%
Basement Walls	40	R-Value	13	78%
On-Grade Slab, unheated	14	R-Value	5	21%
On-Grade Slab, heated		R-Value	6	
On-Grade Slab, depth		Feet	1.4	54%
Air Leakage	44	CFM50	2803	n/a
		ACH50	5.5	n/a
Mechanical Systems				
Programmable Thermostat	44	Present	n/a	91%
Duct Insulation	36	R-Value	4.3	81%
Duct Leakage to Outside	29	CFM25	171	n/a
		Percent floor area	5%	
Furnace Efficiency	31	AFUE	89	n/a
Boiler Efficiency	12	AFUE	86	n/a
Air Conditioner Efficiency	33	SEER	13	n/a
Hot Water Efficiency, gas tank	27	EF	0.62	n/a
Lights and Appliances				
Efficient Lamps	44	Present	29%	n/a
Efficient Fixtures	44	Present	30%	n/a
Ventilation dampers	35	Present	80%	89%

Table I- 7: Average Building Characteristics and 2007 NYS ECCC Component Compliance Rates by Climate Zone

Component	Unit	Climate Zone 4			Climate Zone 5			Climate Zone 6		
		Code Value	Verified Value	Percent In compliance	Code Value	Verified Value	Percent In compliance	Code Value	Verified Value	Percent In compliance
Building Thermal Envelope										
Doors	U-Factor	0.40	0.38	78%	0.35	0.26	96%	0.35	0.29	100%
Windows	U-Factor	0.40	0.37	78%	0.35	0.36	81%	0.35	0.33	89%
Ceiling, attic	R-Value	38	29	56%	38	38	100%	49	39	56%
Ceiling, vaulted	R-Value	30	29		30	32		30	35	
Above-Grade Walls	R-Value	15	17	56%	21	18	100%	21	20	78%
Frame Floor	R-Value	19	23	86%	30	26	75%	30	25	60%
Basement Walls	R-Value	10/13	10	38%	10/13	12	88%	10/13	17	86%
On-Grade Slab, unheated	R-Value	10	3	17%	10	7	33%	10	0	0%
On-Grade Slab, heated	R-Value	15	7		15	8		15	0	
On-Grade Slab, depth	Feet	2	0.7	40%	2	2.6	83%	4	0	0%
Air Leakage	CFM50	n/a	5379	n/a	n/a	2260	n/a	n/a	1795	n/a
	ACH50		9.0			4.3			5.3	
Mechanical Systems										
Programmable Thermostat	Present	Yes	n/a	100%	Yes		100%	Yes		56%
Duct Insulation	R-Value	8	4.9	43%	8	1.7	96%	8	5.3	50%
Duct Leakage to Outside	CFM25	n/a	367	n/a	n/a	172	n/a	n/a	113	n/a
	Percent floor area		13%			5%			4%	
Furnace Efficiency	AFUE	78	84	n/a	78	90	n/a	78	93	n/a
Boiler Efficiency	AFUE	80	84	n/a	80	84	n/a	80	96	n/a
Air Conditioner Efficiency	SEER	13	13	n/a	13	13	n/a	13	14	n/a
Hot Water Efficiency, gas tank	EF	0.59	0.65	n/a	0.59	0.61	n/a	0.59	0.62	n/a
Lights and Appliances										
Efficient Lamps	Present	n/a	46%	n/a	n/a	19%	n/a	n/a	42%	n/a
Efficient Fixtures	Present	n/a	47%	n/a	n/a	19%	n/a	n/a	43%	n/a
Ventilation	Present	n/a	11%	75%	n/a	4%	96%	n/a	11%	75%

The results reported in **Table I-6** and **Table I- 7**are evaluated considering the following points:

1. Not all homes have features subject to all code requirements (e.g. slab insulation). Average efficiency and compliance values are calculated only from homes that have the required code component (e.g. average slab R-values and compliance rates are only for homes with slabs).

2. Cells highlighted in yellow in **Table I- 7** show specific components of concern. These are discussed in more detail later this report.

3. Area weighted nominal R-values are calculated as Total Area/Total UA=R-value.

4. Area weighted U-factors are calculated as Total UA/Total Area = U-factor.

5. Frame floor values do not include uninsulated floors over basements where basement walls are insulated. Includes one home with R-0 insulation where foundation walls were also not insulated.

6. Basement walls values do not include basement walls where overhead floors are insulated. Includes two homes with R-0 insulation where overhead floor was not insulated.

7. Slab values are for on-grade slabs only. The sample includes slabs with R-0 insulation. The average slab includes the distance (in feet) under the slab only in homes where perimeter insulation also exists (i.e. if only under slab insulation was present and no slab perimeter insulation, the under slab insulation distance is not included in the average.

8. Duct compliance rates include ducts that are located inside conditioned spaces (these are considered in compliance). Average duct insulation values are only for ducts not in conditioned spaces.

9. Mechanical system efficiency levels are assumed to be the Federal Government minimum standard.

10. The Federal Government minimum energy efficiency standard for water heating is based on a 40 gallon tank. The average gas tank size in New York is 45 gallons.

11. Ventilation verified values show what percentage of homes had mechanical ventilation systems. The ‘Percent in Compliance’ column shows what percentage of these systems complied with the code requirement for dampers on air intakes and exhausts.

Figure I-3 shows graphically how individual component compliance rates with 2007 NYS ECCC compare in each Climate Zone and for New York State as a whole.

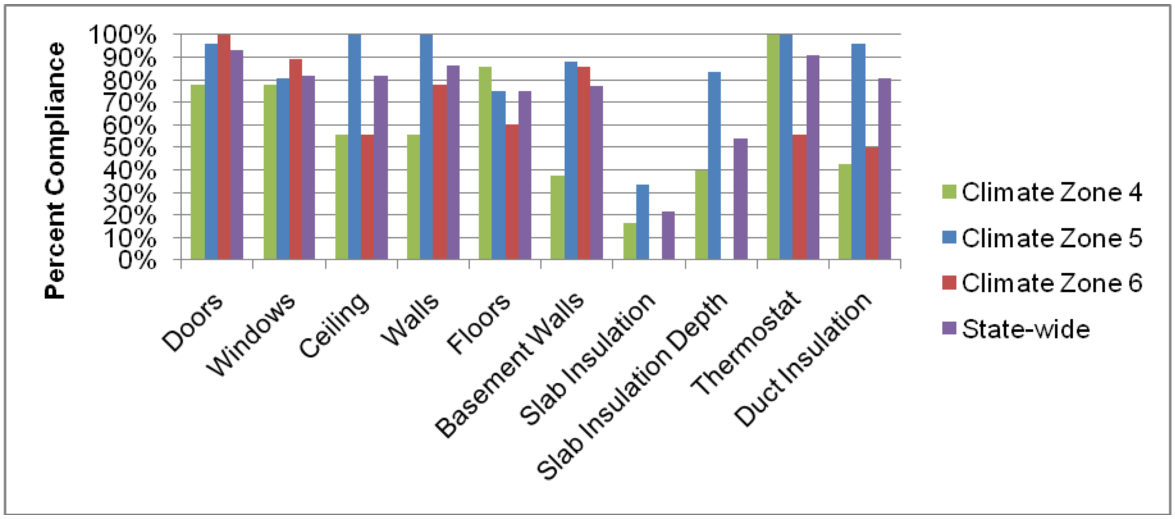


Figure I-3: Summary Component Compliance with 2007 NYS ECCC

While on-grade slabs are clearly a building component that needs attention in order to improve compliance rates above the statewide 21%, there are also other components that deserve focus in order to help builders comply with code. Ceilings in Climate Zones 4 and 5, above grade and basement walls in Climate Zone 4, as well as duct insulation in Climate Zones 4 and 6 all seem to need improvement. On the other hand, fenestration compliance rates are relatively high statewide. Furnace and boiler efficiencies (at 89% and 86% AFUE) are also quite a bit higher than federal standards (of 78% and 80% respectively). While these higher efficiencies have been used to trade-off against lower thermal envelope values in past codes, this is no longer permitted under the IECC 2009 (and 2010 NYS ECCC) Code, which will make it that much more difficult for builders to move from current construction practices to the new energy codes unless they improve the efficiency of other building elements. Identification of areas of non-compliance should aid in future training and support efforts to help builders understand how to improve their homes and code officials where to focus to ensure higher rates of compliance

The high average wall R-value in Climate Zone 4 is due to one home with spray foam insulation in the walls. Setting this one home to a more common R-value seen in Climate Zone 4 (R-13) brings the average to R-14, below code. There were two homes in Climate Zone 6 with on-grade slabs, one radiant, one not. The slab perimeter was not insulated in either home. The radiant slab was insulated to R-3.5 six feet under the slab.

At 5% duct leakage statewide, this value is almost half of the 8% (of CFM_{25} leakage to outside) required by IECC 2009. Low duct leakage rates can be explained in part because the method of deriving that rate is by dividing the total duct leakage to outside by the total conditioned floor area. The code definition of conditioned space, which includes most basements, increases the total conditioned floor area. This issue is discussed further in the sub-section on average building characteristics, below. The majority of duct systems, 86%, were located in conditioned spaces. In homes where ducts were located in unconditioned spaces the average duct insulation level was found to be below code, R-4. Of the 14% of homes with ducts located in unconditioned spaces, only two were insulated to the code requirement, R-8.

Efficient lighting is installed about 30% of the time. Climate Zones 4 and 6 lead the state in lighting efficiency, yet the largest percentage of homes is in Climate Zone 5. This will be a consideration with the IECC 2009 efficient lighting requirement since it requires 50% efficient lighting for homes that use the prescriptive compliance path. The requirement is mandatory for all homes under the 2010 NYS ECCC.

Component Compliance Detail

Buildings were evaluated at the component level to gain insight into which features of the home are most often in compliance, and which are the least often compliance. Overall, homes had high fenestration compliance rates. The three homes in the sample with exterior foundation were all found to have exterior foundation insulation levels that were in compliance. Ceiling and wall compliance rates are high when evaluated against ECCC NYS 2007, but drop significantly when evaluated against IECC 2009. Duct leakage and infiltration compliance rates are also high across the state with the exception of infiltration and duct leakage in Climate Zone 4, where the reported average infiltration ACH_{50} rate was almost twice the statewide average and the reported average duct leakage CFM_{25} rate was over twice the statewide average. Average mechanical system efficiencies are all above the Federal minimum requirements. Where components fall very short of the code are slab insulation and foundation walls in Climate Zone 4. Ceiling and wall compliance rates in Climate Zones 4 and 6 will also need to rise significantly to be in compliance with IECC 2009. Mechanical systems are greatly oversized in all Climate Zones.

Table I- 8: Compliance Rates of Building Elements to 2007 NYS ECCC

Higher Compliance	Lower Compliance
• Fenestration • Exterior foundation wall insulation • Duct leakage rates • Infiltration rates (Climate Zones 5 and 6) • Mechanical system efficiencies	• Slab insulation • Interior foundation wall insulation (Climate Zone 4) • Ceiling and wall insulation in Climate Zones 4 and 6, and when evaluated against IECC 2009 • Infiltration rates (Climate Zone 4) • Duct leakage rates (Climate Zone 4) • Mechanical system sizing

Each of the major code components, including building thermal envelope and mechanical systems, is discussed in more detail in the following sections.

1. Building Thermal Envelope

Insulation and Fenestration

Fenestration, including doors windows and skylights, shows the highest compliance rates across all Climate Zones. The second most compliant components are ceilings and walls, specifically in Climate Zone 5. However, these two components are in compliance with 2007 NYS ECCC largely due to trade-off allowances. As noted in the Trade-Off (e.g. REScheck™) compliance section, over 60% of homes statewide were in compliance by using one of the allowable systems trade-off approach (i.e. high efficiency heating, blower door and/or duct leakage). The least compliant components are slabs and foundation walls, specifically for Climate Zone 4, as well as ceilings and walls in Climate Zones 4 and 6. Building envelope compliance rates, excluding infiltration because it is an optional requirement, for both 2007 NYS ECCC and IECC 2009 are listed in **Table I- 9**.

Table I- 9: Building Envelope Compliance with 2007 NYS ECCC and IECC 2009

	Climate Zone 4		Climate Zone 5		Climate Zone 6		Statewide	
	NYS 2007	IECC 2009	NYS 2007	IECC 2009	NYS 2007	IECC 2009	NYS 2007	IECC 2009
Foundation Walls - Exterior	100%	100%	n/a	n/a	100%	100%	100%	100%
Foundation Walls – Interior	43%	29%	88%	88%	80%	80%	78%	76%
Slabs	17%	17%	33%	33%	0%	0%	21%	21%
Doors	78%	67%	96%	92%	100%	100%	93%	89%
Windows	78%	56%	81%	77%	89%	78%	82%	73%
Floors	86%	86%	75%	42%	60%	40%	75%	54%
Walls	56%	56%	100%	23%	78%	67%	86%	39%
Ceilings	56%	44%	100%	92%	56%	44%	82%	73%

It is readily obvious that slabs are by far the most non-compliant component, followed by foundation walls in Climate Zone 4. This should provide an indication of emphasis for future builder training and for focusing awareness for code officials. Needless to say most every component will need improvement before reaching the 90% compliance rate for IECC 2009.

Comparing component compliance rates between 2007 NYS ECCC and IECC 2009 should be done with some caution. As discussed above, well over one-half of the homes in the sample were compliant by a Trade-Off (e.g. REScheck™) approach that is not applicable under the IECC 2009. Therefore, building envelope components were evaluated against the prescriptive requirements of the IECC 2009 code. Fenestration compliance, while falling somewhat when evaluated against IECC 2009, stays relatively unchanged. Walls and ceiling compliance, and less so floors, show a significant drop. This is again primarily due to the lack of a system trade-off allowance in IECC 2009. The high efficiency system trade-off approach allowable under 2007 NYS ECCC allows walls to be insulated to R-13 for all Climate Zones. Even under an Overall UA approach, wall insulation will need to be a lot closer to R-20 than R-13, the IECC 2009 requirement for Climate Zone 5 where most homes are located.

Air Leakage

As mentioned above in the section on house size, air leakage rates are highly dependent on the calculation of conditioned space. To conduct a blower door test per the RESNET Standard, a basement door must be closed if the basement is considered unconditioned and open if it is considered conditioned. For this report, data was collected for two different purposes: code compliance and a HERS rating. In homes where blower door tests were conducted with the basement door closed per the HERS rating requirement, but code defined the basement as conditioned, an adjustment was made to the CFM_{50} (cubic feet per minute at 50 Pascals of pressure) value to estimate CFM_{50} had the door been open. Experience of raters in the field indicates that 15% increase in CFA_{50} is a reasonable estimate. The CFM_{50} value is then multiplied by 60 and then divided by the volume of the home to give the ACH_{50} (air changes per hour at 50 Pascals of pressure) value as presented in code infiltration requirements. Again, volume may be calculated differently for code and for a HERS rating due to the variance in conditioned space definitions. **Table I- 10** presents the average CFM_{50}value obtained for the HERS rating, adjusted where necessary to account for inclusion of the basement. ACH_{50} values are calculated using the total volume as defined by code.

Table I- 10: Average CFM50 and ACH50 Rates

	Climate Zone 4	Climate Zone 5	Climate Zone 6	Statewide
	n=9	n=26	n=9	n=44
CFM50	5379	2260	1795	2803
ACH50	9.0	4.3	5.3	5.5

Both the 2007 NYS ECCC and IECC 2009 have air leakage requirements, but neither code requires blower door testing. As a point of reference, the optional tested infiltration requirement of 2007 NYS ECCC that allows for alternative ceiling and wall insulation R-values, is 5.5 ACH_{50}. The optional blower door testing requirement for IECC 2009 is less than seven ACH_{50}. Climate Zone 5 and 6, as well as the statewide average, meet both code optional testing requirements. Climate Zone 4, however, has a long way to go before it meets either optional requirement. While blower door testing is currently optional, it is reasonable to think that is will be required in future codes.

Because New York State had very few truly unconditioned basements (uninsulated foundation walls with an insulated floor overhead) the calculated ACH_{50} rates for code and for a HERS rating were very similar. ACH_{50} rates can be as much as 10% higher due to the inclusion of a basement space during the blower door test.

2. Systems

The compliance rates reported for systems only include those homes with the given component. For example, 89% compliance with the ventilation damper code requirement does not include those homes without mechanical ventilation. **Table I- 11**lists the compliance rates with mechanical systems requirements for both 2007 NYS ECCC and IECC 2009.

Table I- 11: Mechanical Systems Compliance Rates for ECCC NYS 2007 and IECC 2009

	Climate Zone 4		Climate Zone 5		Climate Zone 6		Statewide	
	NYS 2007	IECC 2009	NYS 2007	IECC 2009	NYS 2007	IECC 2009	**NYS 2007**	**IECC 2009**
Programmable Thermostat	100%	100%	100%	100%	56%	60%	**91%**	**94%**
Duct Insulation	43%	43%	96%	96%	50%	50%	**81%**	**81%**
Duct Sealing	0%	0%	88%	88%	25%	25%	**68%**	**68%**
Duct Leakage	n/a	67%	n/a	96%	n/a	75%	**n/a**	**90%**
Ducts in Building Cavity	100%	100%	100%	100%	100%	100%	**100%**	**100%**
Mechanical System Piping Insulation	75%	75%	95%	52%	100%	0%	**91%**	**52%**
Ventilation Dampers	75%	75%	96%	96%	75%	75%	**89%**	**89%**
Equipment Sizing	0%	0%	0%	0%	0%	0%	**0%**	**0%**

Table I- 11 shows that 2007 NYS ECCC and IECC 2009 have very similar compliance rates for the mechanical systems requirements of the code. IECC 2009 shows slightly lower compliance with the mechanical systems piping insulation requirement as the requirement is slightly higher than that of the New York State code (R-3 vs.R-2). IECC 2009 has a slightly higher compliance rate for programmable thermostats. This is because for IECC 2009 the requirement is restricted to Forced Hot Air systems, where the New York State energy code applies to all homes. No homes were found to have a circulating hot water system. That code requirement is therefore not listed in **Table I- 11** above. Two homes were found to have ACCA Manual J sizing calculations, but installed equipment did not match the documentation in either case, nor was it right sized according to REM/Rate™ modeling.

Duct leakage requirements are based on conditioned floor area (total leakage to outside divided by total conditioned floor area). Compliance with the duct leakage requirements of IECC 2009 were assessed based on the code definition of conditioned floor area. As discussed in the section on house size, calculation of conditioned floor area is slightly different for code and for a HERS rating. A HERS rating requires a space to be conditioned and finished, whereas code only requires the space to be conditioned. The average conditioned floor area for the REM/Rate™ models is slightly lower than the average calculated for code. Therefore, the duct leakage compliance rates reported in **Table I- 11** re slightly higher than would be reported from REM/Rate™ based on HERS modeling. The statewide average duct leakage compliance rate based on the HERS models is 79%, vs.90% as calculated for code.

Duct leakage testing was not required under the 2007 NYS ECCC, but it is a requirement of IECC 2009. **Table I- 12** shows how the average duct leakage rates for each Climate Zone and statewide compare with the IECC 2009 requirement.

Table I- 12: Duct leakage rates compared to the IECC 2009 requirement

	Climate Zone 4	Climate Zone 5	Climate Zone 6	Statewide
IECC 2009 Requirement 8 CFM_{25} per100 sq. ft. CFA	**n=3**	**n=24**	**n=4**	**n=31**
CFM_{25}	367	172	113	171
CFM_{25} per 100 sq. ft. CFA	13	5	4	5

All Climate Zones and the statewide average are below the IECC 2009 requirement. Duct leakage testing is not required when ducts are located within conditioned spaces. This was the case for many homes in New York State.

Equipment Sizing

ECCC NYS 2007 requires right-sizing of heating and cooling equipment per section 403.6 of the energy code. Without using the procedures in the ACCA Manual S Residential Equipment Selection, it is difficult to quantify by what percent heating and cooling systems have been *oversized*. Rather, what is presented here is a comparison of the total design load, as calculated by REM/Rate™, and the total installed capacity of the heating or cooling system. Installed capacity is presented as a percentage greater than design. During the code office visits, HVAC sizing documentation (ACCA Manual J) was found for only two homes in the sample. The on-site visit showed that the installed equipment did not match the sizing calculations, but was oversized.

Of the 33 homes with cooling, two homes had undersized systems and two homes had installed capacity within 20% of the design load. The remaining 29 homes (88%) had cooling systems where the installed capacity exceeded the design load by more than 20%. Looking only at cooling systems where installed capacity was 20% or greater than the design load, on average, total system capacity was 116% greater than the design load. This translates to approximately 2 tons of additional installed capacity. There was one home in the sample with extremely oversized heating and cooling systems. The cooling system was oversized by over 300% (270 tons of *additional* capacity than was needed). Removing this home from the sample results in a statewide average installed cooling capacity of about 1.5 tons more than required by the design load. Heating system capacity exceeded the design load by 138%. This translates to approximately 66 kBTUh additional installed capacity over the required design load. Removing the one home with extremely oversized mechanical systems (nearly 380% oversized, or 490 kBTUh additional installed heating capacity) from the sample brings the statewide average to 56 kBTUh additional installed capacity. **Figure I- 4** shows the average installed capacity and average design load for both heating and cooling systems.

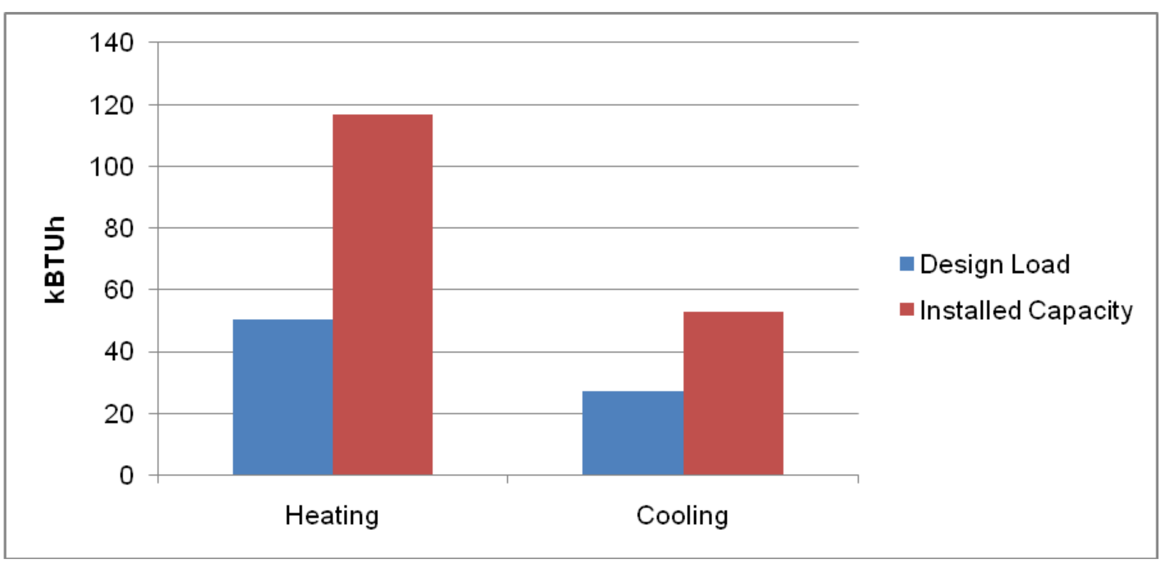


Figure I- 4: Average HVAC Design Load versus Installed Capacity

Both heating and cooling systems are being greatly oversized. Oversizing results in higher upfront and operating costs to the customer, as well as comfort and building performance issues that come with oversized cooling equipment due to a reduced ability to remove moisture from the air.

Table I- 13 below shows the average installed capacity, design load and percent that installed capacity exceeds design load by Climate Zone and statewide for each mechanical system. The average percent installed capacity exceeding the load presented below was calculated individually for each home and averaged for each Climate Zone and Statewide. These percentage results are slightly different than using the overall capacity and design load averages presented in **Table I- 13** to perform the calculation.

Table I- 13: Average Installed Capacity and Calculated Design Loads

	Climate Zone 4	Climate Zone 5	Climate Zone 6	Statewide
Heating				
Installed Capacity (kBTUh)	207	100	81	117
Design Load (kBTUh)	71	29	36	50
Percent Capacity Exceeds Load	218%	117%	125%	138%
Cooling				
Installed Capacity (tons)	10.9	2.9	3.7	4.4
Design Load (tons)	4.7	1.7	1.9	2.3
Percent Capacity Exceeds Load	149%	108%	119%	116%

It is clear from the data shown in **Table I- 13** above that both heating and cooling systems are greatly oversized across the state. Modified installed capacity ranged from a reduction in capacity of 1 ton to 23 tons, with most in the 0.05 to 1.5 ton range. One home had exceedingly oversized mechanical systems, requiring a 23 ton reduction in capacity. Removing this home from the sample brings the average reduction in capacity to 1.5 tons. The lost energy savings potential estimated by REM/Rate™ was unexpectedly low, showing a 2% reduction in cooling consumption on average. The REM/Rate™ models, however, only account for a reduction in installed cooling capacity. The models do not account for proper installation and duct system design which would also contribute significantly to lost savings. Cooling system oversizing has other undesirable impacts including higher installation and operating costs to the homeowner as well as improved comfort and building performance obtained by better humidity control with a properly sized system. Most importantly, system oversizing can have a significant impact on the electric grid. The 1.5

ton average oversized cooling equipment would result in 0.76 kW connected load (assuming a 0.55coincidence factor). For all 12,250 one- to four-unit homes constructed in a typical year, less the approximately 23% that are ENERGY STAR ® labeled and assumed to be right-sized, this represents a potential increase in peak demand of more than 7 MWs from the New York's electrical grid.

I.1.3.3 ECCC NYS 2007 Administrative Compliance

A code office visit was conducted, when possible, for each home. In general, the VEIC Team had difficulty obtaining the required documents for compliance evaluation. **Table I- 14** reports the percent of homes where required documentation existed at the code office. Only homes where a 'Yes' or 'No' was reported are included in the denominator. Where specific documentation was not applicable, or the home was not complete, these homes were not considered in the percent incidence rate. Documented stamped plans show the highest incidence rate. Overall, there was a general lack of documentation found during the code office visits.

Table I- 14: Incidence of Code Office Documentation

	Climate Zone 4	Climate Zone 5	Climate Zone 6	Statewide
Documentation sufficient to demonstrate compliance	22%	73%	44%	57%
HVAC Sizing Calculations	0%	8%	0%	5%
Certificate of Occupancy	38%	75%	86%	69%
Stamped Plans	67%	100%	67%	86%
Residence Inspection Report(s)	25%	24%	44%	29%
Garage Inspection Report	13%	16%	0%	11%
Fireplace Inspection Report	0%	24%	0%	16%
Sewer and Water Inspection Report	44%	55%	56%	53%
REScheck™ Compliance Report	44%	88%	33%	68%
Residential Code Checklist (REScheck™ Inspection Checklist)	56%	56%	33%	51%

I.1.4 Average Building Characteristics

This section reports on the average building characteristics found during the on-site visits.

I.1.4.1 House Size

Calculating average house size in terms of conditioned floor area (CFA) is not a straight-forward task. CFA is defined and interpreted many different ways. For this report, only two are of concern: CFA as defined by code and as defined by the Residential Energy Services Network (RESNET) Standard (which is used in issuing a HERS Energy Rating). The written definitions for CFA are slightly different and there is room for interpretation. The different definitions are important in terms of reporting average CFA as well as average infiltration and duct leakage rates. The ECCC NYS 2007 and RESNET Standard definitions are as follows:

> **ECC NYS 2007:** Conditioned Space: An area or room within a building being heated or cooled, containing uninsulated ducts [or hydronic pipes], or with a fixed opening directly into an adjacent conditioned space.
>
> **RESNET Standard:** Conditioned Floor Area (CFA) – The finished floor area in square feet of a home that is conditioned by heating or cooling systems, measured in accordance with ANSI Standard Z765-2003 with exceptions as specified in Appendix A of this Standard. [Exemption states to include all floor area, even if less than 5' ceiling height.]

The primary difference is that RESNET, and therefore HERS ratings, require a space to be finished as well as conditioned; while, code does not. Beyond that, there are further interpretations of whether or not basements are considered conditioned. For this report, the team recorded the conditioned floor area as defined by code as well as for a HERS rating and distinguish between basements and above grade floor area. **Table I- 15** reports average conditioned floor area as defined by code as well as by RESNET as is required for a HERS rating. Basement and above grade floor areas are reported separately in addition to total conditioned area. Average basement CFA only includes homes with conditioned basements (i.e. no "zero" values are included in the average). This is why the average total CFA does not equal the average basement plus average above grade CFA values presented in the table.

Table I- 15: Average CFA as defined by code and RESNET (for a HERS rating)

	Climate Zone 4	Climate Zone 5	Climate Zone 6	Statewide
Average Conditioned Floor Area as Defined by 2007 NYS ECCC				
Basement	1463	1466	1270	1439
Above Grade	3398	2316	1855	2443
Total	4699	3725	2560	3686
Average Conditioned Floor Area as Defined by RESNET (HERS Rating)				
Basement	1453	1833	1425	1555
Above Grade	3361	2316	1855	2435
Total	4491	2598	2330	2930

Statewide, the average floor area as defined by RESNET, which includes only conditioned and finished space, is about 20% less than as defined by code. By the code definition, basements are more often considered conditioned space. This is important when considering infiltration and duct leakage requirements. As shown in **Table I- 15** it is primarily the basement space that leads to the difference in overall average CFA. There were two multi-family homes in Climate Zone 4 that were modeled as a whole building rather than a single unit. These two buildings actually had smaller CFA than the reported average. The high average in this Climate Zone is due to two single family homes, one with a CFA over 8500 sq. ft., the other over 11,000 sq. ft. Regardless of how one defines "conditioned space", the trend is clear for New York State that the largest homes are built in the southern part of the state and homes get smaller at you go north. In Climate Zone 4, conditioned floor areas are approximately 4,600 sq. ft., in Climate Zone 5 about 3,200 sq. ft. and in Climate Zone 6 approximately 2,400 sq. ft. The statewide conditioned floor average square footage is about 3,300 sq. ft.

Table I- 16 shows the percentage of conditioned vs. unconditioned basement types as defined by code and as required for a HERS rating. While the percentage of conditioned basement type is close as defined by code and a HERS rating, there is a higher percentage of conditioned basements as defined by code (86% vs. 80%). As basement walls are insulated and the temperature comes closer to that of the rest of the house, basements will more often be considered conditioned for modeling purposes.

Table I- 16: Percentage of Basement Type

	Climate Zone 4	Climate Zone 5	Climate Zone 6	Statewide
Percent of Basement Type as Defined by ECCC NYS 2007				
Conditioned	89%	96%	56%	86%
Unconditioned	11%	4%	44%	14%
Percent of Basement Type as Defined by RESNET (HERS Rating)				
Conditioned	56%	96%	56%	80%
Unconditioned	11%	4%	33%	11%
More than one Type	33%	-	11%	9%

I.1.4.2 Housing Characteristics

Additional housing characteristics are presented in **Table I- 17** below. For this report, "Single Family Attached" is defined as a single unit of a duplex or townhouse, and "Multi-Family Whole Building" is defined as the entire building of either a townhouse or duplex, or other multi-family building of three stories or less.

Table I- 17: Average Building Characteristcs for New York State

	Climate Zone 4	Climate Zone 5	Climate Zone 6	Statewide
	n=9	n=26	n=9	n=44
Housing Type				
Single Family Detached	44%	92%	89%	82%
Single Family Attached	33%	4%	11%	11%
Multi Family Whole Building	22%	4%	0%	7%
Number of Stories (SF)	2.6	1.8	1.8	2.0
Number of Stories (MF)	2.0	2.0	n/a	2.0
Number of Stories (Overall)	2.4	1.8	1.8	2.0
Number of Bedrooms (SF)	3.7	3.3	3.3	3.4
Number of Bedrooms (MF	3.5	6	n/a	3.4
Number of Bedrooms (Overall)	3.7	3.4	3.3	3.5
Mechanical Systems				
Central Air Conditioning	67%	92%	33%	75%
Space Heating Fuel				
Natural Gas	92%	83%	60%	80%

Propane	8%	7%	30%	12%
Oil	-	7%	-	4%
Electric	-	-	10%	2%
Wood		3%	-	2%
Space Heating System Type				
Forced Hot Air	42%	86%	50%	70%
Hydronic	58%	14%	50%	30%
Lighting				
Total Lamps in Permanent Fixtures	142	60	56	76
High Efficacy Lamps in Permanent Fixtures	46%	19%	42%	29%
Total Permanent Fixtures	92	36	32	47
High Efficacy Permanent Fixtures	47%	19%	43%	30%

Table I- 17 shows that the large majority of homes sampled for this report were single family detached. As expected, single family attached and multi-family buildings were more heavily concentrated in Climate Zone 4. While fuel type is presented only for space heating, water heating fuel types follow a similar distribution. Climate Zone 4 also shows the highest number, by far, of total lighting sockets as well as fixtures. While Climate Zones 5 and 6 have fewer sockets on average, there is still a great opportunity for savings from the prescriptive lighting requirement in the IECC 2009 code. As reported in **Table I- 17** , only 19% of permanently installed lamps and fixtures in Climate Zone 5 are high efficiency.

I.1.4.3 Average Characteristics of Mechanical Systems

The majority of mechanical equipment installed was standard heating and cooling systems. One Air Source Heat Pump was found in the sample, as well as three combined space and water heating systems. One home had electric baseboard as its primary heating source. The average incidence and efficiency of heating systems by system and fuel type are presented in **Table I- 18** below.

Table I- 18: Percent of Heating System Type and Average Efficiency

	Forced Hot Air		Hydronic	
	Percent of System Type	**Average Efficiency (AFUE)**	**Percent of System Type**	**Average Efficiency (AFUE)**
Climate Zone 4				
Natural Gas	42%	84	50%	82
Propane	n/a	n/a	8%	93
Climate Zone 5				
Natural Gas	76%	90	7%	93
Propane	7%	92	-	n/a
Oil	3%	80	3%	84
Wood	n/a	n/a	3%	65
Climate Zone 6				
Natural Gas	50%	93	50%	96
Statewide				
Natural Gas	64%	90	23%	88
Propane	4%	92	2%	93
Oil	2%	80	2%	84
Wood	-	-	2%	65

Natural gas forced hot air heating systems are the most common type in New York State. Climate Zone 6 is the only Climate Zone with a 50/50 split between forced hot air and hydronic heating systems. System efficiencies for each fuel type are fairly similar across system types and Climate Zones and exception being Climate Zone 4 which has lower natural gas heating efficiencies.

Central air conditioning systems were found in 33 homes, or 75% of the total sample. Of these, one was an Air Source Heat Pump. The highest incidence was found in Climate Zone 5where 92% of homes had central air conditioning. Climate Zone’s 4 and 6 had an incidence rate of 67% and 33% respectively. The average efficiency was 13 SEER across the state. Homes in Climate Zone 6 had a slightly higher average efficiency, 14 SEER.

Water heating fuel types followed a similar distribution as space heating fuel. The one exception to this is electrically heated hot water where 10% of water heating systems were electric; all of these were conventional tanks. These were found only in Climate Zones 5 and 6. The most common system type by far was a conventional tank found in73% of the sample. The second most common system type was an indirect fired tank, accounting for 13% of the sample. The remaining system types were split evenly between instantaneous and combined appliance system types. Water heating system efficiencies were also very similar across Climate Zones. The average statewide efficiency of conventional natural gas and propane tanks was 0.62 EF. The average efficiency of electric tanks was 0.92 EF. Of the remaining natural gas and propane- fired systems, instantaneous water heaters had the highest average efficiency, 0.91 EF, followed by a slightly lower average efficiency for indirect fired tanks and combined appliances of 0.86 EF. Indirect fired tanks in Climate Zone 6 had a higher average efficiency than the statewide average, 0.91 EF.

I.1.4.4 Exceptions to the Average

One home in the sample was a log home and another was electrically heated. The log home had tested infiltration rate below 5.5 ACH_{50}, a high efficiency boiler by the requirements of the ECCC NYS 2007 code and was in compliance by the Simulated Performance Alternative. The log wall, however, did not meet the requirement of Section 402.2.3 stating that the provision for mass walls is applicable where at least 50 percent of the R-value is integral to the wall. Therefore, the code reference wall for this home was a standard wood frame wall as required by the code. Modeled this way, the home did not pass the overall UA requirements. Because REM/Rate™ does not take into account the high efficiency mechanical system trade-off when calculated overall UA compliance, this home may have been considered in compliance under the Trade-Off (e.g. REScheck™) approach had the builder run a REScheck™ analysis. The BECP Protocol compliance score for this home was 43%, well below average.

One home was an electrically heated home. Electrically heated homes must use REScheck™ to demonstrate compliance or meet more stringent prescriptive insulation and fenestration requirements. This home had no REScheck™ report and was not in compliance by either the Trade-Off (e.g. REScheck™) or Performance approach as modeled by REM/Rate™. The BECP Protocol compliance score for this home was 28%, one of the lowest in the sample (only one home scored lower). The comments below were recorded by the HERS rater who visited the code office in this home's jurisdiction:

> "The code officer handles an average of two new buildings per year. This project was under 1500 sq. ft. The code officer states that no plans are required under 1500 sq. ft. The Building Permit fee is $50. The code officer stated that this fee does not cover the time to create a REScheck™ certificate. This was a home built in a very rural community. The Building Inspector was part time from a full time farming career. This inspector believed that high levels of insulation led to poor indoor air quality (IAQ)."

The comments made by this building inspector show that a great deal of training in building science is required, especially as insulation and infiltration requirements continue to become more stringent and IAQ becomes more of a concern.

I.1.4.5 Average Energy Consumption and Costs

The average energy consumption values presented here are modeled estimates produced by REM/Rate™. While actual observed values from the on-site visits are used as model inputs for the majority of energy components of the home, lighting and appliance consumption is estimated by REM/Rate™ using default values based on building size and occupancy assumptions. **Figure I- 5** illustrates graphically how energy consumption is distributed among the end uses statewide.

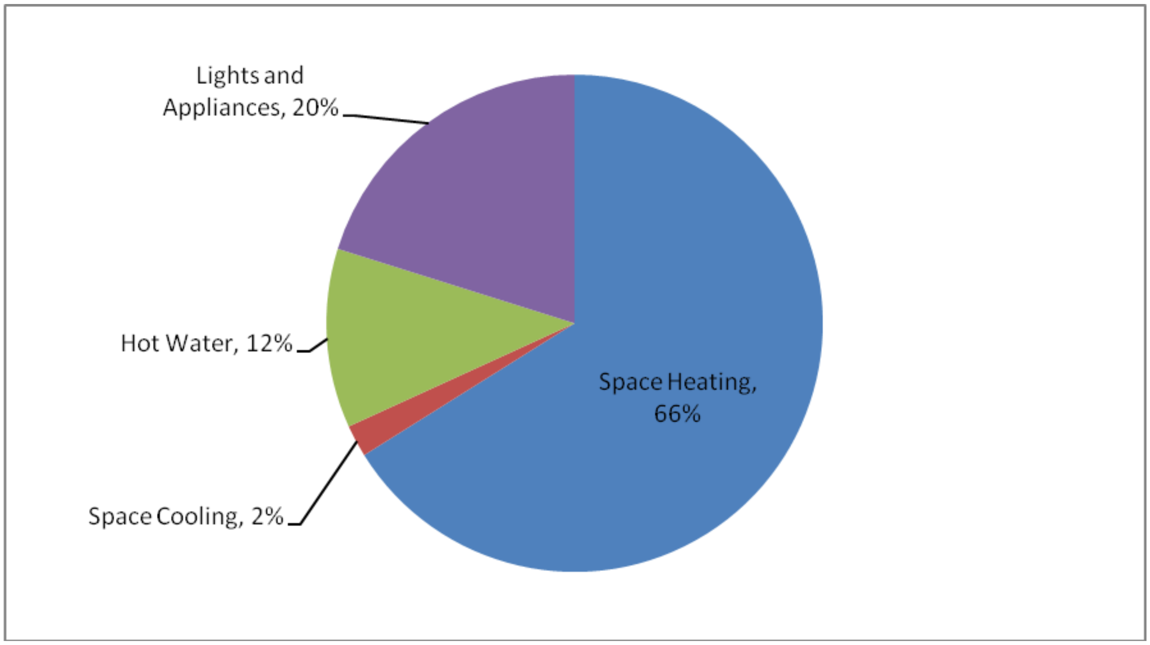


Figure I- 5: Energy Consumption by End Use

Table I- 19 shows the total annual energy consumption results as modeled by REM/Rate™ for each Climate Zone and Statewide.

Table I- 19: Total Energy Consumption by End Use (in MMBtu)

End Use	Climate Zone 4	Climate Zone 5	Climate Zone 6	Statewide
	n=9	n=26	n=9	n=44
Heating	137	108	85	109
Cooling	8	2	2	3
Water	21	19	16	19
Lights and Appliances	48	31	26	33
Total Consumption	214	160	130	165
Total Heating, Cooling and Water Consumption	167	129	103	132

Climate Zone 4 has by far the largest average energy consumption per home, reflecting the larger average home sizes of homes in this Climate Zone. It is interesting to note that though it is the warmest Climate Zone, it has the highest average heating consumption. Climate Zone 4 also has the highest average cooling consumption. Water heating consumption is fairly consistent across the state. Light and appliance consumption in Climate Zone 4 is primarily due to the large home sizes there and how REM/Rate™ estimates consumption for this end use.

Average fuel costs were obtained from NYSERDA's website to estimate annual energy costs. **Table I- 20** shows the average fuel costs by fuel type used for this analysis.

Table I- 20: Average 2010 Fuel Costs by Fuel Type

Fuel Type	Unit	2010 Cost
Natural Gas	$/ccf	$1.59
Propane	$/gal	$2.75
Oil	$/gal	$2.99
Electricity	$/kWh	$0.19

Total annual energy costs were calculated by converting the average modeled MMBtu consumption results from REM/Rate™ to the specific fuel type unit and multiplying by the cost per fuel type listed in **Table I-20** above. Average statewide energy consumption in fuel specific units and the calculated costs are shown in **Table I- 21**.

Table I- 21: Statewide Fuel Consumption by End Use

End Use	Fuel	Unit	Consumption	Cost	End Use Subtotal
Heating	Electricity	kWh	1,154	$214	$2,038
	Natural Gas	ccf	842	$1,337	
	Propane	Gal	138	$381	
	Oil	Gal	30	$91	
	Wood	Cord	0.1	$16	
Cooling	Electricity	kWh	929	$172	$172
Water	Electricity	kWh	652	$121	$459
	Natural Gas	ccf	165	$262	
	Propane	Gal	24	$67	
	Oil	Gal	3	$10	
Lights and Appliances	Electricity	kWh	9,771	$1,813	$1,813
Total Energy Expenditures				$4,483	$4,483

Figure I- 6 illustrates graphically the distribution of total energy expenditure by end use.

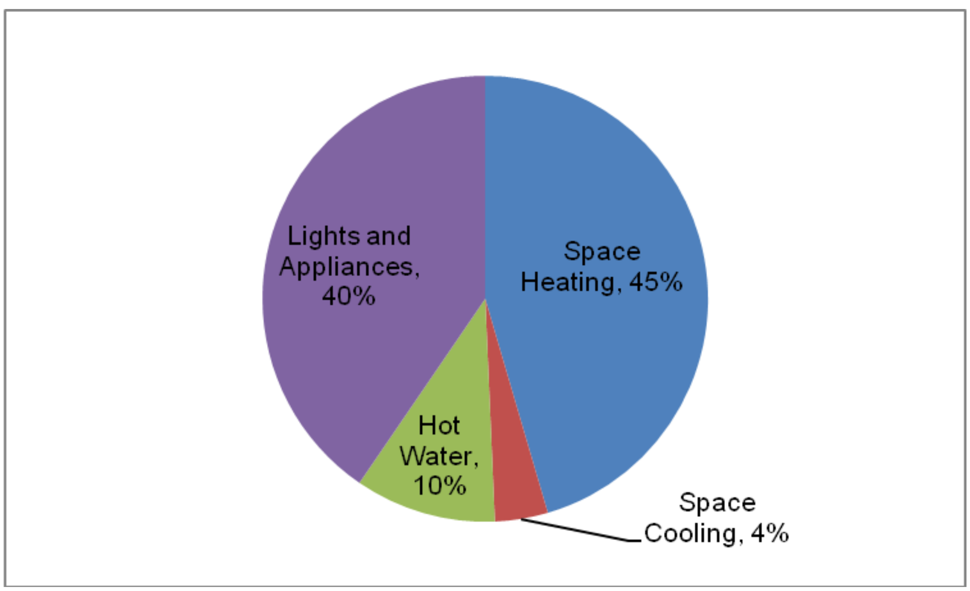


Figure I- 6: Distribution of Energy Expenditures by End Use

While the estimated total energy costs shown in **Table I- 21** may seem high, it is important to remember these numbers are based on modeled energy consumption, not actual energy consumption. The distribution of energy expenditures shown in **Figure I- 6** correlates very closely with a similar graphic shown in the NYSERDA report, “Economic High-Performance Design Options for Residential New Construction”. The estimated cost of lost savings presented in the Energy Impact of Non-compliance section, are based on these estimated annual energy costs.

I.1.5 Qualitative Feedback from Raters

After the CSG Auditors completed their site visits on each building to collect the data for this study, they were asked to complete a two page “General Observations Form” to collect their subjective observations. There were three sets of data collected in these forms:

1. A ranking of:
    a. Construction quality,
    b. Missed energy opportunities, and
    c. Recommendations for energy improvement;
2. A list of the four worst energy features found in the home; and
3. Auditor comments and subjective observations on each of the above rankings.

The data below summarize the findings for each of these data sets.

I.1.5.1 Ranking of Constructions Quality and Energy Opportunities

<u>1. Construction Quality</u>

In general, what is your opinion about the construction quality of this home, from poor to excellent? Are there aspect of the home that are worthy of noting below (good or bad)?

Ranking	Count Response	Percent Response
1 (poor)	0	0%
2	3	11%
3	7	26%
4	11	41%
5 (excellent)	6	22%

Sixty-three percent of the responses stated that construction quality ranked very good or excellent, with almost 90% of the responses indicating that quality was at least three on the scale of one to five. No Auditors ranked construction as “poor,” although several comments indicated concerns of construction quality.

2. Missed Energy Opportunities by Builder

What energy opportunities were missed by the builder that might have improved the home?

Ranking	Count Response	Percent Response
1 (many)	4	15%
2	4	15%
3	10	37%
4	9	33%
5 (none)	0	0%

While overall construction may have been quite good, the Auditors indicated that there were plenty of opportunities for improving energy efficiency. Two-thirds of the responses ranked the homes as having some or many missed energy opportunities. No homes were found to have no missed energy opportunities.

3. Recommendations for Energy Improvements

Do you have any energy efficiency or health & safety recommendations?

Ranking	Count Response	Percent Response
1 (many)	3	12%
2	4	16%
3	8	32%
4	10	40%
5 (none)	0	0%

The Auditors found that 60% of the homes had some or many energy efficiency or health and safety improvements that they would recommend. In 40% of the homes Auditors had few recommendations, and in no homes did they have no recommendations.

I.1.5.2 Worst Energy Features Found in the Sample Homes

Auditors selected from the list of energy features below and rated them as the #1, #2, #3 and #4 worst energy features.

		Worst Energy Feature			
		#1	#2	#3	#4
A	Wall insulation installation	-	-	-	-
B	Wall insulation R-values	4%	4%	-	12%
C	Wall air leakage	4%	7%	4%	-
D	Ceiling insulation installation	-	7%	4%	4%
E	Ceiling insulation R-values	4%	7%	4%	4%
F	Ceiling air leakage	22%	-	4%	-
G	Basement insulation installation (if present)	-	7%	-	-
H	Basement insulation R-value (inclR0)	-	-	4%	-
I	Basement air leakage	7%	-	-	-
J	Window quality	-	-	-	-
K	Window U-value	4%	4%	-	-
L	Window air leakage	4%	-	-	-
M	House air leakage reduction (overall)	22%	7%	7%	4%
N	Furnace/boiler installation quality	-	-	4%	-
O	Furnace/boiler efficiency (AFUE)	-	4%	7%	4%
P	Central air conditioning installation quality	-	-	-	-
Q	Central air conditioning efficiency (SEER)	-	4%	-	-
R	HVAC controls: thermostats/zoning	-	4%	4%	-
S	Duct system installation (not including insulation)	-	7%	-	4%
T	Duct system tightness	4%	11%	-	19%
U	Duct system insulation installation	-	-	-	-
V	Duct system insulation R-value	-	-	-	-
W	Water heater installation quality	-	-	-	-
X	Water heater efficiency (Energy Factor)	-	7%	7%	-
Y	House solar orientation	-	-	4%	4%
Z	Kitchen range hood quality/effectiveness	-	4%	7%	-
AA	Bathroom fan quality/effectiveness	4%	-	15%	15%
AB	Lighting – interior	22%	7%	11%	23%
AC	Lighting – exterior	#N/A	4%	11%	4%
AD	Other:	#N/A	4%	4%	4%

From all of the home components examined, Auditors identified house air leakage, lighting, duct system tightness, and bathroom fan effectiveness in the top four worst energy features of these homes. Second-tier energy features deserving attention included insulation R-values, insulation installation, heating system and water heater efficiencies, and duct system installation.

I.1.5.3 Auditor Comments and Subjective Observations

Auditors also provided subjective comments on each home in the areas of construction quality, missed energy opportunities, recommendations for energy improvements and general comments. Their candid remarks are reported below.

Construction Quality

Home was constructed well and the homeowner seemed to make upgrades to the home during construction like adding larger studding and upgrading the HVAC.
The carpentry and structural and finish work completed to date looks top notch. Tom has some knowledge of building science and wants to do the right thing, his air sealing and insulation is not up to snuff. There is a bypass from the stair to the T&G front porch roof. I am concerned that he addresses that. The windows are sweet!
Air sealing Poor framing and sheetrock finish
Beautiful finish, detailing,
Blow and Go construction? Not exactly doors and windows opened and closed. But the trim work was sloppy and there was little or no air sealing. The duct work was done by tin knockers who just don't care.
"Builder was personal friend of owners. Owners were on site daily.
Mechanical exhaust in master bed was not operating near specified rate. Owner specified larger bath fan (110cfm), and the flow rate was measured at ~25. There was no attic access but it is assumed that the vent ducting is constricted in attic.
Building looked to be constructed very well
Home looked to be constructed very well
I've seen worse houses, but they are mostly hunting shacks built in the forties. The homeowner has called the builder back to fix cracking drywall seams and other visible defects of which there are quite a few. Trim and moldings are not tight. I defense of the house doors and windows seem to function. I really have a problem with using joist cavities to bring unconditioned combustion air into the CAZ which is in the center of the home
Owner involved in design. Chose contractors specializing in 'Italian Tuscany Villa' style. Used HPwES contractors for HVAC and Insulation.
Owner' father was a mason. He had input into the foundation and slab pouring which was above average.
Poor craftsmanship
Poor framing and sheetrock finish
Sloppy framing and insulation.
The wood work and detailing was excellent. The electrical and plumbing and HVAC systems were installed with a pride of workmanship that one can only admire. Top Notch.
This was an owner built home with a lot of love, but little attention to details. Mason poured slab so water drains away from sump, block walls ran out 12" in 30' (therefore the cantilever). Owner did not have a building background and relied on relatives. (excellent sheet-rockers). Floor insulation was falling out in much of the basement ceiling.
While the tile; woodwork; doors and windows and stairs and trim were nicely installed. The insulation where visible failed in two out of three locations. Also even the plans call for sub-standard levels of insulation. I don't see why the plans were approved.

<u>Missed Energy Opportunities by Builder</u>

Detailing of attic insulation poor (grade 3 batts. Baffles sloppy. Sloppy attic hatch application. Basement outside envelope because it was cheaper than wall insulation, Many incandescent lights. Condensing boiler wasted on baseboard designed for 180 ºF HHW.
Start by choosing to locate the windows more strategically. How about at least meeting modern codes with insulation and ducts . How about air sealing before you insulate? What would be so bad about choosing higher efficiency equipment. Spend a few thousand dollars more on the house and then find your buyer and EIM! Let's start making some money and a satisfied customer base! What's not to like about that!
Better insulation, better duct work configuration, better duct insulation, NO garage in the home and if they had to it should have been air sealed and insulated much better.
Exterior insulation on basement foundation walls would be nice, of course renewables would also be nice. Realistically improving the duct sealing and providing more insulation on the attic ducts. With the hydro air he has chosen he could switch to geo or thermal solar in the future without too much horsing around.
Air sealing attic hatch and recessed lights
Foundation Insulation, Air sealing. Envelope detailing around bonus room, Ceiling tray and walls adjacent to attic. Better window. Estar Lighting. Attic air ceiling Duct sealing and better insulation. Drop down stair hatch
The HVAC systems are pitiful given what is available today. Stepping up air sealing and insulating efforts would have been a decent thing to do. Solar hot water or photvoltaics would be out of sight on the tall roofs and receive oodles of sun!
Owner researched wall insulation and specified LD foam. This indicated owners' commitment to energy efficiency. Builder built tight and added ventilation and sealed combustion and power vented combustion equipment but didn't do any diagnostic testing for IAQ.
Energy Efficient Lighting, Attic hatch sealing and insulation, High efficiency hot water heater
Most energy opportunities where met some more energy efficient lighting could have been added.
There was no efficient lighting and an atmospheric non condensing furnace was installed.
Even though this house was large, because it was well insulated with LD foam, and airsealed a Heat Pump could have supplied most of the heat load (57kbtu/hr). Heat Pump DWH would have supplied hot water and addressed humidity. Owner didn't have efficient lighting because he though it would not complement the Italian Villa style.
Air Sealing (general), air sealing rim joists, foundation insulation didn't reach ground; Hard wired CFL's, Exterior rigid insulation under siding; Fully modulating furnace, or Heat pump, higher SEER A/C, insulate DHW pipes.
Missed air sealing, poorly installed spray foam in floor area
Attic hatch not air sealed or insulated, home is set in open field solar DHW would work great in this location
No hard surface behind Tongue and grove pine on walls and ceiling.
Only 1 CFL installed, door to unfinished bonus room is not sealed, install solar DHW customer has open field to the south, bath fans do not exhaust moisture
Attic pull down stairs not insulated. Attic and basement ceiling insulation not installed well. Large penetrations in foundation wall.
The bulbs were mostly incandescent and halogen and there were more than three hundred of

them. There were a lot of luxuries which increase the carbon footprint and which could be dealt with in other ways like the AC unit for the wine room. I guess the house is renewable ready whether geo thermal or solar the systems can be adapted without to much horsing around.
Masonry to wood connection was major source of air leakage. Higher levels of insulation in the attic and floor. Back side of shower stall was open to totally unconditioned basement.
Weil McClain makes more efficient boilers: not chosen. Combustion make up air from the outside is unconditioned. The home was not air sealed (based on Blower door). Insulation levels are not to code? Provide awning or exterior shades on Southwest facing 2nd floor and 3rd floor windows.
Air sealing attic hatch , only 1 CFL in the home, Bath fans were low CFM, solar orientation(a lot of windows face North)
Attic hatch not sealed, a lot leakage around recessed lights and not many CFLs
Basement air sealing
Detailing of attic insulation poor. Baffles sloppy, insulation uneven. Sloppy attic hatch application
No attic hatch cover, range hood vents into cabinet above.

Recommendations for Energy Improvements

BETTER DUCT DESIGN, BETTER INSULATION, WHOLE HOUSE VENTILATION
Complete the air sealing and insulation of the rim joist. As budget permits add renewable energy systems to meet heating and cooling and electrical needs.
Air sealing attic hatch and recessed lights, repair wrongly installed duct work, Install blown in cellulose to fill voids in fiberglass.
Suspected connections to garage.
: Install sealed combustion and instant hot water Eliminate the combustion air. Caulk obvious air leaks and sloppy trim work. Provide covers for skylights for nighttime and summer daytime.
"ERV or HRV, or interval timers on bath fans to bring house to ASHRAE 62.2 compliance.
Range hood vented to exterior to drive cooking moisture outside (not NG)
Owner was interested in geothermal but cost was prohibitive.
Tankless DWH? Or condensing storage tank. Heat pump DWH or add-on.
Rigid insulation on exterior under siding.
Energy Efficient Lighting , Attic hatch sealing and insulation and high efficiency hot water heater
More energy saving lighting fixtures
Use energy efficient lighting and a AFUE 90 plus furnace.
Bring in the attic slopes with 6" High density foam. Spring for mechanical ventilation like an HRV to bring in the Make-up air. Dense pack exterior wall and band and rim joists or Foam those cavities.
Own had 'larger' bath fans installed in bathrooms with showers. The tested flow indicated that the ductwork must be restricting flow. They were operating at 25% of rated capacity and were not ES. Efficient lighting could have be sourced that would insult the design style of the house.
Air seal basement, particularly around where A/C lineset enters, replace DWH with HPWH, or CAT 4 units.
Repair spray foam under floor, air seal around main beams (a lot of leakage at this area), install ENERGY STAR® Appliances and light fixtures.
Air seal and insulation attic hatch, install solar DHW, insulate attic to R48
Install CFLs, seal door leading to bonus room, install Solar DHW, install new ENEGRY STAR bath fans.
Consolidate heating systems into one high efficiency unit. There were two oil systems, the boiler used for heating water (zoned storage tank, and future in slab heating)
Air seal attic and add insulation. Insulate DHW pipes, LED lighting, Lighting motion sensors, bath fan controls.
Even though this family is on municipal electric, they could benefit by replacing their heating system with a highly efficient unit. HP-WH would reduce moisture in basement.
Retro foam or dense pack cellulose the ext walls. Bring in the Attic spray foaming the roof slopes and retro foaming the closed cavity roofs and blowing loose fill into the 3rd floor ceiling. Air seal the elevator shaft as possible. Replace incandescent bulbs w/CFLs. Seal leaky duct work.
Seal attic hatch closed, spray foam rim and band joist, install higher CFM bath fan, install CFLs.

Seal attic hatch, recessed lights, install CFLs, install 14seer or higher AC unit.
High tech furnace ,energy eff lighting
Air sealing, Lighting and
Air sealing, Detail the baffles, apply 4" cellulose to improve the attic insulation, attic hatch weather strip and insulate, lighting and better radiation to take advantage of the condensing boiler's efficiency
Install attic hatch cover, vent range hood to outside

Additional Comments

This was a home built in a very rural community. The Building Inspector was part time from a full time farming career. This inspector believed that high levels of insulation led to poor indoor IAQ.
Air sealing in the attic was not done, insulation should have been much better for the amount of money spent on the home building of the home and other upgrades that were made to the home.
I think the builder is concerned with making his buildings more energy efficient and has shown the willingness to spend time and money to do that. I would like to get a blower door on this home when it is completed.
Builder wasn't familiar with ENERGY STAR® program but was building ENERGY STAR® level homes. Training in Building Science would add important understanding, particularly regarding ventilation requirements.
I observed many bypasses that were not air sealed.
The baffles I mentioned already as being installed to zero advantage, allowing not only the washing of the fiberglass but also and perhaps more significantly the possible infiltration of outdoor air below the paper of the fiber glass. Seal recessed light fixtures. Either form above or with the air sealed trim kits.
Code officer stated that Energy Codes make it harder for builders to make a profit on the build, but were supportive of the NYSERDA project.
The missing cover at the return filter at one of the Basement air handlers should be addressed as well as larger leak/s? near the plenum . I did not see any attempt to seal ducts with tape or mastic anywhere on the exposed duct and assume that where the sloppy insulation was installed on the rigid duct, it too did not first receive air sealing. The doors and windows cabinet work and trim carpentry is top notch. However as we found in the places where we could see into the walls insulation was not continuous and air sealing is absent.
Bypasses from basement to attic need to be air sealed.

I.1.6 General Observations of Homeowners Data Collection Form – Summary Data

CSG Auditors also collected input from a six of the homeowners while visiting the homes. The intent of the "General Observations of Homeowners Form" was to collect the homeowners' priorities and awareness as they relate to energy efficiency. There were two sets of data collected in these forms:

A. A ranking of:
    a. Homeowners' priorities;
    b. Knowledge of building science; and
    c. Involvement in the construction process.
B. Auditor comments and subjective observations on each of the above rankings.

The data below summarize the findings for each of these data sets. However, given the small sample size (six homeowners), this data should not be taken as representative.

I.1.6.1 Ranking of Constructions Quality and Energy Opportunities

Customer's Priorities

How important were energy efficient construction and specification practices and/or lower operating costs to the homeowner at the time the house was designed and built – or if a spec home, one of the priorities considered during the purchase decision making process.

Ranking	Count Response	Percent Response
1 (not considered)	2	33%
2	0	0%
3	1	17%
4	3	50%
5 (top 5 priorities)	0	0%

Most homeowners ranked energy efficient construction as an important consideration. Of note is the fact that no homeowners ranked energy efficiency at a top priority, and one third of the respondents indicated no consideration of energy efficiency.

Awareness of Homeowner of Building Science Concepts

Ranking	Count Response	Percent Response
1 (not at all)	3	50%
2	0	0%
3	0	0%
4	1	17%
5 (highly informed)	2	33%

While half the homeowners had some awareness of building science concepts, half had none.

<u>Homeowner's Involvement in the Process</u>

How involved was the homeowner in overseeing the specification and quality of installation of important energy-related building elements?

Ranking	Count Response	Percent Response
1 (not at all)	2	40%
2	0	0%
3	1	20%
4 (Actively involved with Builder and/or Architect)	0	0%
5 (Involved with A/B and Code official)	2	40%

Homeowner involvement in the specification and quality installation of energy-related building items ranged widely from none to being very involved.

I.1.6.2 Auditor Comments and Subjective Observations

Auditors also provided subjective comments on customers' energy priorities, awareness of building science concepts, their involvement in the home design/building process and general comments. Their candid remarks are reported below.

Customer's Priorities

While he has chosen sealed recessed cans for his lighting we saw boxes of incandescent bulbs he intends to install. We recommended CFLs
Being a center unit in a row house means there are two less wall surfaces exposed to the elements. That's the most efficient thing about this residence.
According to Y, she and her husband pressured the builder to make cosmetic upgrades but are not as energy savvy as they might be. So little was done to address energy issues
He apparently cared enough to upgrade from Icynene that was called out on the plans, to high density foam everywhere. Never the less he insulated ducts within the pressure plane. He has twin high efficiency condensing boilers, an indirect DHW storage tank with R-16 insulation. While the recessed cans were not sealed, they are all within the thermal barrier and aligned pressure plane. The exterior foundation walls are insulated. It is among the three best houses I've been in the last three years.
The use of all of the (over 300) incandescent and halogen bulbs instead of high efficacy bulbs is surprising in this otherwise very reasonable home
Although the Mr. X stated that energy efficiency was a high priority prolific CFL's were the only evidence of this priority. This was a rural built home on a limited budget.
Client did not want to upgrade to foam insulation because it was too expensive

Awareness of Homeowner of Building Science Concepts

The "flash coat of fom on the bottom of the OSB attic floor should have been on the dry wall to more perfectly align the Thermal and Pressure boundaries. Still one of our photos shows it touching. Still in some places there is an air space between the top of the fiberglass and the foamed bottom of the deck. There is a major bypass which is potentially bring air into the conditioned space see pictures.
She has little or no idea.
Again why the bulbs? He claims he could not get ones that dim. Still Peter is highly informed and motivated.
We shouldn't confuse CFL's, 2x6 walls full of FG, and a bunch of FG in the ceiling with BS knowledge. Mr. & Mrs. Miles had a unvented space heater in their living room.
Client educated on blower doors and duct blasters.

Homeowner’s Involvement in Process

The home owner was the builder. He was involved every step of the way. Unfortunately he was out of town when we did the site visit
I think this single woman works hard but has not made energy considerations a priority of her continuing education.
It’s a spec home.
I’m sure he was on site during construction and in constant communication with the architect throughout the design phase. I think the decision to change from Icynene to High density foam allowed X to end up with additional square footage inside the house while preserving the same foot print.
Mr. Miles was the designer and builder. He got his design ideas from the local building yard and relatives

Additional Comments

The homeowner was and continues to be very concerned with cosmetic details and has called the builder to repair cosmetic issues like sloppy drywall taping and such
The light bulbs are his biggest energy hogs.

I.2 Energy Impact of Non-Compliance

I.2.1 Energy Impact of Non-Compliance Calculation Methodology

In order to assess which components of the code have the greatest impact on energy consumption and to calculate “lost savings” due to non-compliance, five different analyses were run. A different lost savings analysis approach was taken depending on the approach used to determine if a home was in compliance.

1. “Prescriptive Analysis” - When no compliance documentation was found showing compliance by the Trade-Off (e.g. REScheck™) approach and components were found to be non-compliant in the REM/Rate™ models, the home was analyzed using a prescriptive approach. In this analysis, all components were modeled in REM/Rate™ to prescriptive code values, the non-compliant component(s) were then set back to the verified value. The difference in consumption is the lost savings potential for that component.

2. “Trade-Off (e.g. REScheck™) Analysis” - When documentation was found demonstrating envelope compliance (e.g. REScheck™) but either one or more basic code requirements were non-compliant, or observed features of the home did not match the documentation, the home was analyzed using a trade-off approach. The REM/Rate™ model for the verified condition of the home was compared to the same model but with the non-compliant component(s) brought into compliance

3. "Overall Lost Savings Analysis" – This analysis compares, for all homes, how the verified condition of homes in New York compared with the prescriptive requirements of 2007 NYS ECCC.

4. "Insulation Quality Analysis" – This analysis looked at the issue of insulation installation quality. This approach estimates the energy savings from homes that are in compliance on paper but may still have lost savings opportunities due to poor or improper installation techniques.

5. "Cooling Equipment Oversizing Analysis" - The final analysis looked at cooling equipment oversizing. Nearly all homes had oversized cooling equipment. REM/Rate™ models for homes with the verified cooling capacity were compared to the same homes modeled with cooling capacity in line with the design load as calculated by REM/Rate™.

Each of these analyses provides a picture of how homes in New York are performing overall, as well as on a component basis. These analyses also allow quantification of the lost savings due to non-compliance with the energy code.

I.2.2 Energy Impact of Non-Compliance Results

Summary Results

Overall, there is an estimated "lost savings" opportunity of approximately 18.6 MMBtu/ per home for non-compliant homes built in New York State. This results from 15.2 MMBtu of sub-code component efficiency levels, and 3.4 MMBtu of inadequate insulation installation. At 2010 fuel prices, this translates into approximately $373 of annual lost energy savings per non-compliant home, about 8% of the average home's total modeled annual energy costs, and 14% of the heating and cooling costs. Over the average non-compliant home's 50-year lifetime, this is a cumulative lost savings of more than $18,000 (in today's dollars). When looked at on a statewide basis, adjusting for the fraction of new homes that are out of compliance (27% to 39%, depending on the evaluation methodology) and the 23% of homes that are ENERGY STAR® qualified and thus assumed to be code compliant, this translates into total lost energy savings of 1.0 - $1.4 million annually. Over the 50 year life of the average 12,250 single-family and low rise multi-family new homes built annually, this translates to approximately $58 million cumulative lost savings on a statewide basis. Assuming that a similar amount of lost savings occurred from the 12,250 homes built each year, over five years of construction, the 50 year cumulative lost savings from these homes would be approximately $300 million. Energy code non-compliance is a significant expense to New Yorkers.

Note that these lost savings are for the 2007 code. As the more stringent 2010 code goes into effect, the leap from current construction practices to the 2010 code will be even greater, resulting in greater lost savings than reported here unless compliance rates dramatically increase.

On a building component level, the “Prescriptive” lost savings analysis showed that basement walls by far provide the most opportunity for reclaiming lost savings. Lost savings due to under or non-insulated basement walls accounts for about half of the total component level lost savings opportunity; averaging about 18 MMBtu annually in those homes with non-compliant basement walls. Above-grade walls, slabs and floors are the second largest contributors to lost savings, at approximately the same rate for each component, about three MMBtu annually. For homes with a compliant envelope but with one or more non-compliant mandatory requirements, the “Trade-Off (e.g. REScheck™)” analysis showed that lost savings were primarily due to the overall fenestration UA requirement, and averaged about five MMBtu annually. Figure I. 7 shows the proportion of lost savings opportunities by component using the weighted average savings from both the “Prescriptive” and “Trade-Off (e.g. REScheck™)” component level savings analyses.

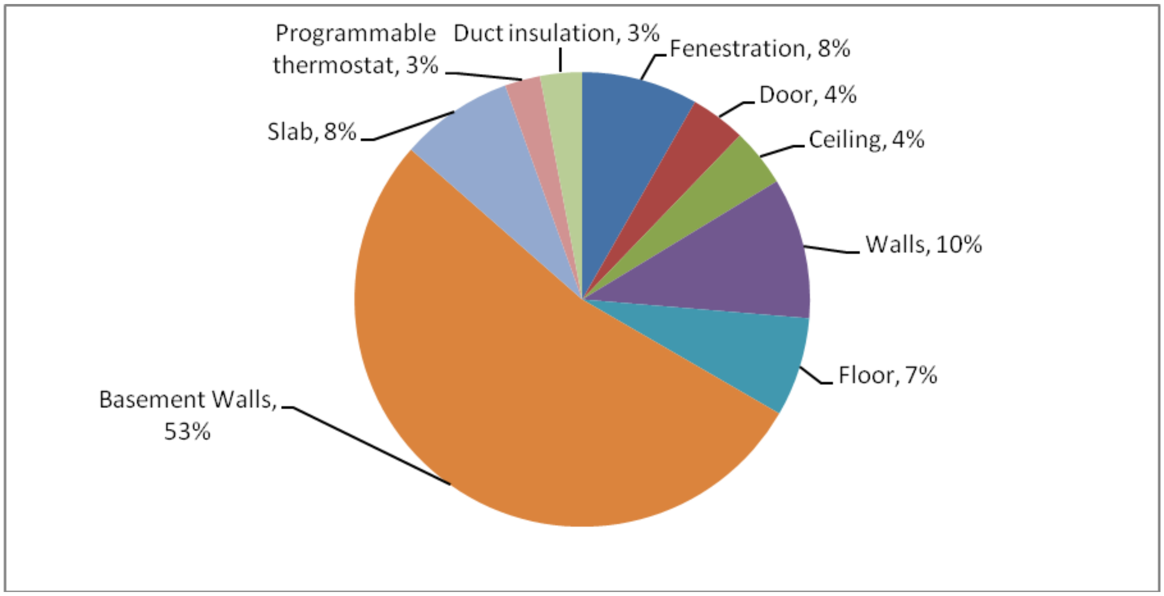


Figure I. 7 Proportion of Lost Savings Opportunity by Component

Figure I. 7 shows that insulating basement walls clearly provides the highest opportunity for reclaiming lost savings. It should be noted, however, that while basement walls show the greatest opportunity for savings *when* they are not in compliance, overall about 78% of foundation walls are found to be compliant. The basement wall savings presented here are primarily from homes in Climate Zone 4 which had significantly lower compliance rates (at 43%, about half that of the statewide average) and include two homes with uninsulated basement walls. For the next tier down of components, above grade walls, frame floors and slab edges provide similar lost savings opportunities. Of these three components, 32% of homes had a slab-on-grade foundation, 55% had frame floors and all had walls. While there are similar savings from each of these components, slabs and floors are seen much less frequently

What is not shown in Figure I. 7 is the lost savings from one home where the filed REScheck™ report indicated the home had a high efficiency furnace. The on-site visit found that a standard efficiency furnace was actually installed. With the standard efficiency furnace, the envelope was no longer compliant. Modeling the home with the high efficiency furnace indicated on the REScheck™ report resulted in significant savings, about 10 MMBtu annually.

All homes included in the “Prescriptive” lost savings analysis had more than one non-compliant component. To see the overall lost savings from these homes as a whole, the fully code compliant model was compared to the field verified As-Built model. Analyzed this way, any above code components were left as is, representing a more accurate, or real world, estimate of the lost savings opportunity from bringing only the non-compliant components into compliance. The average overall whole home savings was 15.2 MMBtu per home. It is this estimated 15.2 MMBtu per home average overall lost savings value that makes up the sub-code component efficiency portion of the total 18.6 MMBtu per home lost savings opportunity for non-compliant homes built in New York.

The “Overall Lost Savings” Analysis that compared the average energy consumption of all homes in the sample to the average energy consumption of those homes had they been built to prescriptive requirements of 2007 NYS ECCC showed an average savings of 14.6 MMBtu per home. These “Overall lost savings” results correlate well with the whole home savings produced by the “Prescriptive” component level analysis.

The “Insulation Quality” lost savings analysis shows there are significant savings to be found simply by ensuring proper installation of materials. Taking a worst case scenario, an average of 10 MMBtu could be saved per home if all insulation were properly installed. However, it is uncommon for all insulation to be extremely poorly installed; thus actual savings should be somewhat less than this worst case scenario. A more realistic estimate is 3.4 MMBtu, as discussed in more detail below.

The “Cooling Equipment Oversizing” lost savings analysis showed that proper sizing of cooling equipment did not show significant energy savings. Cooling system oversizing, however, has other undesirable impacts including higher installation and operating costs to the homeowner as well as decreased comfort and humidity control. The largest impact from cooling equipment oversizing is the potential increase in peak demand of more than 7 MW from New York’s electrical grid

Lost Savings Analysis Results

Of the entire sample of 44, 30 homes had REScheck™ certificates on file. Eight of the remaining fourteen homes had no documentation on file to demonstrate code compliance. Compliance of these homes was evaluated using the REM/Rate™ models. One of these homes was found to be fully in compliance and was not included in the lost savings analysis. The final six homes did have compliance documentation on file. The REM/Rate™ models for these six homes were used to evaluate compliance. Four of the six homes were found to be fully in compliance and are not included in the lost savings analysis. Of the two that were not in compliance, one had non-compliant envelope components and is included in the “Prescriptive” analysis; the other had a compliant envelope but non-compliant duct insulation and is included in the “Trade-Off (e.g. REScheck™)” analysis. Also included in the trade-off analysis are nine homes with compliant REScheck™ reports but non-compliant mandatory requirements or homes where observed features did not match the REScheck™ report. **Table I- 22** below provides a summary description and sample size of each analysis.

Table I- 22: Summary of Energy Analysis Methods

Analysis Method	Sample Size	Comment
1. Prescriptive	8	Prescriptive analysis of homes with no or failing compliance documentation
2. Trade-Off (e.g. REScheck™)	10	Homes with compliant envelope but one or more non-compliant mandatory requirements
3. Overall Lost Savings	44	All homes compared to prescriptive code
4. Insulation Quality	36	Homes with compliant insulation and window requirements
5. Cooling equipment sizing	27	Homes with installed cooling capacity greater than 20% of the design load

Prescriptive Analysis

Eight homes with no, or non-compliant, documentation were analyzed “Prescriptively”. Of these eight homes, five were in Climate Zone 4 and three homes were in Climate Zone 6. Each component was brought to prescriptive compliance per Table 402.1(1). If infiltration, duct leakage or mechanical equipment conformed with the exceptions listed in Section 402.1, ceiling and wall insulation was brought to the alternative compliance requirements listed in Table 402.1(2). Baseline consumption of the prescriptive code home was recorded. Each non-compliant component was then modeled within the code home. The difference in consumption between the code home and the code home with non-compliant component is the lost savings due to that component. Overall lost savings was also calculated as the difference in consumption between the code home and the As Built home. In cases where the As Built home as a whole showed total energy consumption equal to or less than the prescriptive code home model, these values were not included in the average whole home savings. One of the homes in this sample was a log home. The tested infiltration was below 5.5 ACH_{50}, therefore the alternative insulation requirements were used in the code reference model. The log wall, however, did not meet the requirement of Section 402.2.3 stating that the provision for mass walls is applicable where at least 50 percent of the R-value is integral to the wall. Therefore, the code wall for this home was modeled as a standard wood frame wall as required by the code.

Table I- 23 shows the average total lost savings by component when the whole home is brought into compliance. The average percent of lost savings at the component level is shown as the percent of lost savings compared to the total energy consumption of the home at the code level. The total number of homes with each non-compliant component is also shown.

Table I- 23: Average Lost Savings Due to Non-compliance with Prescriptive Code Requirements

Component	Total Count	Total Lost Savings (average MMBtu)	Lost Savings Percent of Total Consumption (average)
Whole Home	6	15.2	11.4%
Fenestration	4	1.2	1.1%
Door	1	1.4	1.2%
Ceiling	5	1.5	1.6%
Walls	5	3.6	3.3%
Floor	1	2.5	3.9%
Basement Walls	5	18.9	10.7%
Slab	2	3.8	3.4%
T-stat	2	0.9	0.9%
Duct insulation	3	0	0%

The average lost savings presented in **Table I- 23** are the total lost savings for those homes, they are not adjusted by the total percent of non-compliant homes as presented in the summary to this section. This analysis shows that insulating basement walls clearly provides the highest opportunity for reclaiming lost savings. This is discussed in more detail in the residential compliance section of the report. It should be noted that while basement walls show the greatest opportunity for savings *when* they are not in compliance, overall about 78% of foundation walls are found to be compliant. The savings presented here are primarily from homes in Climate Zone 4 which had significantly lower compliance rates (at 43%, about half that of the statewide average) and include two homes with uninsulated basement walls. For the next tier down of components, above grade walls, frame floors and slab edges provide similar lost savings opportunities. Of these components, 32% of homes had a slab-on-grade foundation, 55% had frame floors and all had walls. While there are similar savings from each of these components, slabs and floors are seen much less frequently.

All homes included in the Prescriptive lost savings analysis had more than one non-compliant component. To see the overall lost savings from these homes as a whole, the fully code compliant model was compared to the field verified As Built model. Analyzed this way, any above code components were left as is, representing a more accurate, or real world, estimate of the lost savings opportunity from bringing only the non-compliant components into compliance. The average overall whole home savings was 15.2 MMBtu.

Trade-Off (e.g. REScheck™) Analysis

Of the 30 homes with REScheck™ documentation, seven did not pass due to non-compliance with additional mandatory requirements. Four homes were found where the observed values from the on-site visit did not match the REScheck™ report. One of these still met overall compliance when evaluated with the observed data. The other three were included in this analysis. Of these, one included a home with a reported high heating system efficiency where the observed system was standard efficiency. The envelope did not pass the Overall UA check with the standard efficiency unit that was actually installed. One additional home that did not have REScheck™ documentation but met the Overall UA requirements when evaluated in REM/Rate™ is also included here due to non-compliant mandatory requirements. Of the homes that failed Trade-Off (e.g. REScheck™) compliance due to mandatory requirements, three failed due to overall fenestration UA, five failed due to non-compliant duct insulation.

For the analysis of homes found to be non-compliant under the Trade-Off (e.g. REScheck™) approach, baseline consumption of the As Built home was recorded. Each non-compliant component was brought to compliance and consumption recorded for the fully compliant home. Lost savings is the difference between the non-compliant As Built model and the fully compliant As Built model. Of the eight homes not compliant due to mandatory requirements, two homes were in Climate Zone 4, five homes were in Climate Zone 5,and 1 home was in Climate Zone 6. **Table I- 24** below shows the average lost savings for each non-compliant component as well as the total count of each non-compliant component. As in the prescriptive analysis, the average percent of lost savings at the component level is shown two ways: the first being the percent of lost savings compared to the total energy consumption of the code home, the second shows lost savings as a percent of the total lost savings for that home. A value of 100% for component lost savings percent of total lost savings means that only that component was non-compliant.

Table I- 24: Average Lost Savings for Non-compliant Components--Trade-Off (e.g. REScheck™) Approach

Component	Total Count	Total Lost Savings (average MMBtu)	Total Lost Savings Percent of Total Consumption (average)	Component Lost Savings Percent of Total Lost Savings (average)
Fenestration	3	5.3	3%	100%

Duct insulation	5	1.7	1%	75%
Heating Efficiency	1	10.5	6%	98%
Ceiling Insulation	1	1.3	1%	100%
Slab Insulation	1	1.1	0%	100%

As with the Prescriptive analysis, the average lost savings presented in **Table I- 24** are the total lost savings for those homes, they are not adjusted by the total percent of non-compliant homes as presented in the summary to this section. The results of this analysis show that lost savings due to non-compliant duct insulation are very small. Most of these homes had duct insulation, but to levels less than R-8, which is the 2007 NYS ECCC code requirement. The high savings attributed to heating system efficiency is due to the difference in a home with a 90 AFUE furnace vs. an 80 AFUE furnace. As noted above, the envelope was in compliance assuming the higher efficiency heating system, but was not in compliance with the actual installed efficiency. Overall fenestration UA shows a higher average savings in this analysis because the Uo for windows in this sample was higher (worse) than the sample run through the prescriptive analysis.

Overall Lost Savings

The third energy analysis was conducted to show how the entire sample of As Built homes, on average, compared with a 100% prescriptive code home. For this analysis, each component was modified to the prescriptive code requirement listed in the Equivalent U-Factor table, Table 402.1.2of the 2007 NYS ECCC. Duct insulation was also set to code per section 403.2.1. Right sizing of mechanical equipment was not included as part of this analysis due to limitations of the batch modeling function in REM/Rate™. Energy consumption of all homes built to prescriptive code levels was compared to the As Built condition. **Table I- 25** reports the results from the Overall Lost Savings analysis by Climate Zone and Statewide.

Table I- 25: Average Lost Savings Overall for All Homes As Built vs. Prescriptive Compliance

	Average Lost Savings (MMBtu)
Climate Zone 4	14.7
Climate Zone 5	14.4
Climate Zone 6	15.0
Statewide	14.6

On average, the lost savings was 14.6 MMBtu. This is comparable to the 15.2 MMBtu results found in the Prescriptive analysis restricted to eight homes. Only one home had lower consumption in the As Built model vs. the Prescriptive code model. This negative lost savings is included in the averages presented below. The average statewide lost savings is 15.2 MMBtu when this home is removed from the sample.

Insulation Quality Analysis

The fourth energy analysis conducted looks at the impact of insulation installation quality on energy consumption. When homes are evaluated as in compliance based on nominal R-values only, the quality of insulation installation is disregarded. For this analysis, all homes with compliant envelope and window components by the trade-off approach (36 total) were modified in REM/Rate™ to adjust for installation quality. REM/Rate™ includes an insulation grading factor that is are defined in the Residential Energy Services Network (RESNET) 2006 Mortgage Industry National Home Energy Rating Systems Standards, Appendix A. A “Grade I” installation refers to insulation installed per manufactures instruction, as code requires. A “Grade III” installation is used to describe very poorly installed insulation with substantial gaps, voids and/or compression.

Photo Credit: Conservation Services Group, 2011

Figure I- 8 shows examples of Grade III insulation in photos taken from this study sample.

Photo Credit: Conservation Services Group, 2011

Figure I- 8: Examples of Grade III Insulation Installation

For this analysis, each insulation component was set to Grade I to represent insulation installed per manufactures instructions, as code requires. Then each insulation component was set to Grade III to represent a very poor quality insulation installation. While there are certainly instances of Grade III insulation, it is not the case 100% of the time. This represents a worst case scenario. When insulation quality cannot be ascertained, as in a post-construction study like this one, the RESNET Standard instruct to evaluate the insulation as Grade III. This approach is punitive in nature and is probably not a realistic estimation of insulation quality in most cases. To account for this, insulation Grade was modified a third time setting any Grade III insulation values in the As Built model to Grade II. Where components were already Grade II or Grade I, they were left as is. **Table I- 26** shows the average total and percent difference in consumption in homes when insulation grade is adjusted as follows:

1. Grade III applied to all insulation vs. Grade I applied to all insulation
2. As Built model (which includes many instances of Grade III insulation due to lack of observation vs. Grade I)
3. Modified-As Built model (all Grade III insulation adjusted to Grade II) vs. Grade I.

Table I- 26: Total Difference in Consumption Due to Insulation Grade Adjustments

	Climate Zone 4	Climate Zone 5	Climate Zone 6	Statewide
Average Total Difference in Consumption (MMBtu)	n=4	n=26	n=6	n=36
Grade III vs. Grade I	17.3 (6%)	9.7 (7%)	8.5 (8%)	10.3 (7%)
As Built vs. Grade I	10.3 (4%)	7.1 (5%)	6.7 (6%)	7.4 (5%)
Modified (GII) As Built vs. Grade I	5.1 (2%	3.4 (2%)	2.7 (2%)	3.4 (2%)

While 10.3 MMBtu represents a worst case scenario, it is noteworthy given that the potential lost savings due to insulation quality is roughly two-thirds of the total lost savings shown in the prescriptive and overall whole house analyses. A lost savings potential closer to 3.4 MMBtu, that shown by the Modified (GII) As Built vs. Grade I scenario, is likely more representative of real world conditions.

Cooling Equipment Sizing

New York State code requires mechanical systems to be properly sized. A more detailed discussion of the findings related to system sizing is included in the compliance section above. The energy analysis looked only at cooling systems where the total installed capacity was 20% or more than the design load as calculated by REM/Rate™. (This is because it is nearly impossible to exactly match a home's heat load to the capacity of a piece of equipment, so engineers generally allow some leniency in selecting equipment to the next available size.) Of the 33 homes in the sample with cooling, 29 had systems oversized by 20% or more. Cooling and total consumption were recorded for each As Built home. The calculated total required equipment capacity was also recorded. The As Built home was then modeled with a modified cooling capacity to the next highest commercially available capacity over the calculated required capacity. Equipment efficiency and all other components were not modified.

Modified installed capacity ranged from a reduction in capacity of 1 ton to 23 tons, with most in the 0.05 to 1.5 ton range. One home had exceedingly oversized mechanical systems, requiring a 23 ton reduction in capacity. Removing this home from the sample brings the average reduction in capacity to 1.5 tons. The lost savings potential estimated by REM/Rate™ was unexpectedly low, showing a 2% reduction in cooling consumption on average. The REM/Rate™ models, however, only account for a reduction in installed cooling capacity. The models do not account for proper installation and duct system design – each of which would contribute significantly to lost savings. Cooling system oversizing has other undesirable impacts including higher installation and operating costs to the homeowner as well as decreased comfort and humidity control. Most importantly, system oversizing can have a significant impact on the electric grid. This demand impact is discussed above in the Compliance Equipment Sizing Section.

APPENDIX J: RESIDENTIAL ANALYSIS SUPPORT DOCUMENTS

J.1 INSTRUCTIONS FOR THE RESIDENTIAL BUILDING DATA COLLECTION CHECKLIST

Note: The instructions contained in this document were created by PNNL specifically for use by a code official verifying compliance at time of construction. We will need to modify some of the instruction in this document so that it is appropriate for a post-construction verification survey. Where instruction for the NYSERDA code compliance project differs, or requires further guidance, a box like this one with the header "NYSERDA Guidance" will be added just above or below the original instruction.

Use of these instructions with a residential data collection checklist assumes a general understanding of the provisions of the International Energy Conservation Code (2009 IECC) and key concepts and definitions applicable to those provisions. Consult the 2009 IECC and relevant support materials when in doubt about a particular item in the checklist. Each checklist item contains the corresponding 2009 IECC code section(s) for quick reference. While most of the code provisions are included in the checklists, there are a few requirements that are deemed administrative and/or without significant impact, and these are not included. The checklists were originally developed for use in addressing Recovery Act and State Energy Program requirements, both of which are focused on reducing energy consumption in buildings. However, these can be useful inspection tools for all code officials in jurisdictions that have adopted the 2009 IECC, noting that slight modifications may be necessary in jurisdictions that amended the IECC prior to adoption.

The checklist is divided into stages corresponding to traditional building inspection stages. A building may require more than one field visit to gather compliance data during each stage of construction. Multiple buildings can be used to derive a single building evaluation. This may occur where multiple buildings are being simultaneously constructed, with construction in varying stages occurring at the same time (e.g., a housing subdivision, condominium or apartment complex, or commercial office park). In these cases, the same building must be used for at least one complete inspection stage (i.e., plan review, foundation, framing, insulation, or final inspection). Additionally, the buildings must be of the same building type (e.g. single family, modular, multifamily, townhouse, etc.).

Completing the General Information Section. All inputs at the top of the first page of the checklist should be completed. Some of these inputs are repeated at the start of each new construction stage. Where a single building is being evaluated for each stage of construction, the duplicate inputs can be ignored. Where different buildings are used for completing different stages of construction, the top portion of each checklist stage must be completed for each different building evaluated.

- Compliance Approach: Compliance with the energy code can be demonstrated by the prescriptive, trade-off, or performance approach. In evaluating building compliance, the prescriptive approach should be assumed unless documentation is obtained from the building department or responsible authority demonstrating compliance with either the trade-off or performance approach. The *Code Value* column on the checklist contains the prescriptive requirement which must be met under the prescriptive approach. If a trade-off or performance approach is used to demonstrate compliance, the buildings may NOT comply with these prescriptive values and yet may still be deemed to comply with the code (and therefore should be marked as compliant for the given checklist item) on the basis that some other aspect of the building exceeds the code. For example, assume a trade-off approach was used and a valid worksheet or software report was submitted showing a compliant building in Climate Zone 3 with R-3 basement insulation. In Climate Zone 3, the code's prescriptive insulation R-value requirement for a basement wall is listed as R-5. In this example, the basement insulation should be marked as compliant even though it does not meet the prescriptive requirement given on the checklist. If the trade-off submission is valid, there will be some other building component that exceeds code requirements and offsets the non-compliant basement wall.

Complies Column. Each checklist item must be selected as compliant (Y), not compliant (N), or not applicable (N/A). Some examples of where a checklist item might be considered N/A include pool requirements for buildings that do not have a pool, basement requirements for a building that has a slab-on-grade foundation, or sunroom requirements for buildings that do not have a sunroom. When evaluating a renovation or addition, it is also appropriate to select N/A for code provisions that do not apply. 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. If necessary, a different building of the same type but in a different stage of construction would have to be used to complete a checklist stage in order to inspect these items.

NYSERDA Guidance
Where a given code provision cannot be inspected (e.g. wall insulation) the checklist item *should* be marked N/A. Wherever a checklist item is marked N/A for this reason, it should be noted as such.

It should be noted that state or local government may amend the IECC and/or enforcing authorities (code officials and inspectors) may have developed localized interpretations of the code that might result in minor modifications to code requirements where energy usage is not negatively impacted. As an example, the requirement that a certificate identifying the energy-related features of the building be placed in the electrical box might be modified to allow its placement elsewhere in the building. In cases where these minor alterations are deemed by the evaluator to still meet the intent of the code, the checklist item can be marked as compliant with a corresponding comment from the evaluator.

Verified Values Column. The checklists are used to collect information about the building as well as to determine compliance. Provide the observed value (R-value, U-factor, depth of insulation, etc) in the *Verified Value* column. In many cases, you may observe more than one value, in which case all values observed should be recorded. For example, windows in the building may have a different U-factor than sliding glass doors. How compliance is determined when multiple values are found may vary depending on the compliance approach:

- <u>Prescriptive Approach – Insulation R-values</u>: All insulation R-values must be equal to or greater than the prescriptive code value. Enter all observed R-values into the *Verified Value* column. If any are less than the prescriptive code value, this checklist item is deemed to fail.
- <u>Prescriptive Approach – Fenestration U-factors and SHGC</u>: Enter all observed U-factors into the *Verified Value* column. If all values are less than or equal to the code value, the checklist item is deemed to pass. Alternatively, if the area-weighted average glazing U-factor is less than or equal to the prescriptive code value, then the checklist item is deemed to pass. Where multiple U-factors are observed, and some are above and some below the code value, it may be necessary to check the area-weighted average, which will require glazing areas. The areas, U-factors, and calculations can be provided in the *Additional Comments* area of the checklist or on a separate worksheet. A similar approach should be taken for fenestration SHGC. Note that up to 15 ft^2 of fenestration can be exempted from the prescriptive U-factor and SHGC requirements, and one side-hinged door up to 24 ft^2 can be exempted from the prescriptive door U-factor requirements.
- <u>Trade-Off and Performance Approaches</u>: Under alternative approaches, the values and areas to be verified are those on the compliance documentation. Where multiple values are observed, enter the observed R-values, U-factors, and their corresponding areas into the *Verified Value* column if space permits. Where space does not allow this, use the *Additional Comments* area of the checklist or a separate worksheet.

NYSERDA Guidance
Where more than one R-value or U-factor is observed, enter the R-value that accounts for the largest portion of the component, or the most common U-factor, in the *Verified Value* column. Other observed values can be entered into the Notes field. If the building complied via the Prescriptive approach, all insulation R-values must meet or exceed the code Prescriptive value, as noted in the bullet above.

Item Number	**Pre-Inspection/Plan Review**
103.2 **[PR1]**[1]	**Documentation**. Determine if a complete set of plans/construction drawings, specifications, and energy code compliance documentation is available in the building department. If there is no building department or the locality does not conduct plan review, this information should be obtained from the registered design professional or builder having responsibility for the project. If documentation indicating a trade-off or performance approach is not provided, a prescriptive approach must be assumed for verifying compliance. Construction documents should sufficiently demonstrate energy code compliance, including but not limited to the following information: • The location and R-values of insulation materials

	• U-factors and SHGC values for windows, doors, skylights, and other fenestration products • Information related to duct and piping location, insulation type and R-value, and means of sealing Under the assumption that only state or local government with a responsible enforcement and/or permitting agency are included in compliance evaluations, plans and documentation are expected to be held by the responsible agency. If this is not the case, mark this code requirement and the next (PR1 and PR2) as non-compliant, unless there is another entity responsible for enforcement identified (e.g. utility, contractor licensing board, etc.) in which case they should be contacted to review PR1 and PR2 information.
403.6 **[PR2]**[2]	HVAC Load Calculations**. Verify that HVAC load calculations have been completed and submitted. Verify the methodology used in the load calculations. List the resultant heating and/or cooling loads as applicable in the Verified Value column.** **NYSERDA Guidance** Here we are just verifying that the plans include HVAC load calculations. Actual equipment is verified against the plans in the Final Inspection section of the checklist. Note the calculation methodology in the Notes field. Because we are completing REM/Rate models, we will also be able to verify heating and cooling loads, but for this checklist item we are only verifying the documentation. ACCA approved software: RHVAC Residential Load Calculation, RIGHT - J8, DUCTSIZE EF, Right-D, Drawing Board, Right-Radiant, Right-Loop, FLA - J8 Link for Right-Suite Residential, 2-Line Residential Duct Design for Windows, Right-$, AccuLoads, Right-J Mobile

NYSERDA Guidance
For all checklist items below that ask for verification of insulation installation "per manufacturers instructions" (as per IECC2009 Section 303.2 and ECCC NYS2007 Section 102.2) interpret this as a RESNET Grade I installation. Where insulation installation cannot be verified, mark the checklist item N/A. If the component received an N/A entry because it was not observed, note this in the Comments section. RESNET standards should be followed when completing the REM model (i.e. unobserved insulation installations should be marked Grade III).

Item Number	**Foundation Inspection**
402.1.1 **[FO1]**[1]	**Slab Edge Insulation R-Value**. Determine and record the R-value of slab insulation from the label on the insulation or from manufacturer shipping materials available onsite. Slabs are required to be insulated where the floor surface is less than 12 in. below grade. Slab insulation must be inspected prior to pouring the slab—when the insulation installation is completely visible. If the area has been designated as having heavy termite infestation, then insulation is not required and should be so noted.
303.2, 402.2.8 **[FO2]**[1]	**Slab Edge Insulation Installation**. Insulation location can be vertical or horizontal inside the foundation wall, however, it must start at the top surface the slab and extend downward to completely cover the slab edge. It can also be located outside the foundation wall. Where insulation is located outside the wall and where it extends horizontally away from the building, it must be protected by pavement or at least 10 in. of soil. Verify that insulation is installed according to manufacturer's instructions.
402.1.1 [FO3][1]	**Slab Edge Insulation Depth/Length**. Measure and record the length of the slab insulation from the top of the insulation, which must be at the same level as the top of the floor slab, vertically and/or horizontally along the insulation path. The insulation application must be continuous in order to comply with the code.
402.1.1 [FO4][1]	**Basement Wall Exterior Insulation R-Value**. Determine and record the R-value of exterior insulation applied to a wall associated with a conditioned basement or a basement that is unconditioned but does not have the floor above and other components separating the basement from the rest of the building insulated as part of the building envelope. A basement wall is one that is at

	least 50% below grade. This inspection must be done immediately prior to backfilling when the insulation installation is completely visible. Basement wall insulation is not required in warm, humid locations as defined in Table 301.1.
303.2 [FO5][1]	**Basement Wall Exterior Insulation Installation**. Verify that the insulation is installed according to manufacturer's instructions.
402.2.7 [FO6][1]	**Basement Wall Insulation Depth**. Measure and record the length of basement wall insulation on the exterior of the wall from the top of the basement wall to the basement floor or until the insulation stops. For the prescriptive approach, the insulation length must be the lesser of 10 feet or to the top of the basement floor. For alternative approaches, verify the installation by reviewing the energy code compliance documentation.
402.2.9 [FO7][1]	**Crawl Space Wall Insulation R-Value**. Determine and record the R-value of insulation applied to the interior or exterior of walls associated with crawl spaces that are not ventilated to the outside. Insulation installed on the exterior of the foundation wall must be inspected when the insulation is completely visible; immediately prior to backfilling. Insulation installed on the interior of the foundation wall will typically be inspected during the insulation inspection, in which case this checklist item may be left blank until that inspection stage.
303.2 [FO8][1]	**Crawl Space Wall Insulation Installation**. Insulation must be installed according to manufacturer's instructions. If the crawl space is ventilated, the floor above the crawl space must be insulated instead of insulating the crawl space walls.
402.2.9 [FO9][1]	**Crawl Space Vapor Retarder.** Where a crawl space is unvented (e.g. not open to the building exterior) a Class I vapor retarder must be applied to the entire floor and run at least 6 in. up the walls of the crawl space and sealed to the walls. A Class I vapor retarder has a perm rating of less than 0.1 perm (such as polyethylene). If the product is not readily identified as to its perm rating then ask for supporting information or record the manufacturers information and validate it later. Any seams in the vapor retarder must have an overlap of at least 6 in. and be sealed or taped.
303.2.1 [FO10][2]	**Insulation Protection**. Determine that all slab, basement wall, or crawl space insulation exposed to the outside is protected from damage by an opaque covering.
403.8 [FO11][2]	**Snow Melt**. If the building is provided with a snow or ice melting system supplied through the building energy service, verify that the system has controls to automatically shut the system off when above 50 ºF when precipitation is falling, and if no precipitation is falling then manual controls or automatic controls that allow shutoff when above 40 ºF. Verification can be through direct inspection of the controls or, if not already installed, then verification that the system being installed is listed and labeled as having such controls.

NYSERDA Guidance

Where fenestration U-factors cannot be verified by a manufacturer label, try to obtain the information from the manufactures website or www.nfrc.org

If there is still uncertainty about the U-factor, use the default values provided by REM/Rate (or other CSG protocol for determining default U-factors).

To determine if glazing has a tint or low-e coating, follow the RESNET guidelines:

- Check the customer's product literature if available;
- Perform a "match test" - there should be one reflection per pane or coating, including low-e and tinting (e.g., a double-paned window with low-e and tint should show 4 reflections);
- Compare to glazing samples with and without tinting;
- Compare the windows within the space, since tinting is often applied only to certain windows in a house;
- Look for a low-e label or etching on the glass.

! Please note the source of the U-factor in the Comments section (whether manufacturer label, NFRC, or default. If default, please note the source of default data.)

Item Number	Framing / Rough-In Inspection
402.1.1, 402.3.4 [FR1] [1]	**Door U-Factor**. Determine and record the U-factor(s) for the door assemblies installed in the building envelope. This information should be available from a label applied to the assembly, from packaging associated with the product or by recording the manufacturer make and model number and frame type and looking up the information from the manufacturer's web site or www.nfrc.org. Under the prescriptive approach only, up to 24 ft^2 of side-hinged door need not meet the specified U-factor in the code. Indicate in the comments the total area of any non-complying products.
402.1.1, 402.3.1, 402.3.3, 402.5 [FR2] [1]	**Glazing U-Factor.** Determine and record the U-factor(s) for the window, door, and glass block assemblies installed in the building envelope that are not skylights (e.g., are at least 15 degrees from vertical), and excluding glazing installed in a sunroom that is thermally isolated from the rest of the building. This information should be available from the NFRC label applied to the assembly, from packaging associated with the product, or by recording the manufacturer make and model number and frame type and looking up the information from the manufacturer's web site or www.nfrc.org. If default U-factors were used from Table 303.1.3 of the IECC, verify the frame type found in the field matches those on the approved plans. An area-weighted average can be used to satisfy the U-factor requirement. For the prescriptive approach only, up to 15 ft^2 of the total glazed fenestration, including skylights, need not meet the specified U-factor in the code.
402.1.1, 402.3.2, 402.3.3 [FR3] [1]	**Glazing SHGC Values**. Determine and record the SHGC for the window, door, and glass block assemblies installed in the building envelope that are not skylights (e.g., are at least 15 degrees from vertical). Glazing installed in a sunroom is subject to this requirement. This information should be available from the NFRC label applied to the assembly, from packaging associated with the product or by recording the manufacturer make and model number and frame type and looking up the information from the manufacturer's web site or www.nfrc.org. If default U-factors were used from Table 303.1.3 of the IECC, verify the frame type found in the field match those on the approved plans. An area-weighted average can be used to satisfy the U-factor requirement. For the prescriptive approach only, up to 15 ft^2 of glazed fenestration need not meet the specified SHGC requirement. Indicate in the comments column the total area of any non-complying products.
303.1.3 [FR4] [1]	**Glazing Labeled for U-factor and SHGC.** Determine if vertical windows, doors, or glass block are labeled and certified as meeting referenced NFRC standards. If not, verify that compliance was based on the default U-factor and SHGC values from Table 303.1.3 in the code. SHGC requirements apply to Climate Zones 1-3 only.
402.1.1, 402.3.3, 402.5 [FR5] [1]	**Skylight U-Factor**. Determine and record the U-factor for skylights and roof windows (e.g., glazing that is at least 15 degrees from vertical) installed in the building envelope, but excluding skylights installed in a sunroom that is thermally isolated from the rest of the building. This information should be available from an NFRC label applied to the assembly, from packaging associated with the product, or by recording the manufacturer make and model number and frame type and looking up the information from the manufacturer's web site or www.nfrc.org. If default U-factors were used from Table 303.1.3 of the IECC, verify the frame type found in the field match those on the approved plans. For the prescriptive approach only, up to 15 ft^2 of the total glazed fenestration, including skylights, need not meet the specified U-factor in the code.
402.1.1, 402.3.3 [FR6] [1]	**Skylight SHGC Values**. Determine and record the SHGC for skylights and roof windows (e.g., glazing that is at least 15 degrees from vertical) installed in the building envelope, including skylights installed in a sunroom that is thermally isolated from the rest of the building. This information should be available from the NFRC label applied to the assembly, from packaging associated with the product or by recording the manufacturer make and model number and frame type and looking up the information from the manufacturer's web site or www.nfrc.org. If default U-factors were used from Table 303.1.3 of the IECC, verify the frame type found in the field match those on the approved plans. For the prescriptive approach only, up to 15 ft^2 of glazed fenestration need not meet the specified

Item Number	Framing / Rough-In Inspection
	SHGC requirement. Indicate in the comments column the total area of any non-complying products.
303.1.3 [FR7] [1]	**Skylights Labeled for U-factor and SHGC.** Determine if skylights and roof windows are labeled and certified as meeting referenced NFRC standards. If not, verify that compliance was based on the default U-factor and SHGC values from Table 303.1.3 in the code. SHGC requirements apply to Climate Zones 1-3 only.
402.3.5 [FR8] [1]	**Sunroom Glazing U-factor.** Determine and record the U-factor(s) for fenestration assemblies installed in a sunroom that is thermally isolated from the rest of the building. This information should be available from the NFRC label applied to the assembly, from packaging associated with the product, or by recording the manufacturer make and model number and frame type and looking up the information from the manufacturer's web site or www.nfrc.org. If default U-factors were used from Table 303.1.3 of the IECC, verify the frame type found in the field matches those on the approved plans.
402.3.5 [FR9] [1]	**Sunroom Skylight U-factor.** Determine and record the U-factor for skylights and roof windows installed in a sunroom that is thermally isolated from the rest of the building. This information should be available from an NFRC label applied to the assembly, from packaging associated with the product, or by recording the manufacturer make and model number and frame type and looking up the information from the manufacturer's web site or www.nfrc.org. If default U-factors were used from Table 303.1.3 of the IECC, verify the frame type found in the field match those on the approved plans.
402.1.1 [FR10][1]	**Mass Wall Exterior Insulation R-Value**. Determine and record the R-value(s) of insulation applied to the mass walls associated with the building thermal envelope other than basement walls. An above-grade wall is one that is less than 50% below grade. This inspection must be done prior to application of interior finish and after service systems are installed within the wall and/or before exterior finish that would hide the insulation and prohibit complete inspection of the installation. If insulated concrete forms are used, consult the manufacturer's specified R-value for the product. If more than ½ the insulation is on the interior, the mass wall interior insulation requirement applies, and this requirement should be marked N/A.
303.2 [FR11][1]	**Mass Wall Insulation Installation**. Determine that mass wall insulation is installed in accordance with the manufacturer's installation instructions and all places in or on the mass wall that will accommodate insulation are insulated. Verify that the instructions are available onsite or are readily available to the insulation contractors/installers.
403.2.1 [FR12][1]	**Duct Insulation**. Determine and record the R-value(s) of insulation applied to, or used in, the manufacture of heating and/or cooling ducts that are not completely inside the building thermal envelope (e.g., are located outside the conditioned space). **NYSERDA Guidance** Code and REM/Rate have different definitions of conditioned space. Please use the supplemental Floor Area Table (or something similar) to record conditioned floor area, by floor, for code and REM/Rate. This will aid not only completion of the data collection tools, but in calculating average CFA for the NYSERDA final report
403.2.2 [FR13] [1]	**Duct Sealing**. Verify that all ducts, air handlers, filter boxes, and building cavities used as return air ducts have joints and seams sealed. This should be verified before application of any duct insulation and before the ducts are made inaccessible for inspection by subsequent construction. Where flexible ducts containing insulation as an integral component of the duct are installed, the inspection for duct sealing must be conducted before the connections of the flex duct are taped.
403.2.2 [FR14] [1]	**Duct Tightness Testing (Rough-In).** Verify that the ducts and air handler, if not completely located inside the conditioned spaces, were tested for tightness. If a rough-in test was conducted, record the test under Framing / Rough-In Inspection and mark the post-construction test as Not Applicable (N/A). Record the leakage rate from the test, and the specifications under which the test was

Item Number	Framing / Rough-In Inspection
	administered (across the system or without the air handler installed). This information should be available on a test report by the entity conducting the test.
403.2.3 [FR15][1]	**Building Cavities as Supply Ducts**. Verify that no building cavities are used as supply ducts (e.g., function to actually form the duct).
402.4.5 [FR16][2]	**IC-Rated Recessed Lighting Fixtures**. Identify all recessed lighting fixtures installed in the building envelope. Verify that they are rated for installation in areas with insulation (e.g. IC rated), have a label on them from an approved third party indicating that they have an air leakage rate not exceeding 2 cfm at 75 Pa (1.57 psf) when tested under ASTM E283 and have a gasket or caulk applied between the fixture housing and the interior finish of the space where they are located. **NYSERDA Guidance** Where fixtures are completely inaccessible, mark this checklist item N/A. Where some portion of fixtures can be verified, use that data to inform compliance. If only a sample of fixtures was observed, note that in the Notes field.
403.3 [FR17][2]	**HVAC Piping Insulation**. Determine and record the R-value(s) of insulation applied to HVAC system piping, regardless of location, and the design temperature of the fluids being conveyed in the piping. This inspection must be done prior to application of additional pipe coatings or subsequent construction that would make the piping inaccessible for inspection.
403.4 [FR18][2]	**Circulating Hot-Water Piping Insulation**. Determine and record the R-value(s) of insulation applied to circulating service hot water piping, regardless of location. This inspection must be done prior to application of additional pipe coatings or subsequent construction that would make the piping inaccessible for inspection. Also identify all pumps associated with the circulating service hot water system and verify that they have an automatic or readily accessible manual control that can turn the pump off when the system in not in use. This inspection should be done by loading (e.g., turning on) each affected system and observing pump operation.
403.5 [FR19][2]	**Outdoor Intake/Exhaust Openings**. Identify all outdoor intake and exhaust openings and verify that they have either manual (self-closing) or automatic dampers that will close when the system associated with the air intake or exhaust is not functioning. This inspection should be done by cycling each affected system and observing damper operation.
402.4.4 [FR20][2]	**Fenestration Air Leakage**. Inspect each window, skylight, and sliding glass door to validate that it has been tested to the referenced NFRC or AAMA/WDMA/CSA standards and was found to satisfy the required air infiltration rate. If the tested rate is not shown on the assembly, determine the make and model number and consult the manufacturer's web site or other source of data to determine the air leakage of the assembly as tested by an independent laboratory. Site-built windows, skylights, and sliding glass doors are not required to meet this requirement. If any window, skylight, or sliding glass door is site-built, note that in the comments column.
402.4.4 [FR21][2]	**Swinging Door Air Leakage**. Inspect each swinging door to validate that it has been tested to the referenced NFRC or AAMA/WDMA/CSA standards and was found to satisfy the required air infiltration rate. If the tested rate is not shown on the assembly, determine the make and model number and consult the manufacturer's web site or other source of data to determine the air leakage of the assembly as tested by an independent laboratory. Site built swinging doors are not required to meet this requirement. If the swinging door is site-built, note that in the comments column. .
402.4.4 [FR22][2]	**Fenestration and Doors Labeled for Air Leakage**. Inspect each window, skylight, sliding glass door and swinging door to validate that it has a label, seal, symbol or other identifying mark indicating the test results or compliance with the code. Site-built fenestration is not required to meet this requirement. If the fenestration is site-built, note that in the comments column.

NYSERDA Guidance
For fenestration air leakage, where data cannot be verified by a manufacturer label, try to obtain the information from the manufactures website or www.nfrc.org Where air leakage cannot be obtained, mark the item N/A

Item Number	Insulation Inspection
402.1.1, 402.2.5, 402.2.6 [IN1][1]	**Floor Insulation R-Value**. Determine and record the R-value(s) of insulation applied to any wood-framed, steel-framed, or raised (e.g., not slab on grade) concrete floor associated with the building thermal envelope. If continuous insulation is installed, record the R-value of foam board insulation from the label on the insulation or from manufacturer shipping materials available onsite. This inspection must be done prior to completion of subsequent construction that would make the insulation inaccessible.
303.2 [IN2][1]	**Floor Insulation Installation.** Verify that floor insulation is installed in accordance with the manufacturer's installation instructions, that all places in the floor that will accommodate insulation are insulated, and that the insulation is installed in direct contact with the underside of the subfloor decking. Verify the installation instructions are onsite or are readily available to the insulation contractors/installers.
402.1.1 402.2.4, 402.2.5 [IN3][1]	**Wall Insulation R-Value**. Determine and record the R-value(s) of insulation applied to wood-framed, steel-framed, and mass walls that are above grade and associated with the building thermal envelope. An above-grade wall is one that is more than 50% above grade. Mass walls are those of concrete block, concrete, ICFs, masonry cavity, brick (non-veneer), earth/adobe, and solid timber/logs. If continuous insulation is installed, record the R-value of foam board insulation from the label on the insulation or from manufacturer shipping materials available onsite. This inspection must be done prior to application of interior finish and after service systems are installed within the wall and/or before exterior finish that would hide the insulation from inspection.
303.2 [IN4][1]	**Wall Insulation Installation**. Determine that wall insulation is installed in accordance with the manufacturer's installation instructions and all places in the wall that will accommodate insulation are insulated. Verify the instructions are onsite or are readily available to the insulation contractors/installers. If the insulation is integral to a masonry wall (e.g., applied to concrete masonry unit open areas or integral to insulated concrete forms), verify that the insulation is uniformly applied throughout the wall.
402.1.1 [IN5][1]	**Basement Wall Interior Insulation R-Value**. Determine and record the R-value(s) of insulation applied to the interior of a wall associated with a conditioned basement or a basement that is unconditioned but does not have the floor above and other components separating the basement from the rest of the building insulated as part of the building envelope. A basement wall is one that is at least 50% below grade. This inspection must be done prior to application of interior finish and after service systems are within the wall and/or before exterior finish that would hide the insulation from inspection.
302.2 [IN6][1]	**Basement Wall Interior Insulation Installation**. Determine that basement wall insulation is installed in accordance with the manufacturer's installation instructions and all places in the wall that will accommodate insulation are insulated. Verify the instructions are onsite or are readily available to the insulation contractors/installers. If the insulation is integral to a masonry basement wall (e.g., applied to CMU open areas or integral to insulated concrete forms), verify that the insulation is uniformly applied throughout the basement wall.
402.2.7 [IN7][1]	**Basement Wall Interior Insulation Depth**. Report the depth of insulation as measured from the top of the basement wall to the bottom of the insulation. Confirm insulation extends to the basement floor or to 10 ft.
402.2.11 [IN8][1]	**Sunroom Wall Insulation R-Value**. Determine and record the R-value(s) of insulation applied to any sunroom walls. A sunroom wall is one thermally isolated from the conditioned space. If not so isolated, the wall is considered an above grade wall that is part of the building thermal envelope. This inspection must be done prior to application of interior finish and after service systems are within the

	wall and/or before exterior finish that would hide the insulation from inspection.
303.2 [IN9] [1]	**Sunroom Wall Insulation Installation**. Determine that wall insulation applied to sunroom walls is installed in accordance with the manufacturer's installation instructions and that all places in the wall that will accommodate insulation are insulated. Verify that instructions are onsite or are readily available to the insulation contractors/installers. If the insulation is integral to a masonry wall (e.g., applied to CMU open areas or integral to insulated concrete forms), verify that the insulation is uniformly applied throughout the wall.
402.2.11 [IN10][1]	**Sunroom Ceiling Insulation R-Value**. Determine and record the R-value(s) of insulation applied to any sunroom ceiling. A sunroom ceiling is one thermally isolated from the conditioned space. If not so isolated, the ceiling is considered a framed ceiling and is part of the building thermal envelope. This inspection must be done prior to application of interior finish and after service systems are within the ceiling.
303.2 [IN11][1]	**Sunroom Ceiling Insulation Installation**. Verify that insulation applied to sunroom ceilings is installed in accordance with the manufacturer's installation instructions and all places in the ceiling that will accommodate insulation are insulated. Verify that the instructions are onsite or are readily available to the insulation contractors/installers.
402.4.2, 402.4.2.1 [IN12][1]	**Air Sealing (Blower Door Test)**. Determine compliance with the air sealing requirements via testing of the building. If testing was performed, record when the test was conducted (after rough-in and installation of penetrations), the leakage rate from the test, and the specifications under which the test was administered. This information should be available on a test report by the entity conducting the test. If testing was not performed, mark this requirement N/A and complete the requirements related to visual inspection.
303.1 [IN13][2]	**Insulation R-values**. Verify that all insulation installed in the building thermal envelope has a label on the insulation indicating the R-value of the insulation or the insulation installer has provided a certificate verifying the type of insulation, the installed thickness and installed R-value. In addition, a certificate for blown in insulation must provide the installed density, coverage and number of bags of insulation.
402.4.1, 402.4.2 [IN14][3]	**Air Sealing (Visual Inspection) of Openings and Penetrations**. Determine compliance with the air sealing requirements via visual inspection of openings in and penetrations through the building thermal envelope. If blower door testing was performed, mark this requirement N/A and complete the requirement pertaining to testing. If all openings and penetrations are sealed, mark this requirement as compliant (Y). If one or more sources are not adequately sealed, mark N.
402.4.1, 402.4.2 [IN15][3]	**Air Sealing (Visual Inspection) of Joints and Seams**. Determine compliance with the air sealing requirements via visual inspection of all joints and seams in and associated with the building thermal envelope. If blower door testing was performed, mark this requirement N/A and complete the requirement pertaining to testing. If all applicable joints and seams are sealed, mark this requirement as compliant (Y). If one or more sources are not adequately sealed, select N.
402.4.1, 402.4.2 [IN16][3]	**Air Sealing (Visual Inspection) of Other than Openings, Penetrations, Joints and Seams**. Determine compliance with the air sealing requirements via visual inspection of any sources of air infiltration not addressed in the previous two air sealing requirements (visual inspection). This requirement includes sealing of the air barrier. If blower door testing was performed, mark this requirement N/A and complete the requirement pertaining to testing. If all sources of infiltration other than openings, penetrations, joints, and seams are sealed, mark this requirement as compliant (Y). If one or more sources are not adequately sealed, select N.

NYSERDA Guidance
For the IECC 2009 checklist, mark all 'Air Sealing (Visual Inspection)' checklist items N/A. For the NYS 2007 checklist, only mark the Blower Door component as complies (Y or N) if the builder used that insulation trade-off approach. If the builder did not, mark the blower door item N/A. Inspect as much of the Visual Inspection checklist as possible and complete the Complies column as appropriate.

Item Number	Final Inspection
402.1.1 402.2.1 402.2.2 [FI1][1]	**Ceiling Insulation R-Value**. Determine and record the R-value(s) of insulation applied to any framed ceiling. For blown-in attic insulation, verify that the thickness of the insulation is written on markers at a rate of one every 300 ft^2 of attic space and compare this with the insulation certificate. This inspection must be done prior to application of interior finish and after service systems installed within the ceiling and/or before exterior finish that would hide the insulation from inspection. If credit is taken for a raised heel, energy or oversized truss rafter system, verify such a system has been installed.
303.1.1.1, 303.2 [FI2][1]	**Ceiling Insulation Installation**. Verify that insulation is installed in accordance with the manufacturer's installation instructions.
402.2.3 [FI3][1]	**Attic Access Insulation**. Determine and record the R-value(s) of insulation applied to any attic access hatches and doors.
403.2.2 [FI4][1]	**Duct Tightness Testing (Post-Construction).** Verify that the ducts and air handler, if not completely located inside the conditioned spaces, were tested for tightness. If a rough-in test was conducted, record the test under Framing / Rough-In Inspection and mark the post-construction test as Not Applicable (N/A). Record the leakage rate from the test, and the specifications under which the test was administered (across the system or without the air handler installed). This information should be available on a test report by the entity conducting the test.
403.6 [FI5][1]	**Heating Equipment.** Identify each piece of heating, cooling and heating/cooling equipment by manufacturer name and model number. Where multiple components are provided (e.g., split system heat pump or gas furnace/electric air conditioner) the model number of each component should be recorded. This information should be verified against the information identified from the plans and specifications covered under PR1. If there are no plans and specifications or those available do not match the submitted specifications then mark this item as non-complying.
404.1 [FI6][1]	**Lighting**. Determine how many permanently installed lamps there are in the dwelling unit and how many of those have high efficacy lamps (>=60 lumens per watt when over 40 watts, 50 for over 15 to 40, and 40 for 15 or less). One fixture may have multiple lamps. Under the prescriptive or trade-off approach, the building must have at least 50% high-efficacy lamps to be deemed compliant. If the building complies via the performance approach, mark this requirement N/A. **NYSERDA Guidance** Code has different requirements for Lighting than what will be collected for REM/Rate. Please use the supplemental Lighting Table (or something similar) to calculate the % efficient lighting values.
401.3 [FI7][2]	**Certificate**. Verify that a certificate identifying the energy-related features of the building is located on or in the electrical box.
402.4.3 [FI8][2]	**Wood Burning Fireplaces**. Verify that all fireplaces have outside combustion air and gasketed doors.
403.1.1 [FI9][2]	**Programmable Thermostat**. Verify that each dwelling unit has a programmable thermostat for each forced air furnace that can control the heating and cooling system to allow heating temperatures down to 55 °F and cooling temperatures at least 85 °F. **NYSERDA Guidance** Note the IECC 2009 code provision is for forced hot air units only but the NYS 2007 code applies to each dwelling unit, regardless of system type. If the home has a boiler with programmable thermostat, this checklist item will be marked N/A for IECC09 but Y for NYS 2007.
403.1.2 [FI10][2]	**Heat Pump Thermostat**. Verify that heat pumps have a thermostat that will prevent backup heating from operating when the heating load can be satisfied by the heat pump.
403.4 [FI11][2]	**Service Water Piping System Controls**. Verify that circulating service hot water systems have controls to allow manually or automatically turning off the pump(s) when the system is not in use.

403.9	**Swimming Pools**. Verify that swimming pools are provided with vapor retardant covers, that an R-12 blanket is provided for all pools where the water is greater than 90 °F, and that there are controls to allow automatic time control of the circulating pumps and to automatically turn off the pool heating equipment.

KEY	1	High Impact (Tier 1)		Medium Impact (Tier 2)		Low Impact (Tier 3)

J.2 ECCC NYS 2007 AND IECC 2009 GENERAL CHECKLIST INSTRUCTIONS

1 Raters may print hardcopy checklist forms to record data manually and later transfer into the spreadsheet form, OR Raters may enter data directly into the spreadsheet form

2 All sheets are protected. Data entry is only allowed in unlocked cells

3 A new file should be created for each home

4 Complete both NYS2007 and IECC 2009 checklists for the appropriate climate zone for each home

5 Raters may delete unused climate zone checklists (worksheets)

6 Raters should have a copy of the IECC 2009 DOE Residential Checklist Instructions as well as the IECC 2009 code.

7 Raters should have a copy of the Energy Conservation Construction Code of New York State 2007 edition (Chapters 1 - 4)

9 All checklist items need to be marked as Complies: 'Y', 'N' or "N/A' Until all checklist items are complete, a red 'INCOMPLETE!' comment will show in the ARRA Compliance Check box

10 Code component compliance calculations are made in Columns AB – AF A red '*ERROR!* ' comment will show for each code component until the 'Complies?' field is completed

11 When a checklist item cannot be observed in the field (i.e. insulation installation), the checklist item shall be marked 'N/A'. When a component is marked 'N/A' for this reason, please note it as such in the Comments section Note: This is *in contrast* to the DOE Residential Checklist instructions where the guidance is to inspect a similar building if a checklist component isn't visible

12 Trade-off or Performance Compliance. If documentation was submitted showing the home complied via a Trade-off or Performance compliance approach, field values should be verified against the submitted documentation (e.g. if an observed checklist item does not meet the documentation, it should be marked Complies 'N')

13 Lighting. The IECC09 lighting requirement is Prescriptive only. If the builder submitted documentation showing the home complied via the Performance Approach the lighting checklist list component should be marked as Complies 'N/A' TIP For data entry in Comment fields, press ctrl+Enter to move to next line within Comment field

ECCC NYS2007 Checklist Instructions

1 ECCC NYS2007 allows for alternative insulation requirements listed in Table 402.1(2) if:

a. Tested infiltration is demonstrated to conform with Section 402.4.4 or

b. Tested duct leakage is demonstrated to conform with Section 403.2.4 or

c. Mechanical equipment conforms with Section 403.7

Additional checklist items were included to allow for compliance using one of the above alternative approached

If one of these items was meant to provide an exception to the prescriptive insulation requirements, mark it as Complies (Y or N)

If the component was not meant to provide an exception to the prescriptive insulation requirements, mark it as Complies (N/A)

e.g. Item number IN12 Air sealing testing via blower door. Lower ceiling and wall insulation levels are allowable if air sealing

complies with IN12. If the builder used this trade-off method, mark the Complies field 'Y' or 'N'

If the builder did not use this trade-off method, mark the Complies field 'N/A'

The prescriptive ceiling and wall insulation would also be marked as Complied 'Y' if the trade-off method was used and the

alternative insulation value was met

2 [IN14] 402.4 Air Leakage

402.4.1 Building thermal envelope. The building thermal envelope shall be durably sealed to limit infiltration. The sealing methods between dissimilar materials shall allow for differential expansion and contraction. The following shall be caulked, gasketed, weatherstripped or otherwise sealed with an air barrier material, suitable film or solid material:

1. All joints, seams and penetrations.
2. Site-built windows, doors and skylights.
3. Openings between window and door assemblies and their respective jambs and framing.

4. Utility penetrations.
5. Dropped ceilings or chases adjacent to the thermal envelope.
6. Knee walls.
7. Walls and ceilings separating a garage from conditioned spaces.
8. Behind tubs and showers on exterior walls.
9. Common walls between dwelling units.
10. Other sources of infiltration

J.3 NYSERDA DOE RESIDENTIAL CHECKLIST

The following is a copy of the checklist for ECCCNY2007 for Climate Zone 4 Except Marine. Similar forms were prepared for the other climate zones and for ECCCNY2010, but are not presented here.

Residential Data Collection Checklist

Energy Conservation Construction Code Of New York State 2007 Edition

Climate Zone 4 Except Marine

ARRA Compliance Check	
Points Possible:	0
Points Received:	0
Compliance Percentage:	
Compliance:	

Building ID: ____________ **Date:** ____________ **Name of Evaluator(s):** ____________

Building Contact:

Name: ____________ Phone: ____________ Email: ____________

Building Name & Address: ____________

Subdivision: ____________ **Lot #** ____________ **Conditioned Floor Area:** ____________ ft^2

State: ____________ **County:** ____________ **Jurisdiction:** ____________

Compliance Approach (check all that apply): ☐ Prescriptive ☐ Trade-Off ☐ Performance

Compliance Software Used: ____________ **Green/Above-Code Program:** ____________

Building Type:

1- and 2-Family, Detached: ☐ Single Family ☐ Modular ☐ Townhouse

Multifamily: ☐ Apartment ☐ Condominium

Project Type: ☐ New Building ☐ Addition to Existing Building ☐ Existing Building Renovation

KEY 1 **High Impact (Tier 1)** 2 **Medium Impact (Tier 2)** 3 **Low Impact (Tier 3)**

IECC Section #	Pre-Inspection/Plan Review	Code Value	Verified Value	Complies?	Comments/Assumptions[1]
104.2 [PR1][1]	Construction drawings and documentation available. Documentation sufficiently demonstrates energy code compliance.				
403.6 [PR2][2]	HVAC loads calculations Heating system size(s): Cooling system size(s):		kBtu: ____ kBtu: ____		
402.1.4 [PR3][1]	Residential buildings which use electric resistance heat as the primary heat source shall use DOE software, as provided in Section 101.5.1, for envelope compliance, or conform with Table 402.1.4[2].				

[1] Use Comments/Assumptions to document code requirements that pass due to exceptions, and specify the exception. Also use Comments/Assumptions to document multiple values observed for a given code requirement, such as multiple equipment efficiencies.

[2] ECCCNYS2007 Table 402.1.4 Insulation and fenestration requirements for residences using electric resistance heating:
Roof (R-49); Above grade wall (R26); Fenestration (U-0.31); Floor over unheated space (R-30); Basement wall (R-19); Slab edge (R-15, 4ft).

Additional Comments/Assumptions:

General building information only required if different than above

Building ID: ____________ **Date:** ____________ **Name of Evaluator(s):** ____________

Building Name & Address: ____________ **Conditioned Floor Area:** ____________ ft^2

Building Contact: Name: ____________ Phone: ____________ Email: ____________

Compliance Approach (check all that apply): ☐ Prescriptive ☐ Trade-Off ☐ Performance

Compliance Software Used: ____________ **Green/Above-Code Program:** ____________

IECC Section #	Foundation Inspection	Code Value	Verified Value	Complies?	Comments/Assumptions
402.1.1 [FO1][1]	Slab edge insulation R-value.	Unheated: R-10 Heated: R-15	R-____ ☐ Unheated ☐ Heated		
102.2, 402.2.7 [FO2][1]	Slab edge insulation Installed per manufacturer's instructions.				
402.1.1 [FO3][1]	Slab edge insulation depth/length.	2 ft.	____ ft.		
402.1.1 [FO4][1]	Basement wall exterior insulation R-value.	Continuous: R-10	R-____		
102.2 [FO5][1]	Basement wall exterior insulation installed per manufacturer's instructions.				
402.2.6 [FO6][1]	Basement wall exterior insulation depth.	See footnote[3]	____ ft.		
402.2.8 [FO7][1]	Crawl space wall insulation R-value.	Continuous: R-10 Cavity: R-13	R-____ R-____		
102.2 [FO8][1]	Crawl space wall insulation installed per manufacturer's instructions.				
402.2.8 [FO9][1]	Crawl space continuous vapor retarder installed with joints overlapped by 6 inches and sealed, and extending at least 6" up the stem wall.				
102.2.1 [FO10][2]	Exposed exterior foundation insulation protection present and extends a minimum of 6 inches below grade				

[3]To a depth of 24" below grade, where the HDD are <= 6,000; 48" below grade, where the HDD are >6,000 but <8,000; and to a depth of 84" or to the level of the basement floor, whichever is less, where the HDD are >8,000.

Additional Comments/Assumptions:

General building information only required if different than above

Building ID: ______________ **Date:** ______________ **Name of Evaluator(s):** ______________________________

Building Name & Address: ______________________________ **Conditioned Floor Area:** __________ ft²

Building Contact: Name: ______________________ Phone: ______________ Email: ____________

Compliance Approach (check all that apply): ☐ Prescriptive ☐ Trade-Off ☐ Performance

Compliance Software Used: ______________ **Green/Above-Code Program:** ______________

IECC Section #	Framing/Rough-In Inspection	Code Value	Verified Value	Complies?	Comments/Assumptions
402.1.1, 402.3.4 [FR1][1]	Door U-factor.[2, 4]	U-0.40	U-_____		
402.1, 402.3.1, 402.3.3, 402.5.1 [FR2][1]	Glazing U-factor (area-weighted average).[5]	U-0.40 (0.40 max)[6]	U-_____		
102.1.3 [FR3][1]	Glazing labeled for U-factor (or default values used).				
402.1.1, 402.3.3, 402.5.1 [FR4][1]	Skylight U-factor.[5]	U-0.60	U-_____		
102.1.3 [FR5][1]	Skylights labeled for U-factor (or default values used).				
402.3.5 [FR6][1]	Sunroom glazing U-factor.	U-0.50	U-_____		
402.3.5 [FR7][1]	Sunroom skylight U-factor.	U-0.75	U-_____		
402.1.1 [FR8][1]	Mass wall insulation R-value.	R-5	R-_____		

[4] One side-hinged door up to 24 ft² can be exempted from the prescriptive door U-factor requirements.

[5] Up to 15 ft² of glazed fenestration, including skylights, may be exempted from U-factor requirements under the prescriptive approach.

[6] U-factor mandatory maximum using trade-offs.

IECC Section #	Framing/Rough-In Inspection	Code Value	Verified Value	Complies?	Comments/Assumptions
102.2 [FR9][1]	Mass wall insulation installed per manufacturer's instructions.				
403.2.1 [FR10][1]	Duct insulation.	R-8 (supply & return); R-6 (ducts in floor trusses)	R-_____ R-_____		
403.2.2 [FR11][1]	Duct sealing complies with listed sealing methods.				
403.2.3 [FR12][1]	Building cavities NOT used for supply ducts.				
402.4.3 [FR13][2]	IC-rated recessed lighting fixtures meet infiltration criteria.				
403.3 [FR14][2]	HVAC piping insulation. [7] Exception: Heating piping located entirely within the building envelope	R-2	R-_____		
403.4 [FR15][2]	Circulating hot-water piping insulation.	R-2	R-_____		
403.5 [FR16][2]	Dampers Installed on all outdoor Intake and exhaust openings.				
402.4.2 [FR17][3]	Glazed fenestration air leakage.	0.3 cfm/ft^2	_____ cfm/ ft^2		
402.4.2 [FR18][3]	Swinging door air leakage.	0.5 cfm/ft^2	_____ cfm/ ft^2		
402.4.2 [FR19][3]	Fenestration and doors labeled for air leakage.				

[7] For Mechanical piping systems carrying fluids above 105 deg. F or below 55 deg. F

Additional Comments/Assumptions:

General building information only required if different than above

Building ID: ______________ **Date:** ______________ **Name of Evaluator(s):** ______________________

Building Name & Address: ______________________ **Conditioned Floor Area:** __________ ft²

Building Contact: Name: ______________ Phone: ______________ Email: ______________

Compliance Approach (check all that apply): ☐ Prescriptive ☐ Trade-Off ☐ Performance

Compliance Software Used: ______________ **Green/Above-Code Program:** ______________

IECC Section #	Insulation Inspection	Code Value	Verified Value	Complies?	Comments/Assumptions
402.1, 402.2.4, 402.2.5 [IN1][1]	Floor insulation R-value. N/A when basement walls are insulated.	Wood: R-19 Steel:[8] See Footnote	R-____ ☐ Wood ☐ Steel		
102.2 [IN2][1]	Floor insulation installed per manufacturer's instructions, and in substantial contact with the subfloor.				
402.1 402.2.3 402.2.4 [IN3][1]	Wall insulation R-value.	Wood: R-15 (Alt: R-13[9]) Steel:[10] See Footnote	R-____ ☐ Wood ☐ Mass ☐ Steel		
102.2 [IN4][1]	Wall insulation installed per manufacturer's instructions.				
402.1 [IN5][1]	Basement wall interior insulation R-value.	Continuous: R-10 Cavity: R-13	R-____ R-____		
102.2 [IN6][1]	Basement wall interior insulation installed per manufacturer's Instructions.				
402.2.6 [IN7][1]	Basement wall interior insulation depth.	Top of basement wall to basement floor[3]	____ ft.		
402.2.10 [IN8][1]	Sunroom wall insulation R-value.	R-13	R-____		
102.2 [IN9][1]	Sunroom wall insulation installed per manufacturer's Instructions.				

[8] Floor steel frame equivalent: R-19+R-6 in 2x6 or R-19+R-12 in 2x8 or 2x10

[9] The thermal envelope shall be permitted to meet the requirements of ECCC NYS2007 Table 402.1(2) if: 1) Tested infiltration is demonstrated to conform with Section 402.4.4; or 2) Tested duct leakage is demonstrated to conform with Section 403.2.4; or 3) Mechanical equipment conforms with Section 403.7

[10] Wall steel frame equivalent: R-13+R-5; R-15+R-4; R-21+R-3;

IECC Section #	Insulation Inspection	Code Value	Verified Value	Complies?	Comments/Assumptions
402.2.10 [IN10][1]	Sunroom ceiling insulation R-value.	R-19	R-_____		
102.2 [IN11][1]	Sunroom ceiling insulation installed per manufacturer's instructions.				
402.4.4, [IN12][1]	Air sealing complies with sealing requirements via blower door test. This is an optional requirement, see footnote #9	ACH 50 ≤ 5.5	_____ ACH50		
102.1 [IN13][2]	All installed insulation labeled or installed R-value provided.				
402.4.1, [IN14][3]	Air sealing complies with sealing requirements See ECCC NYS2007 checklist instructions				
402.5 [IN15][3]	Vapor retarders installed in accordance with 402.5 Moisture control. Exceptions[11]				

[11] Exceptions to Section 402.5 Moisture Control: 1)In construction where moisture or its freezing will not damage materials; 2) Frame walls, floors and ceilings in Zone 4 (Crawl space floor vapor retarders are not exempted); 3) Where other approved means to avoid condensation are provided.

Additional Comments/Assumptions:

General building information only required if different than above

Building ID: ______________ **Date:** ______________ **Name of Evaluator(s):** ______________________

Building Name & Address: ______________________ **Conditioned Floor Area:** ________ ft²

Building Contact: Name: ______________ Phone: ______________ Email: ______________

Compliance Approach (check all that apply): ☐ Prescriptive ☐ Trade-Off ☐ Performance

Compliance Software Used: ______________ **Green/Above-Code Program:** ______________

IECC Section #	Final Inspection Provisions	Code Value	Verified Value	Complies?	Comments/Assumptions
402.1 402.2.1 402.2.2 [FI1][1]	Ceiling insulation R-value.	Wood: R38[12] (Alt: R-30[9]) Steel Truss[13] Steel Joist: R-49	R-____ ☐ Wood ☐ Steel		
102.1.1.1 102.2 [FI2][1]	Ceiling insulation installed per manufacturer's instructions. Blown insulation marked every 300 ft².				
403.2.4 [FI3][1]	Duct tightness test. This is an optional requirement, see footnote #9	6% of CFA measured at CFM25 (add footnote)	______ cfm		
403.6 [FI4][1]	Heating and cooling equipment type and capacity as per plans.				
403.7 [FI5]1	Heating and cooling equipment efficiency This is an optional requirement, see footnote #9	Gas furnace (90% AFUE); Oil Furnace, Oil/ Gas Boiler (82% AFUE); Heat Pump (8.5 HSFP)	______ AFUE		
401.3 [FI6][2]	Certificate posted.				
102.5 [FI7][2]	Wood burning fireplace - gasketed doors and outdoor air for combustion.				
403.1.1 [FI8][2]	At least one programmable thermostat installed				
403.4 [FI9][2]	Circulating service hot water systems have automatic or accessible manual controls.				

[12] R-30 if insulation is not compressed at eaves. R-30 may be used for 500 ft² or 20% (whichever is less) where sufficient space is not available.

[13] Steel truss equivalent: R-49; R-38+R-3.

Additional Comments/Assumptions:

Additional Comments/Assumptions

J.4 NYSERDA SUPPLEMENTAL DATA COLLECTION FORM

NYSERDA Supplemental Data Collection Form

Floor Area Clarifications

For Determination of Code Compliance						
	Area (sq. ft.)			Volume (cu. ft.)		
Location	Conditioned	Unconditioned	Finished	Conditioned	Unconditioned	Finished
Basement						
First Floor						
Second Floor						
Third Floor						
Other						
Total	**0**	**0**	**0**	**0**	**0**	**0**

IECC 2009: *Conditioned Space: An area or room within a building being heated or cooled, containing uninsulated ducts [or hydronic pipes], or with a fixed opening directly into an adjacent*

For Use in REM/Rate						
	Area (sq. ft.)			Volume (cu. ft.)		
Location	Conditioned	Unconditioned	Finished	Conditioned	Unconditioned	Finished
Basement						
First Floor						
Second Floor						
Third Floor						
Other						
Total	**0**	**0**	**0**	**0**	**0**	**0**

RESNET: *Conditioned Floor Area (CFA) – The finished floor area in square feet of a home that is conditioned by heating or cooling systems, measured in accordance with ANSI Standard Z765-2003 with exceptions as specified in Appendix A of this Standard. [Exemption states to include all floor area, even if less than 5' ceiling height.]*

NYSERDA Supplemental Data Collection Form

	Lighting Table			
	For use in REM/Rate		For determination of Code Compliance	
	Number of *Fixtures*		Number of *Lamps/Bulbs*	
	Fluorescent	(Non) Fluorescent	High-Efficacy	(Non) High-Efficacy
RESNET Qualifying Locations				
Kitchen				
Dining Room				
Living Room				
Family Room				
Den				
Bathroom				
Hallway				
Stairway				
Entrance				
Bedroom				
Garage				
Utility Room				
Home Office				
Outdoor (mounted)				
Other Locations				
Unconditioned basements	**Do not use this section for REM/Rate**			
Closets				
Landscape lighting				
Other				
Other				
Totals	0	0	0	0
	-	<<Percent efficient	-	<<Percent efficient

IECC 2009 Code compliance
404.1 Lighting equipment. A minimum of 50 percent of the *lamps* in permanently installed lighting fixtures shall be *high-efficacy* lamps (e.g. may include SSL/LED's)

For use in REM/Rate
The percentage of *Qualifying Light Fixtures* to all light fixtures in Qualifying Light Fixture Locations. Although not specifically called for in REM/Rate, other high-efficacy fixtures (e.g. SSL) should be included here.

J.5 BUILDING CHARACTERISTICS GENERAL OBSERVATIONS FORM

The intent of this form is to collect the *Auditor's subjective observations from each house* in order to convey what is seen in the field back to those in the office who will be compiling the results and making recommendations to the client in terms of how to improve our homes. You are our eyes and ears and we are relying on you to *interpret what you see and report it back.* Thank you!

Homeowner name ___________________________________

CSG reference number _______________

	Ranking				
	1 (poor)	2	3	4	5 (great)
1. *Construction Quality* In general, what is your opinion about the construction quality of this home, from poor to excellent? Are there aspect of the home that are worthy of noting below (good or bad)?					
Your Subjective Observations:					

	1 (many)	2	3	4	5 (none)
2. *Missed Energy Opportunities by Builder* What energy opportunities were missed by the builder that might have improved the home?					
Your Subjective Observations:					

	1 (many)	2	3	4	5 (none)
3. *Recommendations for Energy Improvements* Do you have any energy efficiency or health & safety recommendations? How many and what are some examples (note below)?					
Your Subjective Observations:					

Please provide any and all other *observations regarding building science issues* (moisture, spillage, construction detailing oversights, bypasses, etc.) and anything else that we should consider when making recommendations about follow-up training and future codes:

Other Comments: ____

____

____

Qualitative Observations

From the list below of home features, please make recommendations for top four (4) worse energy features that could be improved. Rank these in order from #1 (worst) to #4 (not as bad). Place the letter of the feature next to each question.

A	Wall insulation installation
B	Wall insulation R-values
C	Wall air leakage
D	Ceiling insulation installation
E	Ceiling insulation R-values
F	Ceiling air leakage
G	Basement insulation installation (select only if insulation present)
H	Basement insulation R-value (including no insulation)
I	Basement air leakage
J	Window quality
K	Window U-value
L	Window air leakage
M	House air leakage reduction (overall)
N	Furnace/boiler installation quality
O	Furnace/boiler efficiency (AFUE)
P	Central air conditioning installation quality
Q	Central air conditioning efficiency (SEER)
R	Duct system installation (craftsmanship of duct system, not including insulation)
S	Duct system tightness
T	Duct system insulation installation
U	Duct system insulation R-value
V	Water heater installation quality
W	Water heater efficiency (Energy Factor)
X	House solar orientation
Y	Kitchen range hood quality/effectiveness
Z	Bathroom fan quality/effectiveness
AA	Other:

EXAMPLE	
#1 Worst Energy Feature:	**A**
#2 Worst Energy Feature:	**H**
#3 Worst Energy Feature:	**K**
#4 Worst Energy Feature:	**T**

Worst Energy Features	
#1 Worst Energy Feature:	
#2 Worst Energy Feature:	
#3 Worst Energy Feature:	
#4 Worst Energy Feature:	

Photos

Please take digital images of:

1. House from all sides from the outside (can be done in two photos from opposite corners)
2. Building science issues, problems, concerns or well-done detailing
3. Health and safety issues
4. Opportunities for future training and improvement we should note in our report

J.6 BUILDING CHARACTERISTICS GENERAL OBSERVATIONS FORM FOR HOMEOWNERS

Homeowner name ______________________

CSG reference number _______________

Custom home? Yes_____ No______
Spec home? Yes______ No_______

Ranking	1 (Not considered)	2	3	4	5 One of top 5 priorities
1. <u>Customer's priorities</u> How important were energy efficient construction and specification practices and/or lower operating costs to the homeowner at the time the house was designed and built – or if a spec home, one of the priorities considered during the purchase decision making process.					
Your Subjective Observations:					

	1 Not at all	2	3	4	5 Highly informed
2. **<u>Awareness of Homeowner of Building Science concepts</u>**					
Your Subjective Observations:					

	1 Not at all	2	3	4 Actively involved with both Builder and Architect	5 Involved with Architect, Builder **AND** Code official
3. <u>Homeowner's involvement in process:</u> How involved was the homeowner in overseeing the specification and quality of installation of important energy-related building elements?					
Your Subjective Observations:					

Other Comments: ____

____

____

Homeowner's priorities

From the list below of home features, please list your observation of the homeowner's priorities. Place the letter of the feature next to each question.

Note: some letters intentionally skipped

A	Wall insulation type
B	Wall insulation R-values
D	Ceiling insulation type
E	Ceiling insulation R-values
G	Basement insulation type (select only if insulation present)
H	Basement insulation R-value (including no insulation)
J	Window quality (U-value)
K	Presence of mechanical ventilation and/or HRV to ensure air quality
M	House air leakage reduction (overall)
N	Furnace/boiler installation quality
O	Furnace/boiler efficiency (AFUE)
Q	Central air conditioning efficiency (SEER)
R	Geothermal system
S	Duct system tightness and/or location –i.e. if intentionally kept within conditioned space
T	Duct system insulation installation
V	Water heater efficiency (Energy Factor)
W	House solar orientation
X	PVs or Solar DHW
Y	Kitchen range hood quality/effectiveness
Z	Bathroom fan quality/effectiveness
AA	Other:

EXAMPLE	
#1 Highest Priority:	**A**
#2 Priority	**H**
#3 Priority	**K**
#4 Priority	**T**

Highest Priorities
#1
#2
#3
#4

Note type of insulation if it was a priority:

J.7 CODE OFFICE DOCUMENT CHECKLIST

Homeowner: Date:
Address:
Town of: County:
Building Inspector/Code Enforcement Officer:
Building Inspector Phone Number:

<table>
<tr><th colspan="2">Document</th><th>Present</th><th>Not Present</th><th>Matches Site Visit</th></tr>
<tr><td colspan="2">Certificate of Occupancy with Attachments (please list):</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Full Set of Stamped Plans</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">HVAC Sizing (Manual J or equivalent)</td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Inspection Reports for:</td><td>Residence (please list):</td><td></td><td></td><td></td></tr>
<tr><td>Garage</td><td></td><td></td><td></td></tr>
<tr><td>Fireplace</td><td></td><td></td><td></td></tr>
<tr><td>Sewer and water</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">REScheck Compliance Certificate</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Residential Code Checklist</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Other:</td><td></td><td></td><td></td></tr>
</table>

J.8 FUEL INFORMATION RELEASE FORM

Fuel Information Release Form

I hereby authorize release of my energy consumption history information for research and analysis purposes. I understand that it will be kept strictly confidential and may only be made public in aggregate, not attributed to any particular customer.

My account information is provided below.

Electric Utility	
Natural Gas Utility	
Fuel Oil / Kerosene	Dealer:
	Town:
Propane / LP	Dealer:
	Town
Wood Use	# Cords burned last year:
	Tons of pellets burned last year:
Other	

Please Print Name ___________________________________
Address ____
Address ____
Phone ____

Signed _________________________

Date ____________________

J.9 GIFT CERTIFICATE SIGN-OFF FORM

I acknowledge that I have received a $100 gift certificate from

_________________________ in return for allowing Conservation Services Group (CSG) to access plans and perform an energy code analysis on my home. It is understood that this data collection and analysis is for surveying and research purposes only.

Signed ______________________ **Date** ____________________

Please Print Name ____________________________

J-10 REPORT ON RECRUITMENT PLAN

Comprehensive, Statewide Energy Code Compliance Assessment.

CSG Recruitment Plan

Call Center Process

August 25, 2010

It is preferred that advanced notification, including but not limited to direct mail and email blasts, be sent to participants prior to outbound calling efforts beginning. This approach improves the likelihood of participation. Included in this advance notification can be the contact information of the call center. Interested participants may want to proactively contact us or return calls to the call center. To assist this process, a dedicated toll free number could be approved by VEIC and established. The CSRs will leave the toll free number when voice mail is the only alternative for customers that have not been able to be reached. Also, participants who've received the mailings &/or email blasts to can proactively contact the CSG Contact Center to schedule an appointment.

Approximately 3 to 4 days after mailings have been sent and 1 to 2 days after email blasts have been completed, CSG's Customer Contact Center will begin outbound calling efforts. Outbound calling efforts will include no less than 5 outbound calling attempts, at varying times of the day, including evenings, and varying days of the week, including Saturday, unless otherwise instructed, before eliminating a lead from the calling list. CSG Customer Service Representatives (CSRs) will recruit and schedule 44 on-site appointments.

Participants will be asked to call this dedicated number to schedule an appointment. It is expected that this toll free number will also be used by participants when needing to cancel &/or change their appointment date. Finally, when originally scheduling appointments CSR's will, based on participant availability and willingness, create a 'last minute availability list'. This list will assist CSR's in attempting to fill open appointments when cancelations &/or 'no-shows' are received.

In the event of a cancelation, CSG's CSRs will attempt to reschedule the appointment for a later date and/or time that is convenient for the participant. Any cancelations received for the same day, will be immediately communicated to surveyors. Open appointments will be a priority and CSRs will immediately attempt to fill this availability by first attempting to move up the next scheduled appointment, then by looking to move up a future appointment by referencing the 'last minute availability list and contacting participants who've indicated such. Travel concerns will be considered prior to moving up &/or rescheduling any appointments.

Cancelations received for future appointment days will be communicated nightly through the data transfer process.

In the event where a surveyor arrives at the participant's location and the participant is not available, these appointments will be deemed 'no-shows'. It is expected that surveyor's will immediately contact the CSG Contact Center to report the no-show, using a pre-established Contact Center Support Hotline. CSG's CSR's will immediately reach out to the participant to ensure that are unable to keep the original appointment time and date and if necessary reschedule for another day. In these cases, CSRs will attempt to move up the next appointment to minimize any lost production and to maximize surveyor's time.

J-11 ON-SITE HOMEOWNER CALLING SCRIPT

Hello, May I speak to <Homeowner Name> please?

Hello, my name is <CSR Name>, I'm calling from Conservation Services Group. CSG has been contracted by the New York State Energy Research and Development Authority (NYSERDA) to conduct On-Site Energy Compliance Survey which will evaluate the level of energy efficiency in your home. As a thank your for your time and once the inspection has been completed, we'll provide participants with a $100 American Express gift card.

NYSERDA recently sent you a letter introducing the study and inviting you to participate. The purpose of the study is to gain valuable information on energy building code practices. Your participation will assist in improving services to the new construction market in New York State. We're following up today to see if you're interested in participating in scheduling an on-site inspection.
****

Q1. Am I speaking to the homeowner?
Yes
If no, ask to speak with the homeowner

- If homeowner is not available, find out when would be a convenient time to reach the homeowner.
- Thank and end call.
- Note best time to call back for follow up call with homeowner.

Q2. In what year was your home built?
Note to CSR:

- If the home was built from 2007 to current, proceed with On-site details.

- If built before 2007
  "I'd like to thank you for your time; we are currently surveying homes built from 2007 to present." Have a great day!

Q3. Is your home an Energy Star Labeled Home?
Note to CSR:

- If yes, thank the customer for their time.
- Thank you and end the call.

- If no, proceed with the On-site details.

Congratulations!
You are eligible to participate in an on-site Energy Compliance Survey!

If you are interested, and can help us gather this much needed energy information, our field representative will complJ-ete an inspection and conduct diagnostic testing of your home energy usage. The testing will include a blower door test

& duct leakage testing in homes with forced air systems. Upon completion of this data collection process, the field representative will leave you with a $100.00 American Express gift card as a way of thanking you for taking the time to participate in this Energy Survey.

Details of the visit;

- Visits are expected to last 2-4 hours, depending on the size of the home
- Fireplaces/woodstoves, etc should not be used 24 hours prior to the visit
- The technician will ask you a series of question then proceed with a visual assessment of your home.
- In some cases more than 1 technician may arrive, this is done to help expedite the process.
- Technicians will be carrying proper identification stating they are from Conservation Services Group. We recommend you ask to see proper identification prior to allowing anyone into your home.
- The technician will need access to the entire home (attic/basement)
- At the completion of the visit, the technician will present you with the $100 American Express Gift Card
- If you have the blueprints of your home available, we ask that you have them available for the technician at the time of the visit.
- We'll call you 24 to 48 hours prior to your appointment date as a courtesy call.
  If you need to reschedule your appointment, we ask for as much advanced notice as possible. Please call us at 1-877-741-4312

FAQs:

Q1. Why is the New York State Energy Research and Development Authority conducting these surveys?
A1. To ensure that the state of New York meets its 2017 90% code compliance requirement.

Q2. Will I receive a copy of the survey results?
The survey is for data collection purposes only, therefore no reports or documentation will be provided. All results will be aggregated and no individual findings will be shared. All responses are kept strictly confidential. At the completion of the inspection, only the thank you gift card ($100 AMEX card) is left.

Q3. What if I need to cancel my appointment?
Please call us as soon as possible at 1-877-741-4312

Q4. Why can't I use my fireplace/wood stove before the appointment?
A4. Diagnostic testing will be performed (blower door testing & duct leakage testing), using your fireplace/woodstove may scatter ash and/or soot.

Q5. How long will the assessment take?
A5. Depending on the size of your home, the assessment can take 2-4 hours to conduct.

Q6. Is my information shared?
A6. All information obtained in this evaluation will be strictly confidential.

Q7. Will I be asked to buy anything?
A7. I am not selling anything. NYSERDA simply wants to understand the energy efficiency levels of your building for statistical purposes.

Q8. How do I know this is legitimate?
A8. If you would like to talk with someone from NYSERDA about this effort, you can call NYSERDA Project Manager: Marilyn Kaplan at 1-518-862-1090 x3298

Q9. Do I have to do anything before the technician arrives?
A9. The technician will need access to your entire home as well as all duct registers. We ask that you provide a clear access to the attic and basement as well as move any furniture away from registers. These steps will help speed up the assessment process.

Again, all information gathered during the inspection will be kept strictly confidential and used for this research purpose only. NYSERDA will not report your responses in any way that would reveal your identity. The research will be used solely to assess the state Energy Efficiency Building Code compliance at the time your home was constructed.

J-12 RECRUITMENT COLLECTION FORM

VEIC Code Compliance Initiative – Recruitment Calls

Cover Sheet

County: ________________________

Town: _________________________

Name of Code Officer: ___________________________

Phone Number of Code Officer: ____________________

Hours of Office: _____________________________

VEIC Code Compliance Initiative

Data Collection Form

*Homeowner	
*Address	
*Phone Number	
Completion Date	
Size of Home	
Style of Home	
Notes	

J-13 TRAINING SCHEDULE FOR RECRUITERS AND ON-SITE INSPECTORS

Task 4.3: **Recruitment** for on-sites:

- a.) Identification of staff members trained – 1 supervisor, 2 CSRs trained
  - a. Dawn Arruda, Supervisor
  - b. Julie Ann Marks
  - c. Ashley Schuster
- b.) Dates trained
  - a. Staff trained on 10/28 and 1/17 – please note, as details and changes occurred, staff were updated and 'retrained'

Task 5.3: Training for on-site raters

- a.) Identification of staff members trained (and therefore the number of raters): The following raters were involved in the CSG Training
  - Earl Hicks
  -Russ Zimmerman
  -Bob Grindrod
  -Bob Muller
  -Rick Derikart
  -Matt Houle
  -Pete Vento
  - Kyle Archie for a total of 8

- b.) Dates trained: November 3, 2010

- c.) Copy of the script for training –separate file

- d.) Locations each rater inspected. Separate fileAppendix K:

APPENDIX K PPNL CHECKLIST SUMMARY RESULTS

NYSERDA BECP Protocol 90% Compliance Checklist - Summary Results for 2007 NYS ECCC

	Checklist Item and Code Section Reference	Checklist Item Descrtiption	Yes	No	N/A	Not Observed
Pre-Inspection/Plan review	104.2 [PR1][1]	Construction drawings and documentation available. Documentation sufficiently demonstrates energy code compliance.	57%	43%	0%	0%
	403.6 [PR2][2]	HVAC loads calculations	5%	95%	0%	0%
	402.1.4 [PR3][1]	Residential buildings which use electric resistance heat as the primary heat source shall use DOE software, as provided in Section 101.5.1, for envelope compliance, or conform with Table 402.1.4.	0%	2%	98%	0%
Foundaion inspection	402.1.1 [FO1][1]	Slab edge insulation R-value.	7%	25%	68%	0%
	102.2, 402.2.7 [FO2][1]	Slab edge insulation Installed per manufacturer's instructions.	2%	14%	68%	16%
	402.1.1 [FO3][1]	Slab edge insulation depth/length.	16%	14%	68%	2%
	402.1.1 [FO4][1]	Basement wall exterior insulation R-value.	7%	0%	93%	0%
	102.2 [FO5][1]	Basement wall exterior insulation installed per manufacturer's instructions.	7%	0%	93%	0%
	402.2.6 [FO6][1]	Basement wall exterior insulation depth.	7%	0%	93%	0%
	402.2.8 [FO7][1]	Crawl space wall insulation R-value.	0%	0%	100%	0%
	102.2 [FO8][1]	Crawl space wall insulation installed per manufacturer's instructions.	0%	0%	100%	0%
	402.2.8 [FO9][1]	Crawl space continuous vapor retarder installed with joints overlapped by 6 inches and sealed, and extending at least 6" up the stem wall.	0%	0%	100%	0%
	102.2.1 [FO10][2]	Exposed exterior foundation insulation protection present and extends a minimum of 6 inches below grade.	7%	0%	93%	0%
Framing/Rough-in Inspection	402.1.1, 402.3.4 [FR1][1]	Door U-factor.	93%	7%	0%	0%
	402.1, 402.3.1, 402.3.3, 402.5.1 [FR2][1]	Glazing U-factor (area-weighted average).	82%	18%	0%	0%
	102.1.3 [FR3][1]	Glazing labeled for U-factor (or default values used).	18%	0%	0%	82%
	402.1.1, 402.3.3, 402.5.1 [FR4][1]	Skylight U-factor.	14%	2%	84%	0%
	102.1.3 [FR5][1]	Skylights labeled for U-factor (or default values used).	0%	0%	84%	16%
	402.3.5 [FR6][1]	Sunroom glazing U-factor.	0%	0%	100%	0%
	402.3.5 [FR7][1]	Sunroom skylight U-factor.	0%	0%	100%	0%
	402.1.1 [FR8][1]	Mass wall insulation R-value.	0%	2%	98%	0%
	102.2 [FR9][1]	Mass wall insulation installed per manufacturer's instructions.	0%	2%	98%	0%
	403.2.1 [FR10][1]	Duct insulation.	66%	16%	18%	0%
	403.2.2 [FR11][1]	Duct sealing complies with listed sealing methods.	52%	25%	18%	5%
	403.2.3 [FR12][1]	Building cavities NOT used for supply ducts.	68%	0%	18%	14%
	402.4.3 [FR13][2]	IC-rated recessed lighting fixtures meet infiltration criteria.	25%	0%	27%	48%
	403.3 [FR14][2]	HVAC piping insulation. Exception: Heating piping located entirely within the building envelope	68%	7%	25%	0%
	403.4 [FR15][2]	Circulating hot-water piping insulation.	0%	0%	100%	0%
	403.5 [FR16][2]	Dampers Installed on all outdoor Intake and exhaust openings.	70%	9%	0%	20%
	402.4.2 [FR17][3]	Glazed fenestration air leakage.	2%	0%	0%	98%
	402.4.2 [FR18][3]	Swinging door air leakage.	2%	0%	0%	98%
	402.4.2 [FR19][3]	Fenestration and doors labeled for air leakage.	0%	0%	0%	100%

NYSERDA BECP Protocol 90% Compliance Checklist - Summary Results for 2007 NYS ECCC

Insulation Inspection	402.1, 402.2.4, 402.2.5 [IN1][1]	Floor insulation R-value. N/A when basement walls are insulated.	41%	14%	45%	0%
	102.2 [IN2][1]	Floor insulation installed per manufacturer's instructions, and in substantial contact with the subfloor.	7%	11%	45%	36%
	402.1 402.2.3 402.2.4 [IN3][1]	Wall insulation R-value.	86%	14%	0%	0%
	102.2 [IN4][1]	Wall insulation installed per manufacturer's instructions.	7%	0%	2%	91%
	402.1 [IN5][1]	Basement wall interior insulation R-value.	66%	18%	16%	0%
	102.2 [IN6][1]	Basement wall interior insulation installed per manufacturer's Instructions.	50%	7%	16%	27%
	402.2.6 [IN7][1]	Basement wall interior insulation depth.	73%	5%	16%	7%
	402.2.10 [IN8][1]	Sunroom wall insulation R-value.	0%	0%	100%	0%
	102.2 [IN9][1]	Sunroom wall insulation installed per manufacturer's Instructions.	0%	0%	100%	0%
	402.2.10 [IN10][1]	Sunroom ceiling insulation R-value.	0%	0%	100%	0%
	102.2 [IN11][1]	Sunroom ceiling insulation installed per manufacturer's instructions.	0%	0%	100%	0%
	402.4.4, [IN12][1]	Air sealing complies with sealing requirements via blower door test. This is an optional requirement.	27%	0%	73%	0%
	102.1 [IN13][2]	All installed insulation labeled or installed R-value provided.	14%	0%	0%	86%
	402.4.1, [IN14][3]	Air sealing complies with sealing requirements See ECCC NYS2007 checklist instructions	2%	18%	0%	80%
	402.5 [IN15][3]	Vapor retarders installed in accordance with 402.5 Moisture control.	9%	0%	2%	89%
Final Inspection Provisions	402.1 402.2.1 402.2.2	Ceiling insulation R-value.	82%	18%	0%	0%
	102.1.1.1 102.2 [FI2][1]	Ceiling insulation installed per manufacturer's instructions. Blown insulation marked every 300 ft^2.	50%	18%	0%	32%
	403.2.4 [FI3][1]	Duct tightness test. This is an optional requirement.	7%	0%	93%	0%
	403.6 [FI4][1]	Heating and cooling equipment type and capacity as per plans.	0%	100%	0%	0%
	403.7 [FI5]1	Heating and cooling equipment efficiency This is an optional requirement.	30%	0%	70%	0%
	401.3 [FI6][2]	Certificate posted.	2%	98%	0%	0%
	102.5 [FI7][2]	Wood burning fireplace - gasketed doors and outdoor air for combustion.	16%	0%	84%	0%
	403.1.1 [FI8][2]	At least one programmable thermostat installed	91%	9%	0%	0%
	403.4 [FI9][2]	Circulating service hot water systems have automatic or accessible manual controls.	0%	0%	100%	0%

[1] High Impact (Tier 1)
[2] Medium Impact (Tier 2)
[3] Low Impact (Tier 3)

General Housing Characteristics							
Building ID	Climate Zone	Building Type	CFA	Volume	Stories	Beds	Units
			sq. ft.	cu. ft.			
0	cz5	Single-family detached	3560	30404	1	3	1
1	cz6	Single-family detached	2808	25081	2	3	1
2	cz5	Single-family detached	4298	39832	2	3	1
3	cz5	Single-family detached	3252	29268	1	3	1
4	cz5	Single-family detached	4048	35584	2	3	1
5	cz4	Townhouse, inside unit	2847	24723	2	4	1
6	cz4	Single-family detached	4212	35315	3	4	1
7	cz5	Single-family detached	4833	43497	3	3	1
8	cz4	Multi-family,wholebuilding	2903	24289	2	4	2
9	cz4	Townhouse, end unit	2400	21600	3	4	1
10	cz5	Single-family detached	2937	23496	2	4	1
11	cz6	Single-family detached	2355	18844	2	5	1
12	cz6	Single-family detached	4604	36829	1	3	1
13	cz5	Single-family detached	3544	30644	2	3	1
14	cz5	Single-family detached	3615	28920	2	3	1
15	cz5	Duplex, whole building	5423	45571	2	6	2
16	cz5	Single-family detached	4412	37028	2	4	1
17	cz5	Single-family detached	5865	53709	2	5	1
18	cz5	Single-family detached	2892	23136	2	3	1
19	cz6	Duplex, single unit	744	12390	1	2	1
20	cz5	Single-family detached	3670	33798	2	3	1
21	cz5	Townhouse, end unit	2504	25040	1	2	1
22	cz5	Single-family detached	3630	32670	1	3	1
23	cz5	Single-family detached	2625	21000	2	4	1
24	cz5	Single-family detached	2352	18816	2	3	1
25	cz5	Single-family detached	2916	23328	2	3	1
26	cz4	Single-family detached	8869	79020	3	4	1
27	cz4	Duplex, whole building	2874	26040	2	3	2
28	cz6	Single-family detached	2800	23560	3	4	1
29	cz5	Single-family detached	2828	22624	2	3	1
30	cz5	Single-family detached	5246	43032	2	4	1
31	cz5	Single-family detached	1898	15184	2	3	1
32	cz6	Single-family detached	3024	25200	2	3	1
33	cz4	Single-family detached	11320	108982	2	4	1
34	cz5	Single-family detached	5020	50200	1	4	1
35	cz4	Townhouse, inside unit	2146	17677	3	1	1
36	cz6	Single-family detached	1830	16265	2	4	1
37	cz5	Single-family detached	3102	24819	2	3	1
38	cz5	Single-family detached	4423	35384	2	4	1
39	cz4	Single-family detached	4719	41037	2	5	1
40	cz6	Single-family detached	1813	14502	1	2	1
41	cz5	Single-family detached	4113	36213	2	3	1
42	cz6	Single-family detached	3065	25552	2	4	1
43	cz5	Single-family detached	3840	34560	2	4	1

Average Energy Efficiency Values												
Building ID	Climate Zone	Window	Door	Ceiling Attic	Ceiling Slope	Above Grade Wall	Floor	Basement Wall	Slab	Infiltration	Duct Leakage	Efficient Lamps
		Weighted Average U-Factor		Weighted Average R-Value						ACH50	% CFA	Present
0	cz5	0.40	0.14	38	N/A	21	N/A	13	N/A	2.8	3%	22%
1	cz6	0.32	0.23	N/A	38	8	N/A	18	N/A	5.3	N/A	32%
2	cz5	0.31	0.23	38	37	18	30	N/A	N/A	3.2	3%	12%
3	cz5	0.35	0.38	43	N/A	13	N/A	5	N/A	4.4	0%	0%
4	cz5	0.35	0.20	40	N/A	19	N/A	12	12	4.7	2%	0%
5	cz4	0.33	0.59	30	29	11	30	11	N/A	13.7	N/A	100%
6	cz4	0.33	0.14	22	N/A	20	19	13	1	5.0	Not Observed	75%
7	cz5	0.30	0.36	49	N/A	19	N/A	13	5	3.1	2%	0%
8	cz4	0.36	0.67	38	N/A	18	30	13	1	7.6	13%	93%
9	cz4	0.46	0.38	30	N/A	13	1	1	N/A	11.9	N/A	90%
10	cz5	0.33	0.23	40	N/A	19	30	11	N/A	3.7	6%	0%
11	cz6	0.28	0.15	49	N/A	21	38	21	N/A	2.1	0%	94%
12	cz6	0.34	0.30	49	N/A	21	N/A	13	1	3.4	N/A	86%
13	cz5	0.46	0.39	38	35	19	N/A	11	N/A	3.7	3%	47%
14	cz5	0.37	0.28	38	N/A	19	25	13	N/A	3.7	4%	5%
15	cz5	0.32	0.23	30	N/A	19	45	11	N/A	6.1	7%	27%
16	cz5	0.50	0.28	38	N/A	19	30	11	N/A	6.8	6%	0%
17	cz5	0.50	0.28	38	N/A	19	N/A	11	N/A	4.5	4%	90%
18	cz5	0.34	0.15	38	30	19	N/A	11	N/A	5.8	2%	0%
19	cz6	0.29	0.48	33	N/A	33	17	14	N/A	12.3	N/A	25%
20	cz5	0.35	0.23	38	N/A	19	19	19	1	3.6	N/A	24%
21	cz5	0.33	0.38	38	N/A	12	N/A	10	N/A	4.6	3%	5%
22	cz5	0.33	0.28	30	N/A	19	N/A	13	N/A	3.8	2%	9%
23	cz5	0.35	0.16	30	N/A	13	30	11	N/A	5.0	5%	26%
24	cz5	0.34	0.18	38	N/A	13	N/A	5	N/A	4.2	5%	0%
25	cz5	0.33	0.14	38	25	13	N/A	4	N/A	4.7	3%	0%
26	cz4	0.38	0.42	30	N/A	11	N/A	11	N/A	8.6	Not Observed	6%
27	cz4	0.34	0.33	19	N/A	13	N/A	11	10	9.6	Not Observed	1%
28	cz6	0.32	0.35	38	38	21	N/A	25	1	7.7	1%	25%
29	cz5	0.33	0.13	38	26	13	N/A	11	N/A	4.4	8%	0%
30	cz5	0.33	0.36	38	38	19	19	11	N/A	2.3	4%	68%
31	cz5	0.35	0.36	38	N/A	19	19	13	N/A	3.6	0%	91%
32	cz6	0.34	0.21	30	N/A	21	N/A	11	N/A	1.8	2%	0%
33	cz4	0.40	0.30	34	N/A	34	30	13	12	4.3	Not Observed	18%
34	cz5	0.35	0.36	40	N/A	23	N/A	13	11	2.2	Not Observed	0%
35	cz4	0.45	0.29	19	N/A	11	19	11	1	11.9	Not Observed	36%
36	cz6	0.37	0.41	38	N/A	21	20	N/A	N/A	4.8	N/A	45%
37	cz5	0.33	0.41	38	N/A	21	19	24	5	5.1	1%	2%
38	cz5	0.35	0.23	49	N/A	21	19	24	11	4.4	3%	37%
39	cz4	0.29	0.27	38	N/A	20	30	N/A	1	8.3	Not Observed	0%
40	cz6	0.32	0.23	38	N/A	19	19	N/A	N/A	5.5	N/A	58%
41	cz5	0.34	0.23	42	30	21	30	11	N/A	3.9	2%	14%
42	cz6	0.36	0.23	38	30	19	30	N/A	N/A	5.3	12%	22%
43	cz5	0.35	0.28	30	N/A	19	19	N/A	N/A	6.6	31%	16%

Purpose and Scope

To compare the actual efficiency ('as built") of a home with the efficiency levels identified in the plans and in turn to the current energy code (ECCC NYS 2007 and IECC 2009). Homes are randomly selected throughout the state with a total of 44 homes to be surveyed. No Energy Star homes are to be included in the survey and only homes built from 1/2007 to current completions are included. All inspected sites are to be residences under 3 stories. In the case of multi-family you must do the entire building.

CSG's role in the process is primarily that of data collection. We will:

1. Collect data so that VEIC can compare the as-built condition of the home to the code's mandatory requirements
2. Compare the home plans to the as-built condition of the home so that a comparison can be made at VEIC as to whether it meets the code's mandatory requirements
3. When # 1 or #2 above differ, confirm whether the home meets code requirements.
4. Collect pertinent data and complete the DOE Checklist (Excel)
5. Collect pertinent data to complete a REM/Rate analysis

Scheduling

Some homes have been identified by Dodge Reports and reverse look-up. However, on the residential side they sample only about 40% of the agencies. To compensate for this the remaining names were obtained by on-site research at the permit office (19). Homeowners will be given a $100 gift card as compensation for their time.

You will be assigned counties for coverage with coordination by Rick Derikart. Based on your availability, the call center will make appointments for you. We anticipate that the entire process will be about 1.5 days per site with approximately 3-5 hours at the home. You are strongly encouraged to call the homeowner to introduce yourself, get directions, ask remaining questions about the permit office, and to see if they have plans available there on site.

To limit the time spent on site, you may request the help of one of the Empower TFR's to assist in set-up. Please make this request through Bob as we will need to coordinate schedules.

If you happen to know the builder/homeowner in your area that is on the list, please relay that information as it may expedite the scheduling process.

Initial appointments will be scheduled in the Capital Region so any bugs can be worked out of the system. All TFR's with HERs Training will likely be involved in the program.

You may choose to schedule the home before or after the visit to the permit office. Your decision should be guided by accessibility of plans.

Protocols

One of the main concerns is not to alarm the homeowners or provide fodder for a dispute between the homeowner and contractor. While the homeowners will naturally be curious as to your findings, please keep all comments positive or at least neutral/non-committal.

Pictures should be taken whenever significant deviation appears from the plans or when serious health and safety issues arise. These should be included in the customer file. Generally only health and safety issues that pose imminent danger will be cause for action that day or week.

When appropriate, you may refer the homeowner to other programs that may assist them in making energy efficient improvements.

Field Tasks

Your goal is to collect data at the site which will then be compared to the information (plans, building application) available at the permit office.

a. Home

Homeowners will be sent a letter informing them of the process and expectations prior to your arrival (See Tab 2: Customer Letter). Before the inspection day, call the homeowner to confirm the date and time of the appointment and to discuss what the homeowner can do to prepare their home for the inspection. For example, advise the individual against burning a fire in a woodstove 24 hours ahead of the appointment, as this will prevent the completion of the blower door test. Upon arriving, explain to the homeowner what you are planning on doing, that you will need access to most of the house, that you will be running the duct blaster and blower door, and any other tasks needed. Ask about any inaccessible areas, babies, dogs and other variables that may impact your inspection.

Following the homeowner debrief, do a quick walk through to familiarize yourself with the home, heating system, and any issues. If a situation should arise that prevents running the blower door (such as a burning woodstove), complete all evaluation and data collection except the blower door test. The blower door test will need to be rescheduled at a later date and time.

A blower door test and duct leakage test (for forced-air systems only) will be conducted as well as measurements taken to complete the report. You will compare framing, insulation, windows and HVAC system against that which was specified in the plans.

At the home you will complete both the REM/rate analysis and DOE Checklist (See Tab 4: Data Collection Checklists and Instructions) taking necessary measurements, making inspections and confirming specifications. When using the DOE Checklist, refer to the climate zone table for that county (See Tab 5: New York Climate Zones). With the appropriate data collection, the software tools you will be using will identify for VEIC those components that are not in compliance.

At the conclusion of the site visit, you will give the homeowner the $100 gift card and obtain their signature of receipt (See Tab 6: Gift Certificate Sign-off). Inform homeowners that we are merely collecting data, not producing a report, so no report will be available to them.

b. Permit Office

You should always call ahead to determine the hours and availability of plans at the permit office. Many of these are small and will not be open a normal work week. All code enforcement officers should have received a letter of introduction (See Tab 3: Code Official Documents) explaining the program. At the permit office you will ideally have access to:

- ✔ Plans
- ✔ REScheck compliance reports
- ✔ ACCA sizing data possibly

If no plans exist, at either the home or permit office, be sure to note this on your report.

Submittal

The following items will be submitted to Paige Asdoorian (cc. Rick Derikart and Barb Benedix) as part of that customer's folder:

1. REM/Rate datasheet (xls file)
2. REM/Rate model files (blg file)
3. ECCC NYS 2007 DOE Checklist (xls file)
4. IECC 2009 DOE Checklist (xls file)
5. Annotated pictures of deviation from specifications or H&S issues
6. Notes regarding compliance path utilized and exceptions to code and/or plans

APPENDIX N: RESIDENTIAL RECRUITMENT RESULTS

New York State Counties	Original Sample Number	Number of inspections Performed	Deviation
Albany	1	3	+2
Bronx	1	1	
Broome	1	1	
Clinton	1	0	-1
Dutchess	2	1	-1
Erie	5	5	
Jefferson	1	1	
Kings	1	1	
Madison	1		-1
Monroe	4	6	+2
Oneida	2	4	+2
Onondaga	2	3	+1
Orange	2		-2
Oswego	1		-1
Queens	3		-3
Richmond	2	5	+3
Rockland	1		-1
Saratoga	2	6	+4
Schenectady		1	+1
Steuben	2	1	-1
Suffolk	5		-5
Sullivan	1		-1
Ulster	1	1	
Warren	1	1	
Washington	1	1	
Westchester		2	+2
Total Inspections	44	44	

To: NYSERDA

From: VEIC

CC: EFG, CSG

Date: 4/5/2011

Re: Task 5.6 – QA/QC of Residential Survey Data and Data Entry

Introduction

The purpose of this memo is to summarize the QA/QC findings from Task 5.6 Survey Data and Data Entry for the residential portion of the NYSERDA Code Compliance Report. Residential code compliance is being analyzed using three different tools. The first tool is the residential checklist developed by Pacific Northwest National Laboratory (PNNL) for the Department of Energy's (DOE) Building Energy Codes Program (BECP), hereafter referred to as the DOE Checklist. The DOE Checklist was designed to evaluate compliance with the 2009 International Energy Conservation Code (2009 IECC). The original 2009 IECC DOE Checklist was then modified by VEIC to provide a second compliance tool which captured the code requirements of the 2007 Energy Conservation Construction Code of New York State (2007 ECCC NYS). The DOE Checklist tool enables the evaluator to calculate the percentage of code requirements each building has met. This is the preferred metric chosen by BECP to support the goals and objectives of both American Recovery and Reinvestment Act (ARRA) and State Energy Program (SEP) funding. The third tool used in this analysis is the Home Energy Rating System (HERS) modeling software, REM/*Rate*™. REM/*Rate*™ allows the evaluator to assess Overall UA and Performance compliance with both the 2007 ECCC NYS and 2009 IECC codes. Use of these tools enables measurement of code compliance to three different metrics: BECP Compliance Rating, Overall UA, and Overall Building Performance.

While the use of multiple compliance metrics allows for a broader compliance evaluation, it also introduces complexity into the data collection and data entry process. Additionally, the DOE Checklist is a new tool that is currently being tested by several states. In an attempt to preempt errors in data collection and entry, VEIC modified the DOE Checklist Instructions created by PNNL with project specific guidance. VEIC also generated supplemental data collection forms to help provide clarity in areas where the DOE Checklists and REM/*Rate*™ required slightly different data values. Two examples of the tools requiring different input values are the calculation of conditioned floor area (CFA), and percent efficient lighting. These two issues will be discussed in more detail below.

Even with the additional guidance provided for data collection and data entry in the tools, a number of issues arose once we were able to get into the field and start using the tools. The majority of these generally fell into one of three categories:

1. Interpretation of the DOE Checklist requirements
2. Consistency of data entry between three different tools
3. The Three N's: No, N/A, and Not Observed

Specific examples of QA/QC issues for each of these three categories are provided below.

Summary of QA/QC Findings

1.0 Interpretation of the DOE Checklist requirements

Though steps were taken to address many of the DOE Checklist items that seemed vague, once we were in the field and began using the checklists a number of questions arose about how to appropriately complete the checklist in general, and specifically for a post-construction study. Some of these issues were addressed internally; others required the input of PNNL. The following list provides an overview of the more common issues found when reviewing the completed compliance tools.

1.1. Checklist items that cannot be evaluated

The DOE Checklist was originally intended to be used during the various phases of construction. However, all of the buildings we evaluated are post-construction. Therefore, there were many checklist items that could not be given an appropriate compliance assessment. The original compliance options were: Yes, No, or N/A. N/A is to be used only when a code requirement is not applicable (i.e. code requirement for snow melt controls when no such system exists). To deal with code requirements that could not be assessed because they could not be seen, we added a fourth compliance option, Not Observed

1.2. Marking compliance for primary thermal requirements

As noted in item #1.1, many code requirements were not visible during the site visit. Therefore, some of the primary thermal code requirements were coming in marked 'Not Observed'. Because assumptions were made to complete the REM/*Rate*™ model, a decision was made to use those assumptions to complete a 'Yes/No' assessment of the primary thermal code requirements (i.e. ceiling, wall, foundation R-values and door, window U-factors). Additional code requirements following the primary thermal requirements such as installation quality or height/depth of insulation were to be marked 'Not Observed' if they could not be seen.

1.3 DOE Checklist organization

The DOE Checklist is structured to follow the phases of construction. If used during the construction process, the ordering of checklist items probably make more sense. However, for use during a post-construction study, placement of many of the checklist items seems haphazard. For instance, checklist items regarding equipment sizing are in two different sections of the checklist and interior vs. exterior insulation requirements are in two separate sections. In many cases, inconsistency in data entry was difficult to catch because the two requirements are not seen side by side.

1.4 Compliance approach

The DOE checklist includes a field to mark what compliance approach was taken: Prescriptive, Trade-off, or Performance. Initially these were being marked as the compliance approach we were using for this study (i.e. Performance). The checklist needs to be completed with the original approach taken so that compliance may be assessed appropriately. Meaning, if a Trade-off approach was taken, the home needs to be verified against the Trade-off documentation not the Prescriptive code requirement listed in the checklist. This led to a secondary issue of assessing compliance against a Prescriptive code requirement when a Trade-off approach was used. For instance, if REScheck documentation exists showing overall UA compliance, an individual thermal requirement may need to be marked as compliant even though it does not meet the Prescriptive requirement because some other component is making up for it.

1.5 HVAC Load calculations

There are two DOE Checklist items related to HVAC load calculations. One is related to sizing calculations and the other to equipment verification. Both refer to the same code section (403.6), which is vague and makes reference to the International Residential Code (IRC). Follow-up with PNNL was required to determine that the Plan Review checklist item should be used to verify that load calculations were performed and the Final Inspection checklist item should be used to verify that equipment matches the load calculations performed in the plans. Additionally, because these are two checklist items are not placed near each other there were often inconsistencies in how these were treated.

1.6 Foundation walls

Code requirements for foundation walls are found in two different places in the DOE Checklist. The first, which treats exterior insulation requirements, is found in the Foundation Inspection section of the checklist. The second, which treats interior insulation requirements, is found in the Insulation Inspection section of the checklist. The two different sections are meant to be completed as an "either/or" requirement (i.e. if the home has exterior foundation wall insulation, mark the Foundation Inspection as Yes or No and the Insulation Inspection section N/A). However, some homes had alternative wall systems (e.g. ICF's) or were simply insulated on both the interior and the exterior. In the case of ICF's, while the system as a whole meets the code requirement, when treated separately neither the exterior nor the interior foundation insulation meets the code requirement. In these cases a decision was made to mark one of the checklist sections as compliant Yes or No and the other N/A. Exterior foundation wall insulation has more checklist items associated with it than interior foundation wall insulation. Therefore, if one chooses to mark the interior requirements as compliant, there are more checklist items marked N/A. Each checklist item marked as N/A or Not Observed adds zero points to both the numerator and the denominator (i.e. it doesn't help or hurt the overall score). However, fewer possible points mean a smaller denominator which could make it more difficult to obtain a higher score. Additionally, because these two sections are not near each other on the checklist inconsistencies were often found in how the items were completed.

1.7 Multiple checklist items for a given code requirement

As noted elsewhere, oftentimes there are multiple checklist items for a given code requirement. For instance, exterior foundation wall insulation has four checklist items associated with it: installed R-value, installation per manufacturer instructions, depth of insulation, and insulation protection. Many questions arose regarding how to complete the checklist for related checklist items when the primary requirement was not compliant or no insulation existed. If there was no foundation wall insulation, then all related requirements are also to be marked not compliant. This way, the home with no insulation scores worse than one with insulation improperly installed. This was not readily apparent at the beginning of the site inspections.

1.8 Plan review

The first DOE Checklist item states that documentation should exist to "sufficiently demonstrate code compliance." This needed further clarification from PNNL to determine if the intent of this checklist item was to actually demonstrate compliance from the plans (i.e. the plans themselves needed to be checked for compliance), or to simply verify that the plans included sufficient data in order to demonstrate compliance. It was decided that for the residential inspection, the primary intent was to verify that the information was documented.

2.0 Consistent data entry between three different tools

As noted in the introduction, three different tools are being used to assess code compliance in New York State: DOE checklist for 2007 ECCC NYS, DOE Checklist for 2009 IECC, and REM/*Rate*™ HERS modeling software. While utilizing three separate tools allows for a more broad compliance analysis, it also provides more opportunity for inconsistent data entry. The two DOE Checklists generally follow the same format, but the structure of the codes is different and therefore each has different requirements for data entry. REM/*Rate*™, being a HERS modeling tool, requires different values for the same parameter in some cases. Examples are provided below.

2.1 Conditioned Floor Area (CFA).

The definition of CFA is different for code and for REM/*Rate*™. Additionally, the determination of whether a space, specifically basements, are considered conditioned for REM/*Rate*™ is not always straight-forward. VEIC provided a supplemental data collection form to record CFA values for each floor for code and well as for REM/*Rate*™. There were still a number of questions regarding the correct inputs for each tool.

2.2 Infiltration and duct leakage calculations.

Infiltration and duct leakage rates for code are calculated from CFA and volume. Because there were often different CFA and/or volume values for code and REM/*Rate*™, compliance rates were not always calculated correctly (i.e. infiltration was calculated using the volume input for REM/*Rate*™ and not code). Additionally, if a basement was considered unconditioned for REM/*Rate*™ the blower door test would have been conducted with the basement door closed. However, that same basement may have been considered conditioned per code. Therefore, adjustments to the blower door data needed to be made in cases where the test was run with a closed basement door but I should have been open to satisfy the code requirement.

2.3 Percentage of efficient lighting.

The 2009 IECC has a prescriptive requirement that 50% of lamps permanently installed fixture be high-efficacy. REM/Rate™ also has a percent fluorescent lighting input. However, REM/*Rate*™ is looking for a fixture count and only fixtures in specific locations. A supplemental form was created to provide separate inputs and calculations for each tool. Inconsistencies were found in how data was entered into the tools.

2.4 Installation per Manufacturer Instructions.

There is a code requirement that insulation be installed per manufacturer instructions. The correlating REM/*Rate*™ input for this is a Grade I installation. Where the installation cannot be verified, the appropriate REM/*Rate*™ input is Grade III. There were often inconsistencies in what values were used for the DOE Checklist vs. REM/*Rate*™ (e.g. The DOE Checklist would state 'Yes' insulation was installed per manufacture instructions whereas the REM/*Rate*™ input was set to Grade III).

2.5 Optional requirements in 2007 ECCC NYS

The NYS code includes optional requirements: blower door testing, duct blaster testing, and high HVAC efficiencies. When any of these requirements are met, the thermal requirements for ceilings and walls are lowered. There were often inconsistencies in how these code items were treated. If more than one optional requirement was satisfied, only one should be marked as Yes or No. The remaining two should be marked N/A. Likewise, if an optional requirement was marked Yes, the related thermal requirements need to be checked Yes even though they may not meet the prescriptive R-value listed on the checklist. Because these checklist items were not near each other, inconsistencies were often found.

2.6 Blower door and air sealing requirements.

The 2009 IECC includes an optional blower door testing requirement in lieu of visual air sealing inspection. However, the 2007 NYS ECCC includes mandatory air sealing inspection. Since we were performing blower door tests on all homes, the 2009 IECC checklist should mark the blower door requirement as complies Yes or No. All related visual air sealing requirements are then to me marked N/A. In contrast, the air sealing requirements listed in the 2007 ECCC NYS checklist needed to be marked Yes, No, or Not Observed. The blower door checklist item should only be marked Yes or No if it was used to allow for the alternative thermal requirements. This was also a source of inconsistent data entry.

2.7 General inconsistency

Again, due to the fact that three different data collection tools were used, there was general inconsistency found in the data entry between each tool (i.e. for a single requirement that should have had the same value entered in each tool).

3.0 The Three N's: No, N/A, and Not Observed

The DOE Checklists are a multiple choice drop down format. When three of the choices begin with the same letter ('N' in this case), it is inevitable that some mistakes in data entry will occur. During data analysis all of the responses to each DOE Checklist item are pulled together in aggregate form. Most if not all of these types of errors should be found easily and corrected. In addition to this type of error, there were other inconsistencies found in the data sets.

3.1 Labeling requirements.

The code requires that not only installed products meet certain criteria, but that they are labeled. For instance 2007 ECC NYS section 402.4.2 requires that fenestration meet a specified leakage rate and is labeled. This single code requirement is broken into three checklist items: one for the label and two for the leakage rates of glazed fenestration and swinging doors. In most cases this information was not available. A decision needed to be made about how to treat each of these checklist items and we needed to ensure a consistent approach was taken with each home and for both codes. Initially, a variety of responses were recorded depending on the interpretation of the individual performing the inspection.

3.2 Primary thermal requirements

As noted in #1.2 above, the decision was made to mark each of the DOE Checklist items for primary thermal requirements as Yes, No or N/A. Early in the QC process it was noted that walls or ceilings were being marked as Not Observed. Since a judgment needed to be made about these values for the REM/*Rate*™ model, we felt it appropriate to make a compliance assessment judgment for these items as well. This way, all homes will at least start with the similar compliance score denominator which is derived from the total possible points.

3.3 2007 ECCC NYS 2007 optional requirements

As stated in item # 2.5, the optional code requirements for NYS often led to inconsistencies in how No and N/A were used.

3.5 Duct testing for 2009 IECC

There are two checklist items in the 2009 IECC checklist: one for a rough-in test and another for post-inspection. Since we were performing only post-inspection duct blaster tests, the rough-in test checklist item should always be marked N/A and the post-construction checklist item Yes, No, or N/A. Because the checklist is designed to follow construction phases, these items are not placed near each other on the checklist and so inconsistencies in data entry were often found.

3.5 General inconsistency

- Some checklist items required further clarification about whether to mark as No or Not Observed. For instance, the code requirement for code documents listed in the Plan Review section of the checklist. If the code documents did not exists, this item could be marked No, N/A, or Not Observed depending on the interpretation of the individual conducting the site visit.
- Marking the SHGC requirement of 2009 IECC as N/A did not always occur.
- Ducts were sometimes marked N/A and other times Yes when all in conditioned space. A decision was made to mark this checklist item Yes in cases where ducts were 100% inside conditioned space. This also raises the denominator.

APPENDIX P: COMMERCIAL DETAILED METHODOLOGY AND ANALYSIS

A. RECRUITMENT

a. Sample Development

The BECP recommends that the main sample of commercial buildings (44 from each state) include commercial buildings that are distributed equally within the three main building size strata defined in Section 5.2.1.2 (small, medium, and large), resulting in 14-15 samples to be taken from each of the three main size strata.

1. Small: 1-2 stories, single zone, up to 25,000 ft2 in conditioned floor area
2. Medium: Larger than 25,000 ft2 and up to 60,000 ft2
3. Large: Larger than 60,000 ft2 and up to 250,000 ft2

The budget for this evaluation was limited and the project scope went well beyond that envisioned by the BECP protocol, including the development of data collection tools and simulation modeling of building performance. The number of sites was limited to 26 in order to complete all elements of the required scope within the available budget.

The sampling strategy used the Dodge Construction Database data set for 2008-2009 of new construction commercial projects. That sampling automatically selects 44 sites. The Team then used that selection to narrow down list to five counties in the three climate zones. **Table P1** shows the sample as selected by the DOE Sample Generator.

Table P1. Sample Selected from Dodge List of Commercial Permits

City	County	Zone	Number
Bronx	Bronx	4	688
Brooklyn	Kings	4	1909
Hampton Bay	Suffolk	4	25
Hempstead	Nassau	4	25
Mount Vernon	Westchester	4	25
Manhattan	Manhattan	4	890
Riverhead	Suffolk	4	26
Southampton	Suffolk	4	33
Staten Island	Richmond	4	237
White Plains	Westchester	4	31
Yaphank	Suffolk	4	25
Yonkers	Westchester	4	104
Queens	Queens	4	1338
Albany	Albany	5	108
Amherst	Erie	5	81
Buffalo	Erie	5	136
Cicero	Onondaga	5	29
Clay	Onondaga	5	26

Clifton Park	Saratoga	5	53
Glenville	Schenectady	5	25
Greece	Monroe	5	79
Hamburg	Erie	5	52
Henrietta	Monroe	5	47
Hyde Park	Duchess	5	26
Lancaster	Erie	5	36
Latham	Albany	5	44
Malta	Saratoga	5	41
New Winsor	Orange	5	30
Newburgh	Orange	5	63
Niagara Falls	Niagara	5	46
Orchard Park	Erie	5	29
Penfield	Monroe	5	39
Poughkeepsie	Duchess	5	59
Rochester	Monroe	5	182
Saratoga Springs	Saratoga	5	64
Schenectady	Schenectady	5	41
Syracuse	Onondaga	5	94
Troy	Rensselaer	5	57
Victor	Ontario	5	31
Webster	Monroe	5	85
Wilton	Saratoga	5	28
Binghamton	Broome	6	33
Ithaca	Tompkins	6	43
Plattsburgh	Clinton	6	37
Queensbury	Warren	6	50
Watertown	Jefferson	6	43

The Team then selected five counties from those 44 in the same proportion to the climatic distribution. The 26 case study jurisdictions were then selected as shown in **Table P2**.

Table P2. Initial Sample of Commercial Sites

	Number of Permits	Number of Agencies Selected	Number of Sites	Initial Counties Selected
Total permits 2 year average	1587			
Zone 4	1100	3	15	Kings, Suffolk, Westchester
Zone 5	389	1	5	Monroe
Zone 6	98	1	5	Clinton
			25	

The division of building sizes and the cities within the counties are shown in **Table P3** below:

Table P3.

	Small	Medium	Large
Kings County (NYC)	1	1	3
Southampton (Suffolk)	2	2	1
Yonkers (Westchester)	1	2	2
Greece (Monroe)	2	2	1
Plattsburgh (Clinton)	2	2	1
Total	8	9	8

To maintain a random draw, we started with the first name on each list of buildings per size and worked our way down the list, skipping only when size quota for that county was full.

As recruiting proved to be more difficult than expected (explanation to follow), we ended up expanding into neighboring towns and counties in order to attain the correct number and types of buildings for the sample. Our final sample included buildings in the following areas:

Table P4. Final Sample of Buildings and Locations

Building County	Building Size	City/Town
Queens	Large	Flushing
Queens	Small	Corona Park
Manhattan	Large	Manhattan Upper East Side
Kings	Large	Brooklyn
Kings	Large	Brooklyn
Manhattan	Medium	Manhattan
Monroe	Medium	Rochester
	Medium	Rochester
	Small	Rochester
	Large	Greece
	Small	Greece
Suffolk	Small	Hampton Bays
	Small	Riverhead
	Large	Yaphank
	Medium	Riverhead
Westchester	Small	Tuckahoe
	Medium	White Plains
	Large	Yonkers
	Medium	Somers
	Medium	Rye
Clinton	Small	Ellenburg
	Medium	South Plattsburgh
	Large	Town of Plattsburgh
	Large	City of Plattsburgh
Franklin	Medium	Malone
	Large	Malone

b. <u>Recruitment</u>

Commercial recruitment was started with a mailing blitz to 153 commercial buildings listed in the Dodge database as new construction in the identified five counties. This introductory letter, on NYSERDA letterhead and signed by the NYSERDA project manager, introduced the study, gave credibility to the project, notified people that they would be called, and invited interested parties to contact the Cx Associates project manager. This letter proved to be instrumental in opening many doors. Eight building owners contacted Cx Associates themselves and all building owners subsequently called on for participation knew of the project and were prepared to discuss it. Toward the end of the recruiting work we needed to expand into other neighboring counties that did not receive this letter and participation was considerably more difficult to obtain.

Simultaneously, the New York Department of State emailed an introductory letter to the code officials in the five identified counties. This letter, and a verbal appeal at the code officials' annual meeting in Lake Placid in February 2011, helped achieve cooperation from the code officials and gave credibility to the engineers that called on them. As with the building owners, code officials that did not receive this official email were much less cooperative than ones that were officially asked for cooperation.

The goal of the recruiting process was to obtain permission to visit a specific number and size of buildings in the five identified counties, as well as organize a plan review visit at the code official's office. At the time, we were under the impression that each town or city would have only one code official's office to visit and that we would be able to schedule all the plan reviews with only five code officials. This proved not to be the case as the code official jurisdictions were smaller than expected and the result was that 26 buildings required 20 different code officials. (For example: the Town of Plattsburgh and the City of Plattsburgh are two different jurisdictions, even though the buildings were approximately 3 miles apart.) In the end, plans were received from the owner or design firm for 9 buildings and those corresponding code official visits were eliminated.

Initial calls to building owners were made by a VEIC administrative person. This person called to follow up on the NYSERDA letter, ascertain the correct contact person, obtain their telephone number and determine their willingness to participate. The VEIC employee used the recruiting script developed by Cx Associates and an outline of the sizes of buildings required in each county. When the required amount of buildings was identified, the VEIC employee did not pursue further buildings in that category for that county.

With considerable effort, VEIC was able to identify approximately 12 interested building owners before project time constraints forced the calls to be taken over by the engineers. Cx Associates and Buro Happold continued these calls as well as followed up with the interested buildings to schedule building site visits. For the recruited buildings, the engineers also scheduled the review of the plans either with the building owner or the appropriate code official.

The following table shows the number of calls made and the outcome of these calls (actual numbers are larger, as repeat attempts were not fully documented). The "number of potential participants" is the quantity of buildings we reached and for which the administrative person received a preliminary positive response. Approximately one-third of these subsequently fell through mainly due to the plans not being attainable or the building not being far enough along in the construction process to be able to inspect any of the building systems. The VEIC recruiting team declined 11 sites in the end because the sample size for that location had been met already with other buildings.

Table P5. Recruitment Outreach

# of calls made	328
# of unreachable/unresponsive	131
# of refusals	32
# of respondents from intro letter	8
# of potential participants	52
# of potentials that fell through	15
# declined by VEIC Team	11

The recruitment outreach for the code officials is shown in **Table P6** below.

Table P6. Code Official Recruitment Outreach

# of calls made	49
# of unreachable/unresponsive	0
# of refusals	4
# of participation	19

The recruitment efforts resulted in a final building sample as shown in Table P7.

Table P7. Final Building Sample

County	Small (<25,000sf)	Medium (25,000-60,000sf)	Large (+60,000sf)
Suffolk	Retail Government	Academic	Government
Westchester	Office	Retail Housing Medical office	Housing
Clinton and Franklin	Retail	Government Office	Hotel Hotel Housing
Monroe	Office Medical office Office	Government Lab	Hospital
NYC Burroughs	Office	Housing	Housing Academic Housing Housing

Cx Associates was responsible for the buildings in the northern counties of Clinton and Franklin; Buro Happold worked with the buildings in the other counties. Site visits and plan review visits were scheduled in a manner that minimized travel time.

The recruiting of both the buildings and the code official's office visit were considerably more time-intensive than originally planned. Contact information from the Dodge database was incomplete and often out of date. Many of the people listed as "owner" in the database, were actually part of the design team or a developer. These people were not associated with the building if the construction was complete and occupied. Because these contacts had received the introductory NYSERDA letter, they knew about the study and were typically fairly helpful in identifying another person associated with the building. This process of calling multiple times, leaving multiple messages, not getting callbacks and finding the correct contact person took a lot longer than was expected and was quite disheartening to the recruiter.

Although the methodology of recruiting was arduous, it was also sound and affective. There were a few lessons learned from the process that are beneficial to consider for future studies:

- The Dodge database should be vetted for buildings that fit the desired building requirements with great scrutiny. Buildings that went through the NYSERDA New Construction Program, buildings that have not started construction or have been put on hold after permits have been issued should be deleted from the database before letters are sent or calls commence.
- Determining the correct contact information for a building in the Dodge database took considerably more time than expected because most of it was incorrect or missing. Contact information had to be found through other means such as the internet and multiple calls.
- Introductory communication about the project from the Department of State and NYSERDA to building owners and code officials is very affective and should not be underestimated.
- Providing detailed, albeit high-level, information about the project to an administrative person making the initial calls has a significant impact on the credibility of the study and brings about more favorable responses from building owners.
- An administrative person is the right person to make the initial calls because most of the time is spent determining the correct contact information. The engineer is the right person to make the follow up scheduling calls for the actual site and plan review visit. Only the engineer can answer questions in enough detail to make the building personnel feel confident in what the site visit will entail.

One concern this commercial engineering team has about the recruiting process is the potential bias of the sample. We encountered a lot of skeptical building owners who refused to participate because they did not trust this study would remain anonymous and did not want people inspecting their building. The people who contacted us proactively were ones who were eager to see how their buildings compare to code, because they were either proud of the energy-efficiency they had attained or because they were interested in seeing what they might improve in the building. The final participant list was comprised of owners who seemed to be conscientious about the performance of their building and who feel confident they have built above code. This brings a bias into a study that is trying to determine the baseline rate of compliance across the entire spectrum of new construction.

c. Survey Tool Development

New York State conducted this ARRA funding compliance assessment as the first in the nation. At the time this project began, PNNL was still in the process of finalizing the BECP Protocols and their checklists for DOE. This study was auspicious for PNNL and DOE as it was an opportunity to test the checklists out in the field and learn from the experience.

The Survey Tool was designed to provide information for future eQuest modeling and to calculate two compliance scores: the BECP Protocol percent of compliance score and the Prescriptive/Trade-Off Method Pass/Fail score. The BECP Protocol measures the proportion of the energy code requirements to which a building complies. The commercial sector is measured against ASHRAE Standard 90.1-2007 and the score is a percentage (0-100%) of the applicable code requirements. The Prescriptive/Trade-Off Method evaluates the minimum energy efficiency requirements for the design and construction of new buildings and their systems (envelope, lighting and HVAC). Compliance is determined on a Pass/Fail basis; every component (or the UA value of the envelope under the Trade-Off option) must pass in order for the building to achieve a passing score.

The Survey Tool incorporated the PNNL checklist as of November 2010 into the Excel spreadsheet in order to use it in the field for the site inspection. The checklist scoring procedure was incorporated into the spreadsheet, so that the field engineer could see the score while still in the field. As the checklist has the plan review inputs as well as the field verified inputs on one sheet and the engineer did not have the plans with them in the field, the checklist was also used to ensure all the relevant building systems were reviewed before leaving the site.

In addition to the checklist, the field engineers required a tool in which they could input all the energy-efficiency related data about a building and calculate Prescriptive and Trade-Off Method compliance in the field. This tool had data inputs entered during plan review which were verified in the field. The idea was that the entire analysis of the building could be completed while in the field, ensuring that all the data was documented before the field engineer left the premises. In reality, there was so much missing information between the plans and the site visit, and the site visits already required so much time from the building owner, that much of the data input work was done after returning back to the office.

As this study also included energy modeling, the Survey Tool required an input mechanism for all of the eQuest parameters of the building. eQuest is a DOE modeling tool that uses the Energy Cost Budget Method to assess compliance against the same building with components set to meet code. If the energy cost of the as-built structure is less than the modeled 100% code compliant building, then the building complies with code. The Energy Cost Budget Method is a Pass/Fail assessment as is the Prescriptive and Trade-Off Method.

The Survey Tool was developed by the VEIC Team specifically for this study. The Tool includes all of the ASHRAE 90.1 2004 and 2007 component compliance tables that list the minimum efficiency requirements of the mechanical (HVAC) and domestic hot water (DHW) systems, as well as all of the envelope system component efficiencies. A lighting fixture table with wattages per fixture type was also developed, enabling the field engineer to input the fixture information from a dropdown menu. The Survey Tool then calculated the HVAC, DHW and lighting power density (LPD) as well as calculating the envelope system compliance score (Pass/Fail) through the Trade-Off option.

The outputs of this data provided a final Pass/Fail score for the building with respect to the Prescriptive/Trade-Off Method of compliance as well as answering the component efficiency questions in the PNNL checklist for scoring within the BECP Protocol.

The outline of the building components that were analyzed in the Survey Tool are found in Appendix Q1 - Required Data Survey Tool.

B: DATA COLLECTION

Data collection for the commercial buildings was performed in three parts: plan review, building inspection and code official or building owner interview (when possible).

i. Plan Review

The first step for each building was to obtain the plans and input the building components into the Survey Tool. This part of the data collection process took between 4-6 hours per building, depending on the complexity of the buildings. When possible, plans were obtained electronically and the compliance data was input into the Survey Tool before the site visit. If that was not possible, a plan review at the building site or the code official's office was conducted prior to the building inspection. This arrangement allowed the engineer to become familiar with the building prior to performing an on-site inspection. Where feasible, the team made copies of building plans to enable future review.

In general, the plans were informative, but lacked crucial data related to the energy performance of the components. Items such as the window and door U-values and Solar Heat Gain Coefficients (SHGC), motor efficiencies, variable speed drives (VFD), lighting power density (LPD), lighting controls, HVAC controls and control schedule, and air and duct sealing procedures were not required on the plans. Items such as heating, cooling, and domestic hot water (DHW) loads were not documented on the plans and, although model numbers of the HVAC and DHW systems typically where listed, their efficiencies were typically not. In addition, although the State requires a COM*check*™ report for every building permit, only about 30% of the plans had accompanying ComCheck reports and specifications were only available on approximately half of the buildings. As-built drawings and product submittals were not available for most projects.

ii. Site Visit

For this evaluation, the subsequent site inspection provided information with which to complete the PNNL Checklist, verified the information found on the plans, and ascertained the modeling parameters on a number of specific component efficiencies not found on the plans. If the building construction was complete it was difficult to ascertain window, door or insulation efficiency levels, but light fixtures, lighting power density and mechanical equipment were reviewable. For buildings under construction the opposite was true.

Owners were very accommodating: most were interested in how their building rated and none seem to be concerned that the building would not comply. Each site visit took approximately three hours for the small buildings, up to four hours for the medium buildings and up to six hours for the large buildings. The knowledge that the field engineer had of the building prior to the site visit was critical to being time efficient and thorough. The owner or Facilities manager typically knew where equipment was, but did not know everything that our field staff was interested in looking at, so items would have been missed if the Survey Tool wasn't populated with at least the major components.

In general, the issues that arose during the site visit were time (it took longer than anyone planned) and the fact that that many components and PNNL checklist items were not visible or able to be verified. The PNNL Checklist is designed to be used by the code official during the various phases of construction. It requires analysis of the building components such as wall insulation, insulation of piping in the slab and slab-on-grade insulation that can only be reviewed at the time these components are being installed. This evaluation gives a snap-shot review of the construction of the building. This means these types of buried components were not able to be analyzed.

iii. Code Official/Building Owner Interview

When possible, an interview with the code official or the building owner was conducted. The interview was focused on the building construction and the building process. Code officials were also asked questions about the commercial building code, their ability to enforce the code and their impression of the energy efficiency levels of new construction in their territory.

An incentive of $150 was offered to cover the building owner's time, but only two out of 26 buildings made use of this offer. Owners seemed more interested in the assessment of the building than the incentive and many spent time or gave their Facilities Manager's time to walk with the engineers and discuss their findings. As mentioned earlier in this Appendix, we fear the sample is bias toward owners who are conscientious about their building's energy performance. It must be said, however, that many of the property managers or developers were unfamiliar with the intricate details of the equipment and the construction of the building. They had a "feel" for the level of efficiency and the quality of the installation, but not much intimate knowledge. For more accurate and complete information about the construction process and the level of energy efficiency, it may have been more beneficial to have worked with the design team.

Except for the New York City boroughs, code officials were generally gracious with their time and very forthcoming and open with their input. They did not seem hesitant to answer questions about the limitations of their jobs when it was made clear that their names would not be used in the study. Each person has different expertise in energy evaluation, so the depth of the energy analysis of the plans and the construction varied significantly (some have time, interest and expertise to comb through the plans, but some do not know what they are looking for so they take the easier items such as wall insulation). None of the code officials we spoke with were doing LPD calculations as they rely on the fact that a design professional has signed off on this in the COM*check*™ report. They do not seem to look at the fine details (motor efficiencies, for example) for the same reason. An area which is most typically given a thorough inspection is insulation levels and overall insulation installation quality. These items can be easily assessed when they are accessible and the code officials realize the importance of these components to the energy costs and comfort of the occupants. As an additional step, the officials we interviewed said they would welcome someone doing a blower door test to attain even higher levels of building air sealing.

iv. Field Staff Findings/Recommendations

1. Plans that were considered thorough still lacked the necessary details needed to entirely complete the database. Some examples of this are material details, window U-values and SHGC, and equipment efficiencies. These items were often globally stated in the plans (for example, windows were described as "double-pane, low-e, clear glass", without a U-Value or SHGC). Assumptions had to be made, usually from ASHRAE standards.
2. The plans were almost always missing information required for the Plan Review section of the PNNL Checklist. Besides the efficiency details mentioned above, items such as system load calculations were hardly ever provided on the plans. As-built drawings and product submittals were also found to be unattainable in almost all cases.
3. Over 60% of the data collection time was devoted to the documenting the plans and familiarization with the building before conducting the site visit. While most plans were straightforward, there were a few buildings with plans that were partly incorrect, incomplete, or unavailable. Some plans had completely different systems than what was installed and others had missing equipment on the plans.
4. Four hours, as indicated to the building owners prior to the site visit, is an underestimate especially if they provided the plans too.

5. The BECP Protocol seems useful for the code officials' use during the construction of the building, but its accuracy for this study is questionable. The checklist is designed to be used by the code official to determine compliance and check the quality of installation during a number of site visits at differing stages of construction. The one site visit performed in this study can only provide a snapshot of the building components that can be inspected at that time. If the building is still under construction, many components are not yet installed. If the building is completed, many components are not visible anymore.
6. The BECP Protocol is a document that requires the person who is filling it out – presumably the code official – to be knowledgeable about energy-efficient construction practices and efficient equipment. As this same official is also responsible for all the other codes and, most specifically the Fire and Safety code, it is potentially unrealistic to expect this person to be able to be thorough in this energy analysis.
7. Commercial buildings are required to provide a COM*check*™ output or a Prescriptive Compliance document before a building permit is issued. Many of the plans did not have either of these documents filed with them and often the specifications were not available. When requesting building plans to be made available, it is recommended that a special request for the COM*check*™ report and project specifications be made.
8. HVAC information gathered from the plans and verified on site were usually further developed back at the office into data that was useful to the database. Since efficiencies and performance of the equipment were usually not given, manufacturers were contacted and catalogs were downloaded. Some buildings had different equipment installed than what was indicated on the plans and care was taken to re-enter and research the information for what was actually installed. The procedure of turning the data collected into useful information that can be used in the energy model or compliance checklist took an average of a further four to five hours. If COM*check*™ reports were available; the time it took to adequately complete the database was cut in half. R-values of the materials would not have to be calculated and light fixtures would not have to be counted from the plans.
9. The field staff would have preferred to have had two separate spreadsheets - one strictly for eQuest model inputs and the other to check for compliance.
10. If future studies do not require lost savings calculations and building modeling, the time required for Survey Tool data inputs will be greatly reduced. The Survey Tool spreadsheet could be used to only calculate code compliance with the inputs required for Prescriptive/Trade-Off compliance and the BECP Protocol. Separate inputs for building modeling would not be needed.

v. <u>Survey Tool Quality Assurance and Quality Checks</u>

Due to the lack of information on the plans and in the field and the complexity of many of the buildings, there was a lot of quality assurance required for most of these buildings. Engineers at both Buro Happold and Cx Associates reviewed the Survey Tool inputs with the plans and photographs of the buildings. The amount of time this QA/QC requires should not be underestimated and is critical to data integrity.

C: CASE STUDIES

Cx Associates identified seven of the eight buildings that would be appropriate case studies. The selection criteria ensured there would be a wide geographic distribution, as well as representatives from each of the size categories: small, medium and large. Sites were also selected where Cx Associates had a good experience in gaining cooperation of the building owner and the code official. The rationale for this latter criterion was to help ensure that the trade allies would be more likely to be willing to participate in follow-up interviews.

These case studies were conducted to gather more in-depth information regarding the construction industry. Interviews with the design professionals – architects and engineers – of the buildings we analyzed enabled us to ask why certain code compliance parameters were incorporated or not incorporated into these buildings. It also gave us the opportunity to ask about the construction process from an inspection and permitting perspective.

In general, it was difficult to reach these design professionals. Many architects and engineers had left the companies that performed the work and others were reluctant to give information for the study.

vi. Architects

Architects generally understand that code officials look to them as the experts, expect them to be up to speed on the details of the most current code, rely on them to specify the measures and details that the contractors need to build, and count on them to provide all the necessary documentation. Of the architects interviewed, this role seemed to be taken seriously.

One architect in the health field noted that the State Department of Health is downsizing and shedding its responsibility for policing building requirements. "The philosophy appears to be that the responsibility for code compliance falls back on the design professional." More than one architect felt that no enforcement exists to police submissions or to penalize those that knowingly or unknowingly submit plans that violate codes. The threat of losing a license because of an improper energy code submittal was deemed unlikely to happen because it is thought that those types of punishments should be reserved for violations threatening health or safety.

Architects feel there is not always adequate attention paid to their efforts by code officials. As with the code officials interviewed, the architects also reported that as long as there was a passing COM*check*™ or documentation of prescriptive measures submitted, the energy code was considered done. Rarely was more than the bottom line reviewed and almost never did any of the interviewed architects report plans that had been "tagged" for energy code non-compliance if they submitted a passing COM*check*™ or prescriptive checklists. From upstate New York, one architect reported that "very few of the energy code elements are being followed" for most of the residential projects being built, due to a lack of understanding of energy issues by local code officials.

Architects take on the role of ensuring code compliance due to potential liability issues. They acknowledged that if anyone were to question a building for deficiencies, they would be responsible, and, therefore, they need to ensure that all codes are followed. Architects note that while they and the supporting engineers may be required to sign-off on the energy code plan, they are not in position to be responsible for ensuring the as-built complies with the energy code. As one architect noted, the quality of the construction determines if a building is actually compliant or not. No written submittal will ensure good quality construction. The typical fee structure does not permit architects or engineers to offer to guarantee construction quality for energy code components. The typical contract barely gets them enough funds to visit a site once or twice a week at most. Given this frequency, they cannot guarantee that every building component is built to energy code.

vii. Engineers

Engineers play a similar role in supporting the energy code as architects. In fact, since in most instances engineers are a subcontractor to the architect, it is the engineers that may prepare the COM*check*™ or RES*check*™ files for the architect. Interviewed engineers reported that they typically bring new code issues to the code officers and end up educating them. They stated that it would help architects/engineers justify doing it right if the code officers were better educated on all aspects of the code.

Engineers are now finding that they are required to put their stamp and signature on COM*check*™ plans submitted. This has put a lot of pressure on engineers to make sure plans meet code. However, unless the engineer is also paid to provide construction phase services including equipment validation, the engineer does not have responsibility for verifying that the as-built systems are as planned and still meet code. One engineer said that only about 15% of the jobs he does include a post-inspection verification. The engineers also noted that their responsibility only extends to the base building and common areas, and not to any of the built-outs or tenant areas. This leaves a significant portion of the lighting, in particular, outside the engineers' or architects' responsibilities, and not covered in COM*check*™ plans.

An engineer noted that code officials in New York City do require that energy efficient boilers be installed. Stricter enforcement is tied to buildings designated as affordable in that the owner has to install centralized heating systems meeting NYSERDA's standard of above 85% efficiency. New York City requires both a signed plan submittal and a signed post-construction signature. This engineer's firm uses a third-party to verify that code is met. The city is now employing similarly trained consultants to spot check code compliance.

A lighting engineer found problems with the code in that it does not allow for specialty needs in lighting applications. He noted that there needs to be provisions for theater with stage lighting or special medical applications such as sleep centers where incandescent lighting is needed.

For rural upstate projects, engineers are pulled in to adjust owner or builder designed plans and specifications to energy code levels and then run COM*check*™ in order to obtain a building permit. However, many of the smaller commercial buildings in these more rural jurisdictions do not have a knowledgeable code official overseeing them and may not involve an architect or engineer. One engineer stated, “Energy is given next to zero importance in New York State. I have never had a comment about insulation in 20 years.”

The one thing engineers stated they are looking for is more local training and opportunities to help upgrade the code official’s, engineer’s and architect’s knowledge base.

viii. Contractors

General contractors on commercial projects are obligated to follow the plans and specifications provided by the architect and therefore have very little leeway in ensuring compliance with the energy code. They assume that the architect has done their homework and has designed to meet the requirements of the energy code. The contractors interviewed said, “We don’t have a choice. We build what the architect designs. They are responsible for the code.” The construction manager for a particularly large (three year build-out) project said, “In my 40 years, I have never seen the inspectors look at insulation before they close up the wall; maybe in residential, but not on commercial jobs. They are concerned about egress, safety, but not inspecting insulation.” Another contractor/owner noted that he did see the code official inspect the insulation, but not specifically with energy code aspects in mind.

ix. Recommendation from Design Professionals and Builders

The architects and engineers had some recommendations that they thought would help them and code officials with the energy code compliance process:

4. Provide a checklist that would require code officials to actually look at more than the bottom line and focus on the important energy elements that could be included on the checklist.
5. Provide personnel to help interpret code, such as a “hotline” that has some authority and cuts across jurisdictions.
6. Access to tools (e.g. COM*check*™ and RES*check*™) is critical; allow free access to tools that are to be used. A public code should have public tools.
7. Provide regular and local training.

D: ANALYSIS

The analysis of this data was performed with three different compliance assessments:

BECP Protocol – measures the proportion of the energy code requirements to which a building complies; the residential sector is measured against the IECC 2009 code and the commercial sector is measured against ASHRAE Standard 90.1-2007; the score is a percentage (0-100%) of the applicable code requirements.

Prescriptive/Trade-Off Method – evaluates the minimum energy efficiency requirements for the design and construction of new buildings and their systems (envelope, lighting and HVAC); compliance is determined on a Pass/Fail basis; every component (or the UA value of the envelope under the Trade-Off option) must pass in order for the building to achieve a passing score. In Residential this is called the "Performance Method".

Energy Cost Budget Method – an alternative to the prescriptive provisions that evaluates the compliance of the building on its energy cost; compliance is determined on a Pass/Fail basis, designs with energy costs less than the building's 100% prescriptive baseline energy cost budget receive a passing score.

x. BECP Protocol Compliance

The main focus of this study was to determine the average building compliance score as defined in the BECP Protocol. The *BECP Compliance Protocol,* developed by the Pacific Northwest National Lab (PNNL) for the U.S. DOE's Building Energy Codes Program (BECP), is comprised of the PNNL Checklist that quantifies component and equipment efficiencies, documentation, control strategies, installation quality and other requirements of the ASHRAE 90.1 Standard. Compliance was measured against either ASHRAE 90.1 2004 or 2007 depending on the applicable code at the time the building permit was issued. Four of 26 projects were designed to the 2004 standard, the rest are measured against ASHRAE 90.1 2007.

The PNNL checklist assigns points to the listed items in three tiers of importance – Tier 1 earns 3 points, Tier 2 earns 2 points and Tier 3 earns 1 point. The Tier 1 items are deemed the most influential on the energy performance of the buildings; items such as the component efficiency level. Tier 2 has items less influential, such as the DHW temperature setpoints. Tier 3 includes items which affect the energy performance the least, such as the O&M manuals and as-built drawings. If an item is not-applicable (such as slab insulation for a building with a basement) or an item is not-reviewable (such as the post-construction inspection of piping insulation under a slab), the points for these items are not counted in the overall possible point score. The table below shows how the number of possible points differs depending on what is 'applicable' and what is 'reviewable'. For example, **Table P8** shows one small building has a total possible points of 40 and another has a total possible points of 107.

Table P8. PNNL Checklist Point Achievement

Tier 1		Tier 2		Tier 3		Total	
Possible	Received	Possible	Received	Possible	Received	Possible	Received
Small Buildings							
60	39	28	18	9	8	97	65
51	45	28	20	6	2	85	67
36	18	24	20	8	3	68	41
57	45	38	36	12	12	107	93
57	51	24	22	7	5	88	78
30	24	8	8	2	2	40	34
48	36	30	24	8	8	86	68
					Total	571	446
Medium Buildings							
45	33	38	34	15	13	98	80
57	42	30	28	11	10	98	80
60	54	32	32	6	6	98	92
54	45	32	32	17	15	103	92
48	36	36	36	6	5	90	77
60	57	32	28	11	10	103	95
66	45	36	36	14	13	116	94
63	51	26	24	10	10	99	85
30	18	30	26	10	10	70	54
54	36	34	32	13	12	101	80
54	45	38	32	13	12	105	89
					Total	1081	918
Large Buildings							
51	42	28	28	17	13	96	83
66	57	52	48	11	11	129	116
54	36	30	30	12	12	96	78
57	51	32	28	10	6	99	85
57	48	32	30	13	12	102	90
66	48	34	32	12	9	112	89
57	45	24	20	11	9	92	74
57	42	38	34	11	10	106	86
					Total	832	701

The following table shows that the amount of items that could be reviewed and were applicable, out of the total checklist, averaged between 22% and 47%. This is the percentage of the entire checklist that applied to the buildings in the sample. No building would ever have all of the items on the checklist, but this average will increase if multiple inspections are done over the course of a building's construction.

Table P9. Percentage of Possible Points Out of the Entire Checklist

(Average of Possible Points) / (Total Points in Checklist)	Tier 1	Tier 2	Tier 3
SMALL	39%	27%	22%
MEDIUM	44%	34%	34%
LARGE	47%	35%	36%

Although the number of possible points differs greatly between buildings, the score of each building does not differ greatly. The final BECP score for the building is calculated as the percentage of earned points divided by the overall possible points. The building scores are then weighted by area to determine the overall compliance rate of this study. These scores are shown in **Table P10**.

Table P10. BECP Protocol Compliance Scores

Building	Building Size (sf)	BECP Score
1	1,440	79%
2	3,848	85%
3	4,000	79%
4	5,426	60%
5	6,931	87%
6	14,000	77%
7	14,500	89%
8	18,228	67%
9	22,910	85%
10	30,100	82%
11	30,375	94%
12	33,244	79%
13	35,701	86%
14	37,760	86%
15	40,426	81%
16	41,964	92%
17	49,819	89%
18	60,315	81%
19	67,220	79%
20	76,729	82%
21	76,853	86%
22	111,082	80%
23	140,003	86%
24	146,476	88%
25	255,271	81%
26	260,737	90%

Total	1,585,358	85%

xi. Prescriptive/Trade-Off Method

Commercial new construction buildings in New York State are required to submit a COM*check*™ report or the ASHRAE 90.1 Energy Cost Budget Method (ECB) Section 11 calculations to prove design compliance. Code officials require the COM*check*™ or ECB report to accompany the building plans when the builder applies for a building permit, because they rely on these reports to ensure them that the building is compliant with ASHRAE 90.1.

COM*check*™ allows designers to trade-off envelope measures against each other, placing all new construction in the Trade-Off Method of envelope compliance. The commercial Trade-off Method allows buildings to trade envelope components as long as the 'envelope performance factor' of the building is less than the 'envelope performance factor' of the base, 100% code-level envelope design. 'Envelope performance factor' includes efficiency levels of the roof, windows, skylights, floors, slab-on-grade floors, and above and below grade walls values. If the overall energy load (UA) of the envelope system is less than this building with these components set to code-compliant levels, the overall envelope will be considered 'compliant', even if not every individual component complies. Other systems, mechanical and electrical, are required to comply prescriptively and only if all three systems – mechanical, electrical and envelope – each comply, does the building receive a passing score. If one of these systems is not compliant, the building as a whole fails.

As all new construction requires COM*check*™ for compliance, this study has calculated the Prescriptive/Trade-Off compliance analysis using the Trade-Off method – not the Prescriptive method - for the envelope system compliance. In practice, the Survey Tool calculated all three systems (mechanical, electrical and envelope) prescriptively. If a building's envelope did not comply prescriptively, then it was analyzed using the Trade-Off method. In our sample, the buildings that failed the envelope assessment under the Prescriptive Method, also failed under the Trade-Off Method.

Table 11. Prescriptive/Trade-Off Method Score

County	Building Type	Applicable Code	Envel.	HVAC	LPD	Rx Score
Clinton	retail	2007	Pass	Pass	Pass	Pass
Clinton	hotel	2007	Pass	Pass	Pass	Pass
Clinton	dormitory	2007	Pass	Fail	Pass	Fail
Clinton	public safety	2007	Pass	Pass	Fail	Fail
Franklin	hotel	2007	Pass	Pass	Pass	Pass
Franklin	office	2007	Pass	Pass	Pass	Pass
Monroe	office	2004	Pass	Pass	Pass	Pass
Monroe	office	2007	Fail	Pass	Pass	Fail
Monroe	office	2007	Fail	Pass	Pass	Fail
Monroe	healthcare	2007	Pass	Fail	Pass	Fail
Monroe	laboratory	2007	Pass	NR	Pass	Pass
Kings	multi-family	2007	Pass	Pass	Pass	Pass
Kings	multi-family	2007	Pass	Fail	Pass	Fail
New York	education	2004	Pass	Fail	Pass	Fail
New York	multi-family	2007	Fail	Fail	Pass	Fail
Queens	office	2007	Fail	Pass	Pass	Fail
Queens	multi-family	2007	Pass	Pass	Pass	Pass
Suffolk	prison	2004	Pass	Fail	Pass	Fail
Suffolk	education	2007	Fail	Pass	Pass	Fail
Suffolk	bank	2007	Pass	Pass	Fail	Fail
Suffolk	public safety	2007	Fail	na	Pass	Fail
West-chester	multi-family	2004	Pass	Pass	Pass	Pass
West-chester	healthcare	2007	Pass	Fail	Fail	Fail
West-chester	office	2007	Fail	Pass	Fail	Fail
West-chester	retail	2007	Pass	Pass	Pass	Pass
West-chester	multi-family	2007	Pass	Pass	Fail	Fail

xii. Energy Cost Method

NYSERDA asked this evaluation to include the value of "lost savings" – the energy lost to New York State due to non-compliance. To analyze the energy consumption of the buildings, composite buildings were modeled using the ASHRAE 90.1 2007 Chapter 11 Energy Cost Budget Method (ECB). ECB is the measurement of energy cost of a building and of its 100% compliant counterpart. If the as-built building energy cost is less that the same building with all energy related components set to 100% code compliant levels, then the building receives a passing score and is in compliance. Composite models representing typical features of the buildings in the sample were used for this analysis. Individual buildings were not modeled.

Each statewide composite building for the three building sizes (small, medium and large) is calculated by designing a composite building that is developed using the weighted average of the buildings visited in this study. The steps used to develop these composite buildings are as follows:

<u>Methodology for Composite Building Development</u>

8. Determine what the average building should look like for each building size (small, medium, large). In the contract, the proposal was as follows. Check to see if this fits with the building stock we have in our sample and what we now think is a reasonable building type to make.

    a. Small – one story office or retail building with HVAC rooftop systems

    b. Medium – 40,000 sf office, retail (maybe classroom) building with rooftop systems

    c. Large – multistory office building (maybe office/retail or retail/condo) with central systems

9. Create a spreadsheet with all the components of each building in the size sample so that they can be compared to each other. Refer to Appendix Q7: Composite Building Development Table.

10. Create the composite building for each stratum size as shown in Appendix Q7: Composite Building Development Table.

11. Create the composite building for each size using the building size of the average of the entire NY new construction database (based on the Dodge database for 2009-2010).

    a. Building size

        i. Small = 9,478sf

        ii. Medium = 38,700sf

        iii. Large = 131,026sf

    b. Adjustments to Building components – adjust the building components proportionally for the composite-sized building as follows:

*Final Composite component = Sample_component / Sample_building_size * Final_building_size*

c. Other Building Components – the composite building will remain the same for all building components except for:

i. Wall perimeter
ii. Potentially the number of doors into the building (if the building sizes are grossly different)
iii. Equipment sizing (capacity)
iv. Number of HVAC units
v. Total supply air (cfm)
vi. Supply air fan (kW)
vii. Return air fan (kW)
viii. DHW storage tank size
ix. DHW circulation pump GPM and/or kW
x. Exterior lighting kW for building entrance only
xi. Potentially the number of doors (correlate to envelope information)
xii. Interior Lighting kW

Composite Building Description

The descriptions of the three composite buildings that were developed are shown in the following three tables. These composite buildings reflect the weighted average of all of the sampled buildings in each stratum. The final building composite is not reflective of any actual building.

Table 12. Small Building Model Information

Parameter	**Composite Building General Summary**	
Location	Massena, NY	
Climate Zone	6A	
Building Use		
Office	100%	
Geometry		
Shape	Rectangular with aspect ratio of 3.77:1	
Total Area (sf)	9,478	
Number of Floors	1	
Floor-Ceiling Height (ft)	10	
ACH	0.35	
	Composite Building	**ASHRAE 90.1-2007 ECB**
Envelope		
Roof U-value	0.031	0.048
Exterior Wall U-value	0.057	0.064
Window-Wall-Ratio	15.65%	15.65%
Window U-value	0.35	0.45
Window SHGC	0.44	0.40
Slab-on-Grade	0.54 F-factor	0.54 F-factor
Door U-value	Opaque 0.7 Glass 0.853; SHGC 0.5	Opaque 0.7 Glass 0.8; SHGC 0.4
Lighting		
Interior - Average LPD (W/sf)	1.028	1.000
Exterior - kW	0.670	0.391
Heating Systems % of Building, Efficiency		
Furnace-Single Zone VAV	100% of building, 85.875 AFUE	100% of building, 80.0% efficient
Cooling Systems % of Building, Efficiency		
DX-Single Zone VAV	100% of building, 13.0 SEER	100% of building, 13.0 SEER for Systems < 65,000 btu/hour 11.0 EER for systems between 65,000 and 135,000 btu/hr 10.8 EER for all systems > 135,000 btu/hr
Fan Power		
DX-VAV AHU	0.820 W/cfm; VFD	0.8 W/cfm; Constant Volume
DX-VAV AHU		
% of Building Served	100%	100%
Type	Rooftop AHU	Rooftop AHU
Heat Recovery	yes (1/3 of units)	no
Economizer	yes (2/3 of units)	no
Demand Control Ventilation	no	no

Furnaces		
% of Building Served	100%	100%
Type	Gas-fired	Gas-fired
Thermal Efficiency	85.875 AFUE	80%
Heat Rejection System		
% of Building Served	100%	100%
Heat Rejection Type	Air Cooled (Rooftop AHUs)	Air Cooled (Rooftop AHUs)
DHW		
Type	Electric Instantaneous (5 gallon)	Electric Storage HW Tank (40 Gallons)
Thermal Efficiency	heater efficiency- 100%	heater efficiency- 87.7%

Table 13. Medium Building Model Information

Parameter	Composite Building	
Location	Albany	
Climate Zone	5A	
Building Use		
Occupancy Type	Mixed Use (Weighted average of profiles)	
Office	29%	
Residential	71%	
Geometry		
Shape	L-shaped building	
Total Area (sf)	38,700	
Number of Floors	4	
Floor-Ceiling Height (ft)	10	
ACH	0.35	
	Composite Building	ASHRAE 90.1-2007 ECB
Envelope		
Roof U-value	0.037	0.048
Exterior Wall U-value	0.059	0.064
Window-Wall-Ratio	23.79%	23.79%
Window U-value	0.42	0.45
Window SHGC	0.44	0.40
Slab-Below-Grade U-value	4' R-8 Horizontal Insulation F-Factor = 0.65	4' R-8 Horizontal Insulation F-Factor = 0.65
Below-Grade Wall U-value	NONE	NONE
Door U-value	Opaque 0.221	Opaque 0.7
Lighting		
Interior - Average LPD (W/sf)	0.913	1.000
Exterior - kW	0.668	0.600
Heating Systems % of Building, Efficiency		
HW-VAV AHU	29% of building, 88.9%	System 7: 29% of building,

	efficient	80.0% efficient
Furnace-PTAC	39% of building, 85.6% efficient	System 1: 39% of building, 80.0% efficient
HW-PTAC	25% of building, 88.9% efficient	25% of building, 80.0% efficient
Electric-PTAC	25% of building, 100.0% efficient	System 2: 25% of building, 2.87 COP
Cooling Systems % of Building, Efficiency		
DX-PTAC	71% of building, 10.95 EER	71% of building, 9.82 EER
CHW-VAV AHU	29% of building, 11.8 EER chiller	29% of building, 11.8 EER chiller
Fan Power		
CHW-VAV AHU	1.268 W/cfm; VFD with 0.4 min ratio	1.100 W/cfm; VFD with 0.4 min ratio
DX-PTAC	1.364 W/cfm	0.300 W/cfm
CHW VAV-AHU		
% of Building Served	29%	29%
Type	Central AHU	Central AHU
Heat Recovery	no	no
Economizer	yes	yes
Demand Control Ventilation	no	no
Furnaces		
% of Building Served	39%	PTACs with Furnaces for Heating in composite; does not apply to ASHRAE baseline systems.
Type	Gas-fired	
Thermal Efficiency	85.6%	
HW System		
% of Building Served	54%	54%
Loop Type	Primary Only Variable	Primary Only Variable
Boiler 1	Gas-fired HW Boilers	Gas-fired HW Boilers
Type	Forced Draft	Forced Draft
Thermal Efficiency	88.9%	80.0%
Supply/Return T (F)	180F Supply 140F Return	180F Supply 140F Return
CHW System		
% of Building Served	29%	29%
Loop Type	Primary Only Variable	Primary Only Variable
Chiller Type	Air Cooled	Air Cooled
Chiller Efficiency	11.8 EER	10.6 EER
Supply/Return T (F)	44F Supply 54 F Return	44F Supply 54 F Return
Heat Rejection System		
% of Building Served	100%	100%
Heat Rejection Type	Air Cooled (PTACs and Chiller)	Air Cooled (PTACs and Chiller)
Pump Power		
HW Pump 1 - Power & Control	Variable Speed	Variable Speed
Primary CHW Pump - Power & Control	Variable Speed	Variable Speed
DHW		

Type	Gas Storage HW Tank (527 Gallons)	Gas Storage HW Tank (527 Gallons)
Thermal Efficiency	heater efficiency- 85%	heater efficiency- 80%

Table 14. Large Building Model Information

Parameter	Composite Building		
Location	New York, NY		
Climate Zone	4A		
Building Use			
Occupancy Type	Mixed Use (Weighted average of profiles)		
Multifamily	42%		
Hotel	6%		
Penitentiary	26%		
School/University	26%		
Geometry			
Shape	Rectangular-2:1 ratio; Shorter side facing north		
Total Area (sf)	131,026		
Number of Floors	7		
Floor-Floor Height (ft)	12		
Parameter	Composite Building	ASHRAE 90.1-2007 ECB	ASHRAE 90.1-2004 ECB
Envelope			
Roof U-value	0.038	0.045 (Weighted avg. of 0.048, 0.065, 0.027)	0.057 (Weighted avg. of 0.063, 0.065, 0.027)
Exterior Wall U-value	0.051	0.093 (Weighted avg. of 0.090, 0.113, 0.064)	0.102 (Weighted avg. of 0.104, 0.113, 0.064)
Window-Wall-Ratio	21%	0.21	21%
Window U-value	0.43	0.55	0.57
Window SHGC	0.39	0.40	0.39
Slab-on-Grade	F-0.51 (8" slab; 2" rigid vertical insul-3ft)	F-0.54	F-0.73
Slab-Below-Grade U-value	C-1.47 (6" slab; no insul.)	C-1.190	C-1.140
Below-Grade Wall U-value	C-1.14 (6" wall; no insul.)	C-1.190	C-1.140
Door U-value	0.562	U-0.700	U-0.700
Lighting			
Average LPD (W/sf)	0.78	1.08 (Weighted avg. of building types)	1.08 (Weighted avg. of building types)

Heating Systems % of Building			
HW-Baseboard	43%	50% - System 10: HW PTAC 25% - System 2: HW VAV reheat 25% - System 4: HW VAV reheat	50% - System 10: HW PTAC 25% - System 2: HW VAV reheat 25% - System 4: HW VAV reheat
HW-VAV AHU	24%		
Furnace-PTAC	21%		
HW-PTAC	12%		
Cooling Systems % of Building			
DX-PTAC	27%	50% - System 10: DX PTAC 25% - System 2: CHW VAV reheat 25% - System 4: DX VAV reheat	50% - System 10: DX PTAC 25% - System 2: CHW VAV reheat 25% - System 4: DX VAV reheat
DX-VAV AHU	25%		
CHW-VAV AHU	25%		
DX-Window AC	23%		
Fan Power			
DX-VAV AHU	0.75 W/cfm (0.0007 bhp/cfm); VFD	System 4: 0.60 W/cfm (0.0007 bhp/cfm); Inlet Vanes	System 4: 0.60 W/cfm (0.0007 bhp/cfm); Inlet Vanes
CHW-VAV AHU	0.72 W/cfm (0.0007 bhp/cfm); VFD	System 2: 0.56 W/cfm (0.0007 bhp/cfm); VFD	System 2: 0.56 W/cfm (0.0007 bhp/cfm); VFD
DX-PTAC	Fan power in EER; Cycling	System 10: Fan power in EER; Cycling	System 10: Fan power in EER; Cycling
DX-Window AC	Fan Power in EER; Cycling	System 10: Fan power in EER; Cycling	System 10: Fan power in EER; Cycling
Window AC			
% of Building Served	23%	23%	23%
Type	Air Cooled DX (Assumed avg. size 10,500 Btu/h)	System 10	System 10
Efficiency	9.8 EER	10.3 EER	10.3 EER
PTAC			
% of Building Served	27%	27%	27%
Type	Air Cooled DX (Avg. Size 10,500 Btu/h)	System 10	System 10
Efficiency	10.4 EER	10.3 EER	10.3 EER
Packaged VAV-AHU			
% of Building Served	25%	25%	25%
Type	Water Cooled DX (Avg. Size 250,000 Btu/h)	System 4	System 4
Efficiency	12.6 EER	10.8 EER/10.1 IPLV	10.8 EER/10.1 IPLV
Heat Recovery	Energy Wheel; 76% Effectiveness (80% OA)	Energy Wheel; 50% Effectiveness (80% OA)	Energy Wheel; 50% Effectiveness (80% OA)
Economizer	Water-side Economizer	NR	NR

CHW VAV-AHU			
% of Building Served	25%	25%	25%
Type	Chilled Water	System 2	System 2
Efficiency	NA	NA	NA
Heat Recovery	Energy Wheel; 76% Effectiveness (20% OA)	NR	NR
Economizer	Air Side Economizer; Dual Enthalpy Control	NR	NR
Furnaces			
% of Building Served	21%	NA (PTACs with Furnaces for Heating in composite; does not apply to ASHRAE baseline systems)	NA (PTACs with Furnaces for Heating in composite; does not apply to ASHRAE baseline systems)
Type	Gas-fired		
Thermal Efficiency	81%		
HW System			
% of Building Served	79%	79%	79%
Loop Type	Primary Only Variable	Primary Only Variable	Primary Only Variable
Boiler 1	Gas-fired HW Boilers	Gas-fired HW Boilers	Gas-fired HW Boilers
Type	Non-Condensing (>0.3 MMBtu/h, <2.5 MMBtu/h)	Non-Condensing (>0.3 MMBtu/h, <2.5 MMBtu/h)	Non-Condensing (>0.3 MMBtu/h, <2.5 MMBtu/h)
% of Building Served	24%	24%	24%
Thermal Efficiency	85% Et	80% Et	75% Et
Boiler 2	Gas-fired HW Boilers	Gas-fired HW Boilers	Gas-fired HW Boilers
Type	Condensing (>0.3 MMBtu/h, <2.5 MMBtu/h)	Non-Condensing (>0.3 MMBtu/h, <2.5 MMBtu/h)	Non-Condensing (>0.3 MMBtu/h, <2.5 MMBtu/h)
% of Building Served	12%	12%	12%
Thermal Efficiency	94% Et	80% Et	75% Et
Boiler 3	Gas-fired HW Boilers	Gas-fired HW Boilers	Gas-fired HW Boilers
Type	Condensing (>2.5 MMBtu/h)	Non-Condensing (>2.5 MMBtu/h)	Non-Condensing (>2.5 MMBtu/h)
% of Building Served	43%	43%	43%
Thermal Efficiency	95% Et	82% Ec	80% Ec
Supply/Return T (F)	180/160 F	180/130 F	180/130 F
CHW System			
% of Building Served	25%	25%	25%
Loop Type	Primary Constant/Variable Secondary	Primary Only Variable	Primary Only Variable

Chiller Type	Air Cooled Screw (>300 tons,<600 tons)	Air Cooled Centrifugal	Air Cooled Centrifugal
Chiller Efficiency	COP 2.9	2.8 COP/3.05 IPLV	2.8 COP/3.05 IPLV
Supply/Return T (F)	42/56 F	44/56 F	44/56 F
Heat Rejection System			
% of Building Served	25%	25%	25%
Heat Rejection Type	Axial Fan; Variable Speed	Axial Fan; Two Speed	Axial Fan; Two Speed
Heat Rejection Efficiency	44 gpm/hp	38.2 gpm/hp	38.2 gpm/hp
Supply/Return T (F)	85/95 F	85/95 F	85/95 F
Pump Power			
HW Pump 1 - Power & Control	30 W/gpm; Variable Speed	30 W/gpm; Constant Speed	30 W/gpm; Constant Speed
HW Pump 2 - Power & Control	26 W/gpm; Variable Speed	26 W/gpm; Constant Speed	26 W/gpm; Constant Speed
HW Pump 3 - Power & Control	22 W/gpm; Variable Speed	22 W/gpm; Constant Speed	22 W/gpm; Constant Speed
Primary CHW Pump - Power & Control	15 W/gpm; Constant Speed	35 W/gpm; Variable Speed	35 W/gpm; Variable Speed
Secondary CHW Pump - Power & Control	20 W/gpm; Variable Speed	NA	NA
CW Pump - Power & Control	26 W/gpm; Variable Speed	26 W/gpm; Constant Speed	26 W/gpm; Constant Speed
DHW			
Type	Gas Storage Water Heaters (>75,000 Btu/h)	Gas Storage Water Heaters (>75,000 Btu/h)	Gas Storage Water Heaters (>75,000 Btu/h)
Non-Condensing % of Building	60%	60%	60%
Thermal Efficiency	84% Et; 2,800 Btu/h SL	80% Et; 2,900 Btu/h SL	80% Et; 2,900 Btu/h SL
Condensing % of Building	40%	40%	40%
Thermal Efficiency	96% Et; 1,800 Btu/h SL	80% Et; 1,900 Btu/h SL	80 % Et; 1,900 Btu/h SL

Modeling of Commercial Buildings

Modeling of the composite buildings was performed in the following steps. These steps enabled the comparison of the composite buildings to their respective composite building set to 100% code compliance. This, and further iterations on a component level, provided the lost savings for each building size.

Modeling Steps:

1. Develop the composite building in eQuest in the appropriate Climate Zone.
2. Model each composite building and document each building's consumption.
3. Develop an ASHRAE 90.1 2007 100% code-compliant building model of each composite building to ascertain the base consumption.
4. Model each of the 100% code-compliant composite buildings in the appropriate Climate Zone. Document each building's consumption.
5. *Trade-off Method:* analyze envelope systems for code compliance by comparing the UA of the 100% code compliant building to the Composite building.
    a. If the UA is equal or better than code, no analysis is required.
    b. If the UA of the Composite building is below-code:
        i. Calculate the weighted average UA of the non-compliant buildings within the sample (use only the buildings where the UA was below-code to calculate this average). Create a modified 100% code compliant composite building with the UA at the below-code level.
        ii. Model the modified code compliant composite for consumption in the appropriate Climate Zone. Document each building's consumption.
        iii. The difference between the consumption of the modified code compliant composite building and the 100% code compliant composite building is the lost savings for the envelope system.
6. *Prescriptive Systems:* analyze the HVAC and lighting systems for code compliance by comparing the individual components of these two systems to the code requirements. This step does *not* include envelope components (windows, opaque doors, skylights, opaque roof, opaque above-grade wall, below-grade wall, floor, and slab-on-grade).
    a. For each *non-envelope* related component that is below code:
        i. Determine a maximum of four individual, below-code components that have the largest savings potential. This is done by comparing the component's consumption outputs in eQuest.
        ii. Calculate the weighted average efficiency level of the non-compliant component from the individual buildings in the sample (use only the buildings where this particular component was below-code to calculate this

average). Create a modified 100% code compliant composite building with this one component at the below-code level.

iii. Model the modified code compliant composite for consumption in the appropriate Climate Zone. Document each building's consumption.

iv. The difference between this building consumption and the 100% code compliant building consumption is the lost savings for this component.

v. Repeat these steps for each non-compliant, *non-envelope* component.

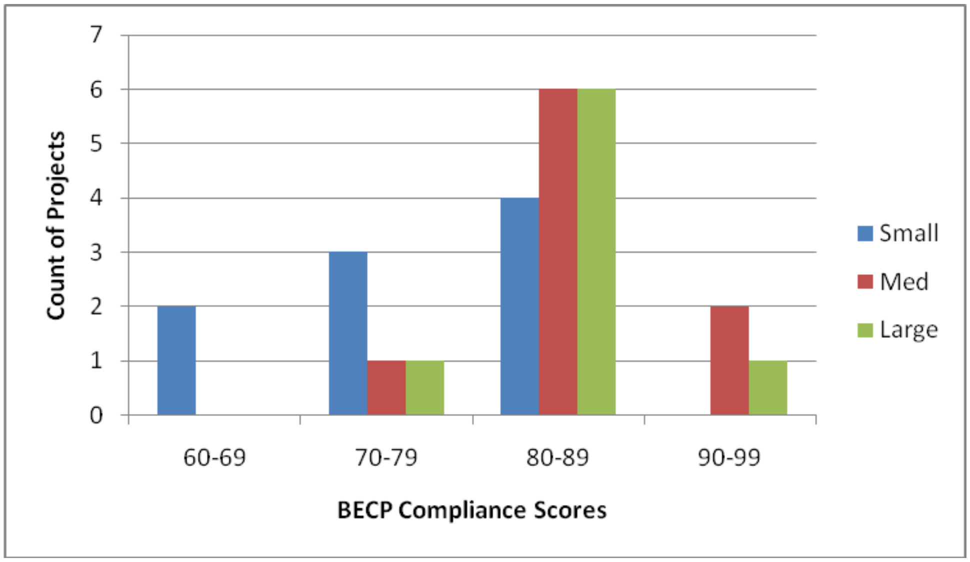
7. *Insulation Installation Quality*: as it was not possible to check the quality of insulation and air sealing in the sampled buildings, the composite buildings assume a code compliant 0.35 ACH rate. To quantify the potential for lost savings due to poor quality installation, two different levels of air sealing are modeled:
    a. Change the ACH for the 100% code compliant buildings to 0.50ACH.
    b. Model the modified composite buildings for the appropriate Climate Zone. Document each building's consumption.
    c. The difference in consumption between the unmodified 100% code compliant building (set at 0.35ACH) and the modified composite building (set at 0.50ACH) is the potential for lost savings.

E: RESULTS

xiii. BECP Protocol

The summary of the BECP Protocol scores, by buildings size, as shown in Chart P1 below:

Chart P1. BECP Protocol Compliance summary



The profile and scores of the buildings in the sample are shown in the following table.

Table 15. BECP Protocol Compliance Score by Building Type

Building Types	Bldgs in Sample	Square Footage	Percent of Sample	BECP Score
Commercial	9	162,362	10%	79%
Bank	1	3,848	0%	85%
Office	6	118,813	7%	77%
Retail	2	39,701	3%	83%
Dwelling	9	721,947	46%	85%
Dormitory	1	146,476	9.2%	88%
Hotel	2	110,134	6.9%	85%
Multi-family	6	465,337	29.4%	84%

Institutional	8	701,049	44%	84%
Education	2	301,163	19%	86%
Healthcare	2	81,220	5%	78%
Laboratory	1	41,964	3%	92%
Prison	1	255,271	16%	81%
Public Safety	2	21,431	1%	89%

The buildings that met the 90% requirement in the BECP Protocol included two institutional facilities and a Federal office building. The seven buildings with the lowest checklist scores included five commercial type occupancies, one of which was a small government office, and two healthcare facilities. Compliance of the buildings with residential type occupancy is relatively consistent at approximately 85%. However, there may be additional opportunities in this occupancy class as the lighting loads in dwelling areas of multi-family housing are currently unregulated. In addition, code LPD allowances for dwelling areas in hotels and dormitories appears high relative to the installed lighting power densities found in new construction.

The compliance results were also analyzed per Climate Zone, but there was not a marked difference between compliance levels as they were all approximately 85% compliant.

xiv. Prescriptive/Trade-Off Compliance Method

Chart P2. Prescriptive/Trade-Off Compliance

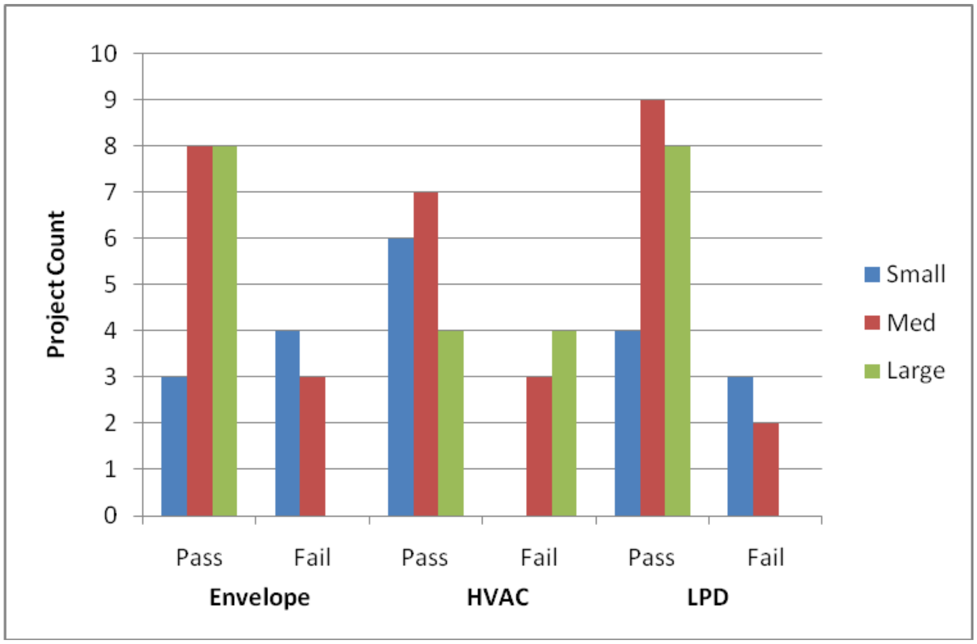


Table 15: Building Component Compliance Rates to ASHRAE 90.1 2007

Component	Sample Size	Buildings In Compliance	Percent Compliance [1]
Thermal Envelope			
Small	7	3	17%
Medium	11	8	77%
Large	8	8	100%
Mechanical Systems			
Small [2]	7	6	87%
Medium	11	7	62%
Large	8	3	25%
Lighting Systems			
Small	7	4	64%
Medium	11	9	87%
Large	8	8	100%

[1] Percent compliant (Pass) by building area.
[2] One project did not have documentation of mechanical system efficiency.

The results in Table 15 above provide some insight into compliance trends in the sample population. The small buildings (<25,000sf) seem to have the greatest trouble with compliance as none of the small buildings reached the minimum requirements for compliance under the BECP Protocols or the Prescriptive/Trade-off method, especially for the envelope system. The medium sized buildings were closer to compliance and more consistent across the three building systems. The large buildings had compliant thermal envelope and lighting systems, but failed to comply with the mechanical systems. Some more specific findings are:

a. Sixty-three percent of medium buildings had packaged HVAC equipment with compliant efficiencies. The below-code equipment was only 5% less efficient than the standard.

b. Only 25% of the large buildings had HVAC equipment including packaged air handling equipment and/or motors that were fully compliant with prescriptive code requirements, but large buildings were consistently designed to comply with the prescriptive envelope and lighting requirements. None of the buildings in the survey included chillers.

c. Large buildings had many more of the design approaches that are captured in the BECP Protocols so were typically pursuing design strategies that incorporated higher levels of efficiency overall.

d. In all three building sizes and all jurisdictions, there were gaps in submitted information making compliance verification at the plan review stage difficult.

e. In medium and large buildings required controls strategies such as automatic lighting control, DHW recirculation control, demand control ventilation, etc. were not typically implemented in accordance with code; these controls strategies were not captured in prescriptive compliance evaluations that found lighting to be compliant. They were captured in the BECP Protocol and in the composite models.

f. Continuous insulation is not consistently applied in small and medium sized commercial building construction.

g. Window and door ratings are underspecified (i.e. not included in the project documents) and difficult to verify in the field due to lack of ratings on installed components.

h. Documentation of compliance with lighting power density (LPD) requirements was found to be limited. Many COM*check*™ documents included a single line item for LPD providing no evidence that a full LPD calculation was performed for the project and calling into question the accuracy of the submitted calculations.

As mentioned, there is a potential bias issue with the sample. In particular, the VEIC Team had difficulty recruiting large building participants. It is likely that there was self-selection bias that resulted in relatively higher efficiency in the large projects included in the sample. The large projects had reputable design teams and while the HVAC compliance appears low on a prescriptive basis, the overall efficiency of the HVAC systems in large buildings was high as demonstrated by the composite model, but included some non-compliant equipment which typically served a small portion of the load. Large building heating equipment, for example, had a very high adoption rate of condensing boilers with efficiency ratings greater than 92%.

The medium buildings had the highest prescriptive compliance rate. They had the highest compliance overall with the prescriptive efficiency requirements of the code. Medium buildings had lighting power densities (LPDs) that ranged from about 130% less efficient than code allows to 60% better than code. Except for the non-compliant buildings, LPDs were generally found to be significantly better than code.

The field inspection forms did not support LPD analysis based on field findings; however, the Team completed field lighting surveys to determine the installed LPD values. It would be beneficial to provide a mechanism for documenting and capturing the installed LPDs in the PNNL Checklists. Medium sized buildings did not tend to incorporate energy recovery or demand control ventilation strategies where they are required. In addition, deficiencies were found in the efficiency of mechanical equipment specified for medium sized buildings

Small buildings have a limited impact on overall statewide compliance as the statewide score is area weighted. These buildings tend to have small, simple mechanical systems. The high level of compliance for small building HVAC equipment may be a result of market penetration of efficient equipment supported through the NYSERDA's prescriptive rebate programs. The lighting had a relatively high compliance for small building LPDs. High efficiency fixtures with low wattage lamps were common in the small buildings surveyed. Small buildings also had the lowest compliance with building envelope requirements, including failing to install slab on grade insulation, failing to meet exterior wall requirements and failure to meet roof insulation values. Evaluation of small building fenestration was limited due to lack of information and could result in lower levels of compliance than found in this study.

There are two areas for which the commercial code does not stipulate a numeric compliance value that were generally observed to have energy savings potential. Commercial building envelopes are not generally air sealed to a high level as indicated by the lack of continuous insulation and limited observations during site visits of the use of foam for air sealing. In addition, mechanical systems, including distribution fans, serving commercial buildings often appear to be oversized. Load calculations, though required by code, are not typically submitted and criteria for reviewing load calculations are not provided by ASHRAE 90.1.

xv. Energy Cost Budget Method

The overall summary of the modeling results (shown in Table P15 below) show the small buildings are the only ones who do not comply to code using the Energy Cost Budget Method of Chapter 11 in ASHRAE 90.1 2007.

Table P16. Small Composite Building Modeling Outputs

Building Size	Composite Building (MMBtu)	Code Compliant Building (MMBtu)	Difference (%)
Small	510	503	-1.4%
Medium	2,323	2,841	18%
Large	9,073	9,386	3%

While the model results give cause for optimism regarding the progress of commercial construction in New York State, there are areas for energy efficiency improvements based on the data collected in the field and the codes that were applicable at the time these buildings were permitted. As the stringency and extent of commercial building codes increases, the savings potential will also increase.

The details of the modeling outputs and the modeling iterations of individual components found to be below code are shown in the following three tables:

Table P16. Small Composite Building Modeling Outputs

eQuest Modeling Output Small Sized Composite Building			
Modeling Step	Electric (kWh)	Gas (MMBtu)	Total (MMBtu)
Aggregate building	98,880	172.51	509.99
100% code-compliant building	75,210	245.86	502.55
Below Code Components	25,598	(24)	64
Component #1: Envelope			
No slab or continuous wall insulation, non-compliant windows	76,851	249.24	511.53
Affected % of Floor Area	36%	36%	36%
Component #2: *Interior Lighting Levels and Automatic Controls*			
High LPD and Low Penetration of Controls	79,390	222.02	492.98
Affected % of Floor Area	36%	36%	36%
Component #3: HVAC Systems are Oversized			
Systems are 1.25 of cooling load	94,327	212.29	534.23
Affected % of Floor Area	60%	60%	60%
Component #4: Air Infiltration			
0.50ACH	75,870	276.16	535.10
Affected % of Floor Area	30%	30%	30%

Table P17. Medium Composite Building Modeling Outputs

eQuest Modeling Output Medium Sized Composite Building			
Modeling Step	Electric (kWh)	Gas (MMBtu)	Total (MMBtu)
Aggregate building	413,020	913	2,323
100% code-compliant building	444,940	1,322	2,841
Below Code Components	134,425	(278)	181
Component #1: *Envelope*			
No slab or continuous wall insulation, non-compliant windows	453,030	1,344	2,891
Affected % of Floor Area	21%	21%	21%
Component #2: *Interior Lighting Levels and Automatic Controls*			
High LPD and Low Penetration of Controls	450,240	1,310	2,847
Affected % of Floor Area	100%	100%	100%
Component #3: PTAC efficiency			
PTAC efficiency is 5% below code	445,610	1,322	2,843
Affected % of Floor Area	13%	13%	13%
Component #4: *Air Infiltration*			
0.50ACH	454,040	1,457	3,007
Affected % of Floor Area	30%	30%	30%
Component #5: *HVAC Control*			
Below Code Level	445,225	1,368	2,888
Affected % of Floor Area	100%	100%	100%
Component #6: Install ERV			
Below Code Level	555,920	853	2,751
Affected % of Floor Area	3%	3%	3%

Table P18. Large Composite Building Modeling Outputs

eQuest Modeling Output Large Sized Composite Building			
Modeling Steps	Electric (kWh)	Gas (MMBtu)	Total (MMBtu)
Aggregate building	1,506,799	3,931	9,073.48
100% code-compliant building	1,505,800	4,246.90	9,386.20
Below Code Components	50,621	936	1,109
Component #1: Envelope- Totally Compliant			
	-	-	-
Affected % of Floor Area	0%	0%	0%
Component #2: Interior Lighting Levels and Automatic Controls			
Lack of Tandem Wiring	1,523,000	4,321.60	9,519.60
Affected % of Floor Area	100%	100%	100%
Component #3.1: AHU efficiency below code			
9% below code	1,526,600	4,305.56	9,515.85
Affected % of Floor Area	2%	2%	2%
Component #3.2: PTAC efficiency below code			
1% below code	1,506,300	4,248.31	9,389.31
Affected % of Floor Area	6%	6%	6%
Component #4: Air Infiltration			
0.50ACH	1,512,200	4,998.10	10,159.24
Affected % of Floor Area	30%	30%	30%
Component #5: HVAC Controls			
Below Code	1,506,508	4,296.98	9,438.69
Affected % of Floor Area	100%	100%	100%
Component #6: Motors			
3% below code	1,510,813	4,246.90	9,403.30
Affected % of Floor Area	23%	23%	23%

There are several caveats that the VEIC Team places on the results of this modeling exercise:

i. Self-selection bias is likely a significant factor affecting the levels of efficiency in the composite buildings. It was noticeable to the VEIC Team that made the recruitment calls, that owners who did agree to participate in this study were ones who had confidence that their buildings were at least compliant with code. Owners who were not attentive to codes when their building were built, or owners who did not use design professionals accustomed to codes, were less likely to be receptive to scrutiny of their buildings for this study. The eight owners who sought out the study by proactively contacting the VEIC Team upon receipt of the recruitment letter were likely proud of their building construction. This means the findings of the building levels of efficiency are probably higher than the overall new construction market in New York State.

j. In order to provide a representation of the system types found in the field, the models are based on an amalgamation of systems that would not be applied in any real world building. This could impact modeling results by driving system sizes down or by creating unexpected interactive effects.

k. While the models reflect the findings in the surveyed buildings, they are not necessarily consistent with the VEIC Team's general experience working in the field of commercial building energy efficiency. The sampled buildings, for example, show a high percentage of LPD above code. It is the experience of the VEIC Team that buildings pursuing LEED certification often do not achieve installed lighting power densities as efficient as those found in the survey. Mechanical equipment sizing is another area where the modeling software assumes properly sized equipment and yet this Team's experience has been that most HVAC systems are oversized. This leads to fans, motors and pumps being oversized and the overall HVAC system consumes more energy than necessary.

l. Because the level of inspection lacked performance testing required to develop a truly accurate estimate of a commercial building's constructed levels of energy efficiency, the composite buildings are more representative of the design intent than of the actual performance of these buildings, particularly for the medium and large models. Performance monitoring through metering, too expensive and time consuming for an evaluation of code compliance, is the only industry sanctioned method which truly represents the actual energy performance of a building. Examples are items such as variable speed drives which are set manually to one speed, economizers and demand control ventilation which are not controlled correctly, programmable thermostats which are manually set to one temperature, condensing boilers which do not operate correctly and therefore do not meet their efficiency ratings, to name but a few.

m. Because the sample is relatively small and there are a number of different HVAC systems per building size in the medium and large buildings, the equipment efficiency levels modeled are based on a very small sample of systems.

xvi. Overall Analysis of Results

Table P19. Overall Summary of Compliance Methods

Applicable Code (ASHRAE 90.1-2004 and 2007)		Climate Zone 4A	Climate Zone 5A	Climate Zone 6A	Statewide
	Metric	n=15	n=5	n=6	n=26
Building Compliance Rate					
	BECP Protocol	84%	81%	87%	85%
Percent of Building Compliance [1]					
	BECP Protocol (90%+ Compliant)	24%	22%	10%	21%
	Prescriptive/Trade-off (Pass)	33%	38%	46%	36%
Energy Cost Budget Relative to ASHRAE 90.1-2007					
Small	eQuest Composite Models			117%	
Medium			87%		
Large		99%			

[1] The area weighted percentage of buildings that met the standard. For the BECP protocol three of the projects with 21% of the project area met the 90% compliance standard. For the prescriptive/trade-off method nine projects with 36% of the project area met the prescriptive efficiency levels of the code.

The modeled results differ from the PNNL Checklist compliance rates and the Trade-off results because modeling cannot account for failure to comply with administrative elements of the code such as submitting the required documentation. They do, however, capture the above code levels of efficiency found in the field. For instance, 55% of boilers in large commercial buildings were condensing boilers rated above 94% efficiency, while the code required boiler efficiency was 82% or lower. Below code cooling equipment in large buildings typically served a small fraction of the building load while the majority of the load was served by equipment that was rated significantly better than the code minimum. Energy modeling is the only way to capture the overall efficiency levels achieved by buildings that have efficiencies that range from 12% worse than to 68% better than that required by code.

Specific components were found to be non-compliant in the review of the sampled buildings. These components, per building size, where compliance improvements would impact the energy consumption of the building are

Small Buildings

The main areas for improvement lie in proper HVAC sizing, code compliant exterior and interior lighting and lighting controls. Many small buildings were also non-compliant for windows, and slab and continuous wall insulation.

These building parameter deficiencies are not surprising for small buildings. The majority of buildings smaller than 25,000 square feet are not designed by an architect and/or engineer. Most of these are designed by contractor design/build firms who size mechanical equipment and design lighting systems by long-standing 'rules of thumb.' ASHRAE 90.1 also does not mandate sizing calculations very clearly. It merely states "Heating and cooling system design loads for the purpose of sizing systems and equipment shall be determined in accordance with generally accepted engineering standards and handbooks acceptable to the adopting authority (for example, ASHRAE Handbook-Fundamentals)".

Engineers are leery of designing below these age-old standards because they often do not trust buildings will be constructed as tight as the design specifies and they do not want to have problems with buildings not being able to meet their temperature setpoints or people complaining that there is not enough light. These particular areas – equipment efficiency, building envelope tightness, and lighting efficacy are areas that have seen great improvements, but some practitioners have not been convinced they can change their design methods. In order to influence a change in standard design practices, designers must be educated and the code compliance process must evaluate building mechanical system MMBtu/sf, lighting power density and air change rate. Mechanical equipment sizing calculations and air change rate could be required as an input in the COM*check*™ report, a blower door test could be required during construction for moderately sized buildings and a post-construction check of LPD and equipment capacity could be required prior to an occupancy permit being issued. These actions will help enable the building designers and contractors to see that these new standards meet building performance requirements and will enable New York to have confidence that energy savings are being realized.

Medium Buildings

The medium building modeled overall building energy consumption was better than the code compliant building due to better-than-code components such as roof and wall insulation and mechanical equipment efficiency ratings. Where the sampled medium sized buildings fell short of BECP Protocol code compliance was in the lack of energy recovery wheels, slab insulation and continuous wall insulation; the high LPD and low penetration of lighting and HVAC control. As many buildings did not have continuous wall or slab insulation, it is likely that air infiltration is higher than necessary. Although it is not stipulated in ASHRAE 90.1, this evaluation has included an analysis of savings that can be realized by decreasing the air changes per hour of the composite building from 0.50ACH to 0.35ACH.

Large Buildings

Large buildings performed better than code for this building sample. In general, these buildings are quite well designed by professional architects and engineers that are accustomed to building to code or beyond. The savings potential included in this analysis is comprised of improved HVAC equipment efficiency, improved HVAC controls, code compliant motors and tandem wiring for fluorescent light fixtures. While the LPD of the composite building was found to be better than code, the lack of tandem wiring imposes approximately a 3% penalty on the LPD. So, if the installed systems had more routinely included tandem wiring, the installed LPDs would have been even better. The use of tandem wiring in certain situations is required by code. The impacts of below-code air sealing were also calculated. This improvement relies on conscientious construction practices, is easily attainable without considerable increased material cost, and will be tested under the 2010 ECCC NYS requirements.

Q1. REQUIRED DATA SURVEY TOOL

Table 17. Required Data for Survey Tool

Required Data for Survey Tool	
Component	Component sub-category
Building Information	
Primary Building Type	
Location	City and State
Project Type	
Building Envelope:	
Code Compliance Path	
Plan/Specifications	All information provided with which compliance can be determined for the building envelope and delineate and document where exceptions to the standard are claimed.
Floor Area	
Number of Floors	
	above grade
	below grade
Floor to Floor height	
Perimeter	
Insulation	Building envelope insulation is labeled with R-value or insulation certificate providing R-value and other relevant data.
	Eaves are baffled to deflect air to above the insulation.
	Insulation is installed in substantial contact with the inside surface separating conditioned space from unconditional space.
	Recessed equipment installed in building envelope assemblies does not compress the adjacent insulation.
	Exterior insulation is protected from damage with a protective material.
	Foundation vents do not interfere with insulation.
	Insulation in contact with the ground has ≤0.3% water absorption rate per ASTM C272.
	Attics and mechanical rooms have insulation protected where adjacent to attic or equipment access.

Air Leakage	All sources of air leakage in the building thermal envelope are sealed, caulked, gasketed or weather stripped to minimize air leakage.
	Fenestration and doors meet maximum air leakage requirements.
Floor	
	Construction
	Construction thickness
	Rigid insulation
	Insulation thickness
	Floor insulation R-value.
	Floor insulation installed per manufacturer's instructions.
Above Grade Wall	
	Continuous insulation
	Continuous insulation type
	Continuous insulation R - value
	Frame type
	Metal or Wood Frame size
	Frame thickness or spacing
	Cavity Insulation R value
	Interior Insulation
	Above-grade wall insulation R-value installed per manufacturer's instructions.
Below Grade Wall	
	Slab on Grade
	Concrete thickness
	Insulation type
	Insulation location
	Insulation width/depth
	Insulation R- value
Windows	
	Window-to-wall percentage
	Products are certified as to performance labels or certificates provided.
	Products rated in accordance with NFRC
	Window Panes
	low-e coating
	Frame type
	U factor
	SHGC value
	Warm edge spacer
Doors	
	Type
	U-value

	Weatherseals installed on all loading dock cargo doors in Climate Zones 4-8
	U-factor and air leakage of opaque doors associated with the building thermal envelope meets requirements
Roof construction	
	Color
	Continuous insulation
	Continuous insulation type
	Continuous insulation R - value
	Frame type
	Frame thickness or joist spacing
	Radiant Barrier
	Cavity Insulation R value
	Roof insulation R-value provided. Installed per manufacturer's instructions.
	Roof insulation R-value. Installed per manufacturer's instructions. Blown or poured loose-fill insulation is installed only where the roof slope is ≤3 in 12.
Skylights	
	% of roof area
	Curb
	Translucence type
	category
	U-factor
	SHGC value
	Frame type
	Warm edge spacer
	Performance compliance approach submitted for vertical fenestration area >40% or skylight area >5%.
	Skylight curbs insulated to the level of roofs with insulation above deck or R-5.
Occupancy - Typical Use	
	Monday
	open
	close
	Tuesday
	open
	close
	Wednesday
	open
	close
	Thursday

	open
	close
	Friday
	open
	close
	Saturday
	open
	close
	Sunday
	open
	close
	Holidays
	open
	close
Footing/Foundation	Exterior insulation protected against damage, sunlight, moisture, wind, landscaping and equipment maintenance activities.
	When contacting ground insulation has $\leq$0.3% water absorption (ASTM C272).
	Piping, ducts and plenum are insulated and sealed when installed in or under a slab.
	Any SWH piping in or under slab is insulated.
	Below-grade wall insulation R-value. Installed per manufacturer's instructions.
	Slab edge insulation R-value, depth/length. Installed per manufacturer's instructions.
	Freeze protection and snow/ice melting system sensors for future connection to controls.
Miscellaneous	Pool covers are provided for heated pools and pools heated to >90˚F have a cover $\geq$R-12
Electrical	
	Feeder and branch circuit load and sizing calculations provided that allow verification of voltage drop.
	Construction documents as-built drawings for electric power systems and O&M manual for electrical power systems and equipment.
	Feeder connectors sized in accordance with approved plans.
	Branch circuits sized for maximum drop of 3%.
	Electric motors meet requirements where applicable.

Lighting	(categories need to be able to be added numerous times for different occupancy types)
Code Compliance Path	
Plan/Specifications	All information with which compliance can be determined for the lighting and electrical systems and equipment is provided; 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.
Lighting controls	Verify separate lighting control devices for specific uses installed per approved lighting plans.
	Automatic lighting control to shut off all building lighting installed in buildings >5,000 ft^2.
	Independent lighting control installed per approved lighting plans and all manual control readily accessible and visible to occupants.
	Automatic lighting controls for exterior lighting installed.
Ballasts/fixtures/lamps	Ballasted one and three lamp fixtures with >30 W/lamp have two lamp tandem wired ballasts when $\geq$2 fixtures in same space on same control.
	Installed lamps and fixtures are consistent with what is shown on the approved lighting plans.
Interior Lighting	
	Space occupancy type
	Lamp Type or Wattage
	type
	wattage
	Ballast factor
	Number of lamps per fixture
	Number of fixtures in this space
	Space area for fixtures
	Hours of occupancy
	Automatic shutoff control
	% of fixtures with occupancy sensors
	% of fixtures with daylight sensors
	Additional interior lighting power allowed for special functions per the approved lighting plans and is automatically controlled and separated from general lighting.
Exterior lighting	
	Surface type
	Lamp Type or Wattage

	Space area for fixtures
	type
	wattage
	Ballast factor
	Number of fixtures for this surface type
	Surface area of fixtures
	Hours of operation
	Automatic shutoff control
	% with photocell
	% with time clock
	Exterior ground lighting over 100 W provides >60 lm/W unless on motion sensor or fixture is exempt from scope of code or from external LPD.
Exit Lighting	Consumption is<5W per face
	Exit signs do not exceed 5 watts per face.
Vestibule	installed per approved plans.
Mechanical Equipment	(categories need to be able to be added numerous times for different occupancy types)
Code Compliance Path	
Plan/Specifications	All information with which compliance can be determined for the mechanical systems and equipment is provided; delineate and document where exceptions to the standard are claimed.
	HVAC load calculations submitted
	Detailed instructions for HVAC systems commissioning included on the plans or specifications
	Construction documents require HVAC “as-built” drawings submitted within 90 days of system acceptance
HVAC	equipment efficiency verified.
	Non-NAECA HVAC equipment labeled as meeting 90.1.
	HVAC ducts and plenums insulated.
	HVAC piping insulated.
	An air and/or hydronic system balancing report is provided for HVAC systems serving zones >5,000 ft^2 of conditioned area.
	Verify HVAC control systems have been tested to ensure proper operation, calibration and adjustment of controls.
Heat Traps	Installed on non-circulating storage water tanks
Humidification/dehumidification controls	When humidification and dehumidification is provided to a zone simultaneous operation is not possible
	Dehumidification controls provided to prevent reheating, recooling, mixing of hot and cold airstreams or concurrent heating and cooling of the same airstream

Heating/Cooling Controls	Heating and cooling to each zone is controlled by a thermostat control
	Temperature controls have the following features: dead band controls, setpoint overlap restrictions, off-hour controls, automatic shutdown, setback controls.
	Zone controls can limit simultaneous heating and cooling and sequence heating and cooling to each zone
Cooling equipment	
	Quantity of units (of one type and size)
	Source
	Type
	Zone
	Capacity
	Model number
	Efficiency
	Condenser Type
	Supply air setpoint
	% of building served by equipment
	Percent outside air
	Return air path
	Space temperature setpoint
	Unoccupied space temperature setup
Heating equipment	
	Quantity of units (of one type and size)
	Source
	Fuel type
	Zone
	Capacity
	Model number
	Efficiency
	Supply air setpoint
	% of building served by equipment
	Percent outside air
	Return air path
	Space temperature setpoint
	Unoccupied space temperature setback
	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.
	Service water heating equipment used for space heating complies with the service water heating equipment requirements
	Temperature controls installed on service water heating systems (≤120 ºF to max temp for intended use).

	Unenclosed spaces that are heated use only radiant heat
	Heating and cooling to each zone is controlled by a thermostat control
Boiler	
	Quantity of units (of one type and size)
	Model number
	Fuel type
	Efficiency
	Temperature setpoint
	turndown ratio
	HW loop temperature
	quantity of pumps
	pump efficiency
	pump size
	% of pumps with VFD
	pump VFDs in manual override
Chillers	
	Type
	Efficiency
	Size
	Condenser Flow Rate
	Leaving Chilled Water Temp
	Entering Condenser Water Temp
Heat recovery	
	code required (exhaust system>5,000cfm and +70% of supply OA
	ERV/HRV
	% of building served by heat recovery
	Condenser heat recovery system that can heat water to 85 ºF or provide 60% of peak heat rejection is installed for preheating of service hot water in 24/7 facility, water cooled systems reject >6 MMBtu, SHW load ≥1 MMBtu.
Economizer	
	code required
	type
	control type
	integrated control
	control to reduce heating/cooling/dehum
	high-limit shutoff control setting: when outside air exceeds:
	Excess outdoor air relief
	Air economizers provided where required, meet the requirements for design capacity, control signal, and high-limit shut-off and integrated economizer control.
	Means provided to relieve excess outside air.

	Water economizers provided where required, meet the requirements for design capacity, maximum pressure drop and integrated economizer control and heating system impact.
	Economizer operation will not increase heating energy use during normal operation.
	Water economizer specified on hydronic cooling and humidification systems designed to maintain inside humidity at > 35 ºF dewpoint if an economizer is required
Ductwork	Ducts and plenums sealed based on static pressure and location.
	Ductwork operating >3 in. water column requires air leakage testing
	Return air and outdoor air dampers meet minimum air leakage requirements
	Stair and elevator shaft vents have motorized dampers that automatically close
	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.
Demand control ventilation	provided for spaces >500 ft^2, >40 people/1000 ft^2 occupant density and served by systems with air side economizer, auto modulating outside air damper control or design airflow >3,000 cfm.
	Reset static pressure setpoint for DDC controlled VAV boxes reporting to central controller based on the zones requiring the most pressure
	Systems with air capacity >10,000 cfm include optimum start controls
Fans	
	type
	quantity
	motor size
	brakehorsepower
	design cfm
	# of poles
	RPM
	motor efficiency
	motor nameplate
	% with VFD control
	VAV fans have static pressure sensors positioned so setpoint ≤1/3 total design pressure
	Ventilation fans >0.75 hp have automatic controls to shut off fan when not required
	Two-position automatic valve interlocked to shut off water flow when hydronic heat pump with pumping system >10 hp is off

	Fan systems with motors ≥7.5 hp associated with heat rejection equipment to have capability to operate at 2/3 of full-speed and auto speed controls to control the leaving fluid temp or condensing temp/pressure of heat rejection device
Motors/Pumps	
	quantity
	motor size
	motor efficiency
	type
	# of poles
	RPM
	motor nameplate
	% with VFD control
	pump control (limit recirc pump operation)
	Pump controls installed to limit operation of recirculating pumps
	Hydronic heat pump systems connected to a common water loop meet heat rejection and heat addition requirements.
	VAV fan motors ≥10 hp to be driven by mechanical or electrical variable speed drive, or have a vane-axial fan with variable pitch blades, or have controls or devices to limit fan motor demand to ≤30% of design wattage at 50% design air volume at static pressure of 1/3 total rated static pressure of the fan
	HVAC fan motors not larger than the first available motor size greater than the bhp
	HVAC pumping systems >10 hp designed for variable fluid flow
	Reduce flow in pumping systems >10 hp. to multiple chillers or boilers when others are shut down
	Temperature reset by representative building loads in pumping systems >10 hp for chiller and boiler systems > 300,000 Btu/h
	Two-position automatic valve interlocked to shut off water flow when hydronic heat pump with pumping system >10 hp is off
	Heat pump controls prevent supplemental electric resistance heat from coming on when not needed
	Controls are installed that limit the operation of a recirculation pump installed to maintain temperature of a storage tank
	PTAC and PTHP with sleeves 16 in by 42 in. labeled for replacement only
Fume Hood Exhaust	
	system >15,000cfm
	VAV hood w/ direct make up air or HRV
	Kitchen hoods >5K cfm have make up air ≥50% of exhaust air volume
Exhaust Air	energy recovery on systems ≥ 5,000 cfm and 70% of design supply outside air.
Hot Gas	bypass limited to: ≤24 kBtu/h – 50%, >24 kBtu/h – 25%

Insulation	Insulation exposed to weather to be protected from damage. Insulation outside of the conditioned space and associated with cooling systems is vapor retardant.
Hot Water	
Code Compliance Path	
Plan/Specifications	All information with which compliance can be determined for the service water heating systems and equipment is provided; delineate and document where exceptions to the standard are claimed.
	Service water heating load calculations submitted.
Efficiency	Service water heating equipment meets efficiency requirements.
Time Switches	installed to automatically switch off the recirculating hot-water system or heat trace.
Domestic Hot Water	
	Heat source
	Type
	Temperature setpoint
	Input size category
	Subcategory
	Rated Efficiency
	Usage
	gal/day
	days/yr
	Heat traps on non-circulating storage tanks
	Automatic on/off control of recirculating pumps
	Unfired storage tank insulation
	Pool heater
	Pool heaters are equipped with on/off switch and no continuous burning pilot light
	Time switches are installed on all pool heaters and pumps
	Public lavatory faucet water temperature not greater than 110^{o}F
Piping Insulation	
	Nominal pipe size
	Insulation thickness

Q2. COMMERCIAL CODE OFFICIAL INTERVIEW GUIDE

What was your involvement in case study building? (Plan review, field inspections, compliance calculations)

What was tagged at the plan review stage as non-compliant with respect to the Energy Code?

How many inspections did you do for this project?

How many of these included inspections with specific attention to energy requirements?

Were any energy-related times identified as non-compliant? If so, which items?

For commercial buildings, what energy-related aspects do you generally focus on when doing plan reviews?

For commercial buildings, which energy-related aspects do you see as particularly problematic for contractors?

In general, what do you consider the problems facing the industry in building code compliant buildings?

What areas do you have the most trouble with when determining building compliance?

What tools do you use to determine compliance (ie. ComCheck, other database, own database, plans)?

Do you feel your review is thorough enough to be accurate?

How familiar are you with the new 2010 energy code requirements? What training have you had?

Do you feel this training is accessible, sufficient and timely? If not, what would you suggest would help the situation?

Do you feel the design and building industry (architects, engineers, builders, manufacturers) has accessible, sufficient and timely training in the code?

Do you feel they generally build to the code? If not, what do you think may help improve overall compliance?

The future code will require air and duct leakage checks. How would you propose that these requirements be checked so that you get the results?

What areas do you think contractors will have the most trouble complying with?

1. Temperature setpoint deadbands between heating and cooling within allowed tolerances

2. Above-deck roof insulation is R-20 or higher
3. Maximum voltage drops on feeder conductors less than 2% and branch conductors less than 3%
4. Occupancy sensors are installed in all classrooms, meeting rooms, and lunch rooms
5. Lighting power densities (lpd) provided as part of the design drawings
6. Demand-Controlled Ventilation (DCV) systems in spaces larger than 5000 square feet
7. Submission of detailed control schematics for lighting and mechanical systems
8. Correct sizing of fan/pump motor horsepower

If you also are responsible for residential buildings, compliance with which energy code requirements do you think will be most difficult for contractors?

Q3. SMALL BUILDING MODEL INFORMATION

Table 18. Small Building Model Information

Parameter	Composite Building General Summary	
Location	Average across small sized buildings in all of NY	
Climate Zone	4A, 5A, 6A	
Building Use		
Occupancy Type		
Office	100%	
Geometry		
Shape	Rectangular with aspect ratio of 3.77:1	
Total Area (sqft)	9,478	
Number of Floors	1	
Floor-Ceiling Height (ft)	10	
	Composite Building	ASHRAE 90.1-2007 ECB
Envelope		
Roof U-value	0.031	0.048
Exterior Wall U-value	0.057	0.064
Window-Wall-Ratio	15.65%	15.65%
Window U-value	0.35	0.45
Window SHGC	0.44	0.40
Slab-on-Grade	0.54 F-factor	0.54 F-factor
Door U-value	Opaque 0.7 Glass 0.853; SHGC 0.5	Opaque 0.7 Glass 0.8; SHGC 0.4
Lighting		
Interior - Average LPD (W/sqft)	1.028	1.000
Exterior - kW	0.670	0.391
Heating Systems % of Building, Efficiency		
Furnace-Single Zone VAV	100% of building, 85.875 AFUE	100% of building, 80.0% efficient
Cooling Systems % of Building, Efficiency		
DX-Single Zone VAV	100% of building, 13.0 SEER	100% of building, 13.0 SEER for Systems < 65,000 btu/hour 11.0 EER for systems between 65,000 and 135,000 btu/hr 10.8 EER for all systems > 135,000 btu/hr
Fan Power		
DX-VAV AHU	0.820 W/cfm; VFD	0.8 W/cfm; Constant Volume
DX-VAV AHU		

% of Building Served	100%	100%
Type	Rooftop AHU	Rooftop AHU
Heat Recovery	yes (1/3 of units)	no
Economizer	yes (2/3 of units)	no
Demand Control Ventilation	no	no
Furnaces		
% of Building Served	100%	100%
Type	Gas-fired	Gas-fired
Thermal Efficiency	85.875 AFUE	80%
Heat Rejection System		
% of Building Served	100%	100%
Heat Rejection Type	Air Cooled (Rooftop AHUs)	Air Cooled (Rooftop AHUs)
DHW		
Type	Electric Instantaneous (5 gallon)	Electric Storage HW Tank (40 Gallons)
Thermal Efficiency	heater efficiency- 100%	heater efficiency- 87.7%

Q4. MEDIUM BUILDING MODEL INFORMATION

Table 19. Medium Building Model Information

Composite Building General Summary	
Average across medium sized buildings in all of NY	
5A (Albany)	
Mixed Use (Weighted average of profiles)	
29%	
71%	
L-shaped building	
38,700	
4	
10	
Composite Building	ASHRAE 90.1-2007 ECB
0.037	0.048
0.059	0.064
23.79%	23.79%
0.42	0.45
0.44	0.40
4' R-8 Horizontal Insulation F-Factor = 0.65	4' R-8 Horizontal Insulation F-Factor = 0.65
NONE	NONE
Opaque 0.221	Opaque 0.7
0.913	1.000
0.668	0.600
29% of building, 88.9% efficient	System 7: 29% of building, 80.0% efficient
39% of building, 85.6% efficient	System 1: 39% of building, 80.0% efficient
25% of building, 88.9% efficient	25% of building, 80.0% efficient
25% of building, 100.0% efficient	System 2: 25% of building, 2.87 COP
71% of building, 10.95 EER	71% of building, 9.82 EER
29% of building, 11.8 EER chiller	29% of building, 11.8 EER chiller
1.268 W/cfm; VFD with 0.4 min ratio	1.100 W/cfm; VFD with 0.4 min ratio
1.364 W/cfm	0.300 W/cfm
29%	29%
Central AHU	Central AHU
no	no

yes	yes
no	no
39%	NA (PTACs with Furnaces for Heating in composite; does not apply to ASHRAE baseline systems)
Gas-fired	
85.6%	
54%	54%
Primary Only Variable	Primary Only Variable
Gas-fired HW Boilers	Gas-fired HW Boilers
Forced Draft	Forced Draft
88.9%	80.0%
180F Supply 140F Return	180F Supply 140F Return
29%	29%
Primary Only Variable	Primary Only Variable
Air Cooled	Air Cooled
11.8 EER	10.6 EER
44F Supply 54 F Return	44F Supply 54 F Return
100%	100%
Air Cooled (PTACs and Chiller)	Air Cooled (PTACs and Chiller)
Variable Speed	Variable Speed
Variable Speed	Variable Speed
Gas Storage HW Tank (527 Gallons)	Gas Storage HW Tank (527 Gallons)
heater efficiency- 85%	heater efficiency- 80%

Q5. LARGE BUILDING MODEL INFORMATION

Table 20. Large Building Model Information

Composite Building General Summary		
New York, NY		
4A		
Mixed Use (Weighted average of profiles)		
42%		
6%		
26%		
26%		
Rectangular-2:1 ratio; Shorter side facing north		
131,026		
7		
12		
Composite Building	**ASHRAE 90.1-2007 ECB**	**ASHRAE 90.1-2004 ECB**
0.038	0.045 (Weighted avg. of 0.048, 0.065, 0.027)	0.057 (Weighted avg. of 0.063, 0.065, 0.027)
0.051	0.093 (Weighted avg. of 0.090, 0.113, 0.064)	0.102 (Weighted avg. of 0.104, 0.113, 0.064)
21%	0.21	21%
0.43	0.55	0.57
0.39	0.40	0.39
F-0.51 (8" slab; 2" rigid vertical insul-3ft)	F-0.54	F-0.73
C-1.47 (6" slab; no insul.)	C-1.190	C-1.140
C-1.14 (6" wall; no insul.)	C-1.190	C-1.140
0.562	U-0.700	U-0.700
0.78	1.08 (Weighted avg. of building types)	1.08 (Weighted avg. of building types)
43% 24% 21% 12%	50% - System 10: HW PTAC 25% - System 2: HW VAV reheat 25% - System 4: HW VAV reheat	50% - System 10: HW PTAC 25% - System 2: HW VAV reheat 25% - System 4: HW VAV reheat
27% 25% 25% 23%	50% - System 10: DX PTAC 25% - System 2: CHW VAV reheat 25% - System 4: DX VAV reheat	50% - System 10: DX PTAC 25% - System 2: CHW VAV reheat 25% - System 4: DX VAV reheat

0.75 W/cfm (0.0007 bhp/cfm); VFD	System 4: 0.60 W/cfm (0.0007 bhp/cfm); Inlet Vanes	System 4: 0.60 W/cfm (0.0007 bhp/cfm); Inlet Vanes
0.72 W/cfm (0.0007 bhp/cfm); VFD	System 2: 0.56 W/cfm (0.0007 bhp/cfm); VFD	System 2: 0.56 W/cfm (0.0007 bhp/cfm); VFD
Fan power in EER; Cycling	System 10: Fan power in EER; Cycling	System 10: Fan power in EER; Cycling
Fan Power in EER; Cycling	System 10: Fan power in EER; Cycling	System 10: Fan power in EER; Cycling
23%	23%	23%
Air Cooled DX (Assumed avg. size 10,500 Btu/h)	System 10	System 10
9.8 EER	10.3 EER	10.3 EER
27%	27%	27%
Air Cooled DX (Avg. Size 10,500 Btu/h)	System 10	System 10
10.4 EER	10.3 EER	10.3 EER
25%	25%	25%
Water Cooled DX (Avg. Size 250,000 Btu/h)	System 4	System 4
12.6 EER	10.8 EER/10.1 IPLV	10.8 EER/10.1 IPLV
Energy Wheel; 76% Effectiveness (80% OA)	Energy Wheel; 50% Effectiveness (80% OA)	Energy Wheel; 50% Effectiveness (80% OA)
Water-side Economizer	NR	NR
25%	25%	25%
Chilled Water	System 2	System 2
NA	NA	NA
Energy Wheel; 76% Effectiveness (20% OA)	NR	NR
Air Side Economizer; Dual Enthalpy Control	NR	NR
21%	NA (PTACs with Furnaces for Heating in composite; does not apply to ASHRAE baseline systems)	NA (PTACs with Furnaces for Heating in composite; does not apply to ASHRAE baseline systems)
Gas-fired		
81%		
79%	79%	79%
Primary Only Variable	Primary Only Variable	Primary Only Variable
Gas-fired HW Boilers	Gas-fired HW Boilers	Gas-fired HW Boilers
Non-Condensing (>0.3 MMBtu/h, <2.5 MMBtu/h)	Non-Condensing (>0.3 MMBtu/h, <2.5 MMBtu/h)	Non-Condensing (>0.3 MMBtu/h, <2.5 MMBtu/h)
24%	24%	24%
85% Et	80% Et	75% Et
Gas-fired HW Boilers	Gas-fired HW Boilers	Gas-fired HW Boilers

Condensing (>0.3 MMBtu/h, <2.5 MMBtu/h)	Non-Condensing (>0.3 MMBtu/h, <2.5 MMBtu/h)	Non-Condensing (>0.3 MMBtu/h, <2.5 MMBtu/h)
12%	12%	12%
94% Et	80% Et	75% Et
Gas-fired HW Boilers	Gas-fired HW Boilers	Gas-fired HW Boilers
Condensing (>2.5 MMBtu/h)	Non-Condensing (>2.5 MMBtu/h)	Non-Condensing (>2.5 MMBtu/h)
43%	43%	43%
95% Et	82% Ec	80% Ec
180/160 F	180/130 F	180/130 F
25%	25%	25%
Primary Constant/Variable Secondary	Primary Only Variable	Primary Only Variable
Air Cooled Screw (>300 tons,<600 tons)	Air Cooled Centrifugal	Air Cooled Centrifugal
COP 2.9	2.8 COP/3.05 IPLV	2.8 COP/3.05 IPLV
42/56 F	44/56 F	44/56 F
25%	25%	25%
Axial Fan; Variable Speed	Axial Fan; Two Speed	Axial Fan; Two Speed
44 gpm/hp	38.2 gpm/hp	38.2 gpm/hp
85/95 F	85/95 F	85/95 F
30 W/gpm; Variable Speed	30 W/gpm; Constant Speed	30 W/gpm; Constant Speed
26 W/gpm; Variable Speed	26 W/gpm; Constant Speed	26 W/gpm; Constant Speed
22 W/gpm; Variable Speed	22 W/gpm; Constant Speed	22 W/gpm; Constant Speed
15 W/gpm; Constant Speed	35 W/gpm; Variable Speed	35 W/gpm; Variable Speed
20 W/gpm; Variable Speed	NA	NA
26 W/gpm; Variable Speed	26 W/gpm; Constant Speed	26 W/gpm; Constant Speed
Gas Storage Water Heaters (>75,000 Btu/h)	Gas Storage Water Heaters (>75,000 Btu/h)	Gas Storage Water Heaters (>75,000 Btu/h)
60%	60%	60%
84% Et; 2,800 Btu/h SL	80% Et; 2,900 Btu/h SL	80% Et; 2,900 Btu/h SL
40%	40%	40%
96% Et; 1,800 Btu/h SL	80% Et; 1,900 Btu/h SL	80 Et; 1,900 Btu/h SL

Q6. COMMERCIAL MARKET ANALYSIS – NEW YORK STATE

Table 21. Commercial Market Analysis - New York State - Market Data

Market Data				
	sq ft	count	total value (x $1000)	total area (x1000)
Small	<25,000	3,063	$ 4,436,079	28,291
Medium	25k-60k	742	$ 4,142,726	28,819
Large	>60k	683	$ 23,580,530	123,108
		4,488	$ 32,159,335	180,218

Table 22. Commercial Market Analysis - New York State - Building Types, Value, and Square Footage

Building Type	Number of Projects	Value $1,000	Area 1,000 sq ft	Market Share (% sq ft)	Sample Distribution (% sq ft)
Commercial	***1,236***	***5,821,861***	***49,233***	***27%***	***10%***
Office and bank	482	3,176,609	23,927	13%	7%
Stores and rest	537	2,186,353	18,913	10%	3%
Warehouses	217	458,899	6,393	4%	
Dwelling	2,271	***13,320,937***	***95,412***	***53%***	***46%***
Apartments	2,067	11,160,964	79,674	44%	30%
Dormitories	56	826,671	4,225	2%	9%
Hotel/Motel	148	1,333,302	11,513	6%	7%
Institutional	***981***	***13,016,537***	***35,573***	***20%***	***44%***
Amusement, social, rec	134	1,062,265	3,118	2%	
Capitals/Court-houses/City Hall	29	269,972	817	0%	

Hospital/health	221	2,352,598	9,694	5%	5%
Houses of Worship	75	148,565	1,381	1%	
Laboratories	22	1,666,190	2,170	1%	3%
Libraries/Museums	36	301,445	794	0%	
Other Govt Bldgs	86	828,326	2,147	1%	17%
Other Religious Bldgs	9	8,831	86	0%	
Schools & Colleges	369	6,378,345	15,366	9%	19%
Total	***4,488***	***32,159,335***	***180,218***	***100%***	***100%***

Q7. COMPOSITE BUILDING DEVELOPMENT

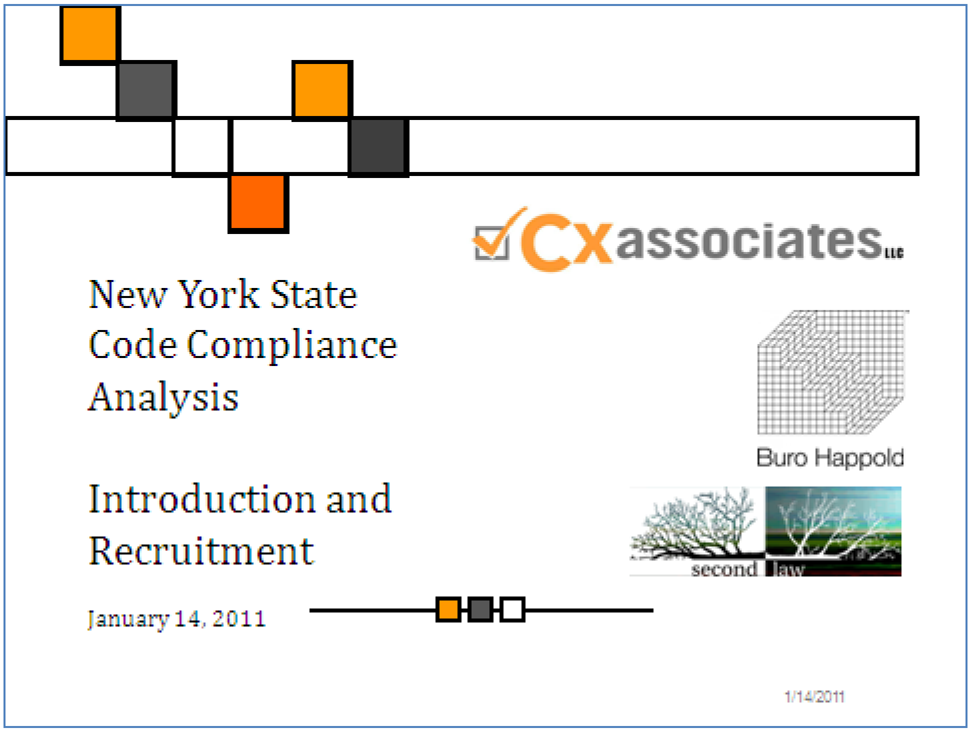
Table 23. [WHAT IS THE TITLE?]

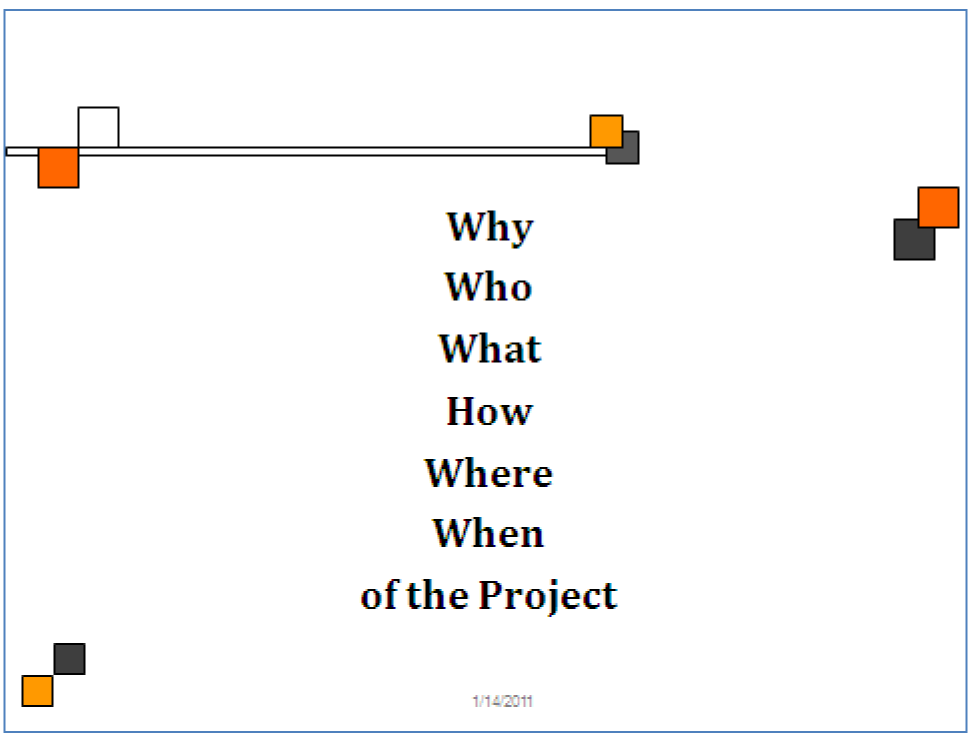
1. Average for all buildings = average for the buildings that make sense to include in the calculations. For instance, the Forestry building was too different in all respects and was not included in the small building composite at all.			
2. Weighted average = component / bldg size * composite building size			
Building Envelope and Size Inputs:			**Composite Building Development**
	TOTAL BUILDING FLOOR AREA		average of all buildings; could be deleting some parts of the building that don't fit the use of the rest of the building (i.e. Firestation only looked at the office portion of the building)
	FIRST FLOOR WALL PERIMETER		average of all buildings used in the floor area calculations.
		1/2 of wall perimeter	
		Calculated Area	
		Difference Between True and Calculated Areas	
		x	
		y	
		Aspect Ratio	
	FLOOR TO CEILING HEIGHT		average of all buildings in the sample.
	NUMBER OF FLOORS		average of all buildings in the sample.
	WINDOW TO WALL RATIO		weighted average of all buildings in sample
	GLASS		
		U-VALUE	average of all buildings in the sample.
		SHGC	average of all buildings in the sample.
		VISIBLE LIGHT TRANSMITTANCE	average of all buildings in the sample.
	WALL		average wall assembly U-value (based on cavity and continuous insulation, frame type and frame spacing) of all the buildings, weighted by floor area
	UNDERSLAB INSULATION R-VALUE		average of all buildings in the sample.
	FOOTING		
		INSULATION R-VALUE	average of all buildings in the sample.
		INSULATION LOCATION (INSIDE OR OUTSIDE OF FOOTING)	average of all buildings in the sample.
	GLASS DOOR		weighted average of all buildings in sample
		U-VALUE	weighted average of all buildings in sample
		SHGC	weighted average of all buildings in sample

VISIBLE LIGHT TRANSMITTANCE	weighted average of all buildings in sample
OPAQUE DOOR U-VALUE	average of all buildings, sf should be weighted per building area.
SKYLIGHT	
ROOF TO WALL RATIO	weighted average of all buildings in sample
U-VALUE	average of all buildings in the sample.
SHGC	average of all buildings in the sample.
VISIBLE LIGHT TRANSMITTANCE	average of all buildings in the sample.
ROOF INSULATION U-VALUE	average roof assembly U-value (based on cavity and continuous insulation, frame type and frame spacing) of all the buildings, weighted by roof area.
HVAC Inputs:	
Number of units:	sum of total units/sum of total sf * composite sf
for each piece of equipment:	
cooling mode:	
coil type (description)	Use judgement across all buildings
capacity	weighted average of all buildings in sample
EER or SEER (indicate which in the notes)	weighted average of all buildings in sample
supply air setpoint temperature	average of all buildings in sample
heating mode:	
coil type (description)	
capacity	weighted average of all buildings in sample
efficiency (indicate units in the notes)	average of all buildings in the sample.
supply air setpoint temperature	average of all buildings in the sample.
total supply air cfm	average of all buildings in the sample.
% outside air	average of all buildings in the sample.
supply air fan KW	weighted average of all buildings in the sample.
return air fan KW	weighted average of all buildings in the sample.
demand controlled ventilation provided?	average of all buildings in the sample.
economizer provided?	average of all buildings; assign to a proportional number of the units
heat recovery ventilation (indicate ERV, HRV or NONE)	average of all buildings; assign to a proportional number of the units
heat recovery ventilation total fan KW	average of all buildings in the sample.
fan control - indicate Variable or Constant Volume	average of all buildings in the sample.
if variable, indicate minimum flow ratio	average of all buildings in the sample.
thermostat:	
heating setpoint - occupied	average of all buildings in the sample.
heating setpoint - unoccupied	average of all buildings in the sample.
cooling setpoint - occupied	average of all buildings in the sample.
cooling setpoint - unoccupied	average of all buildings in the sample.

	ductwork	
	location (ie. in vented unconditioned attic)	average of all buildings; assign to a proportional number of the units
	ductwork insulation R-value	average of all buildings; assign to a proportional number of the units
	vestibule heating	average of all buildings that have vestibules
Domestic Hot Water		
	Hot water heating type (instantaneous, direct fired…)	make determination from sample as to what is average type
	Storage Tank	
	tank size (gallons)	average of buildings with this type of DHW
	tank insulation R-value	average of buildings with this type of DHW
	heater efficiency	average of buildings with this type of DHW
	hot water recirculation pump	average of buildings with this type of DHW
	GPM	average of buildings with this type of DHW
	KW	average of buildings with this type of DHW
Lighting:		
	Exterior Lighting	
	KW for building entrance lights	weighted average of all buildings in sample
	# of main building entrances	rounded weighted average of all buildings
	# of secondary building entrances	rounded weighted average of all buildings
	light control (eg photocell, timeclock, none)	percentage for all buildings; assign to a proportional number of the entrances
	Interior Lighting	
	for each space type (major space types such as office building, or retail building - don't break it down into private office vs open office):	
	area	average per space type for all buildings
	installed lighting watts	average per space type for all buildings
	% controlled by occupancy sensor	weighted average of all buildings (= sum of % * bldg size divided by sum of bldg sizes)
	% controlled by daylight	weighted average of all buildings (= sum of % * bldg size divided by sum of bldg sizes)
	LPD	watts/sf calculated from space type info above

Q8. COMMERCIAL STAFF TRAINING POWERPOINT





Why: New York State Code Compliance Analysis

Overall Purpose of Project:

Determine the current level of new construction code compliance and provide guidance to achieving 90% compliance by 2017.

The state's ARRA funding depends on this compliance.

Who: Our Team

VEIC holds contract with NYSERDA

Building Sampling & Surveys = Bob Wirstschafter

Residential Buildings = VEIC, EFG and CSG

Commercial Buildings = Cx Associates, Buro Happold and Second Law

1/14/2011

What: Overview of Our Responsibilities

- ✓ Recruit commercial sites and code officials
- ✓ Conduct on-site building inspection and plan review
- ✓ Perform building analysis for code compliance
- ✓ Complete DOE checklist for code compliance
- ✓ Develop 3 “typical” building models
- ✓ Conduct 3 modeling simulations per building size
- ✓ Write report with findings and recommendations

1/14/2011

What con’t: Final Report

- ✓ VEIC will write final report to NYSERDA

- ✓ Our Team will provide VEIC with:
  - findings of building performance
  - findings on barriers to compliance
  - suggestions to overcoming barriers
  - suggested roadmap to enable 90% compliance by 2017

1/14/2011

How: On-Site Data Gathering

- ✓ Conduct building plan review at code officials' office
- ✓ Conduct building construction review at building site
- ✓ Input site data in the "Survey Tool"
- ✓ Ensure DOE Checklist compliance is calculated in Survey Tool

1/14/2011

How: Data Analysis

- ✓ Ensure completion of DOE Checklist
- ✓ Buro Happold to develop 1 "typical" as-built large (complex) building comprised of findings from site work
- ✓ Second Law will develop the "typical" as-built models for small and medium sized buildings
- ✓ Model the typical buildings 3 ways (ASHRAE 2007, applicable code and average as-built)

1/14/2011

Where: New York State Counties

- ✓ Kings County (BH):
  - Brooklyn
- ✓ Westchester County (BH):
  - Yonkers
  - Mount Vernon
- ✓ Suffolk County (BH):
  - Hampton Bays
  - Southampton
  - Riverhead
- ✓ Suffolk County (BH):
  - Hampton Bays
  - Southampton
  - Riverhead
- ✓ Monroe County (BH):
  - Greece
  - Rochester
- ✓ Clinton County (Cx):
  - Plattsburgh
  - ?

1/14/2011

Schedule

Task	Estimated Due Date
	(Calendar Date)
Site Recruitment and Scheduling	Jan 17 – Jan 31
On-site Data Collection	Jan 19 – Feb 18
Electronic Data Entry/Quality Control of Data	Jan 19 – Feb 18
Data Analysis and Modeling	Feb 18 – Mar 25
Interim Report on Findings and Recommendations	Mar 31
Final Report Input and Review	Apr 14

1/14/2011

Appendix: The Obstacles

- **Obstacle #1 - the participants have:**
  - FEAR! (what are the ramifications of cooperating?)
  - No interest/incentive (what are the ramifications of not cooperating?)
  - No time
- **Obstacle #2 – the code officials have:**
  - FEAR! (what are the ramifications of cooperating?)
  - No interest/incentive (what are the ramifications of not cooperating?)
  - No time
- **Obstacle #3 – difficulty in obtaining information:**
  - Plans have insufficient information
  - Plans aren't available
  - Components are not visible when construction is complete

1/14/2011

Appendix: Solutions

Posturing to Building Owners/Managers:

- Present project as a state-wide anonymous analysis of the current energy efficiency of new construction
- The project is part a large study across the nation because states are required to do this in order to retain the ARRA funds they received
- All building information is kept confidential and is not part of any report
- **This is NOT an analysis of their particular building**
- **This is NOT an analysis if their building meets code**
- All the buildings get compiled together and an average building is modeled for energy efficiency
- We can walk around the building without them, we just need access, but not much of their time
- Dangerous conversation – use with caution: We can let them know how their building performs compared to code and how much money they are saving due to the efficiency upgrades (use this only if they seems interested in energy efficiency and you get the feeling the building is built better than code)

1/14/2011

Appendix: Solutions

- Posturing to Code Officials:
  - Present project as a state-wide anonymous analysis of the current energy efficiency of new construction
  - The project is part a large study across the nation because states are required to do this in order to retain the ARRA funds they received. The information will be used to assist code officials, architects, engineers, developers and others in meeting ARRA mandated code compliance targets for 2017.
  - All building information is kept confidential and is not part of any report
  - **This is NOT an analysis of any particular building**
  - **This is NOT an analysis if any particular building meets code**
  - All the buildings get compiled together and an average building is modeled for energy efficiency
  - We just need access to the plans in their office, but not much of their time (we can look at the plans in their office without them)
  - Give them the NYSERDA letter (even if you already sent it) and let them know they can call NYSERDA to ask more questions about the project or our firms.

1/14/2011

Appendix: Solutions

- Insufficient Information:
  - Ask code official if there are similar buildings by same builders/designers in their area
  - Ask code official what he/she knows about the building and the builders/designers that can help answer the Survey Tool questions
  - If the building is completely constructed, ask the code official what he/she saw of the construction and what was verified

1/14/2011

Last, but Not Least: Team Communication

- Due to the short time frame and the amount of obstacles we already anticipate, keeping the information flowing within our team is especially important
  - if you find something that works – share with us all!
  - if you have ideas for improvement – please share!
  - if you run into obstacles and dead ends, let Jeremy and Eveline know as soon as possible
- Jeremy and Eveline will have weekly meetings to manage the project. But if things can't wait, definitely let us know any time.
- Eveline will set up a Google docs Project Tracker that we will all be able to update with the progress of our work.
- We'll have another team meeting this month on the Tracker and the Survey Tool. We will also discuss the Outreach efforts.

1/14/2011

Q9. COMMERCIAL RECRUITMENT PLAN

New York Statewide Energy Code Compliance Assessment

Commercial Recruitment Plan

It is preferred that advanced notification, including but not limited to direct mail and email blasts, be sent to participants and code officials prior to commencement of outbound calling efforts. This approach improves the likelihood of participation. Included in this advance notification will be the contact information of Cx Associates. Interested participants may want to proactively contact or return calls to us.

Approximately 3 to 4 days after mailings have been sent, VEIC will begin outbound calling efforts to commercial businesses. Calling efforts will include no less than 5 outbound calling attempts, at varying times of the business day and varying days of the week, before eliminating a lead from the calling list. The sample plan consists of a combination of small, medium and large commercial buildings for each of the five counties throughout the state of New York. VEIC will continue calls until a minimum of 25 interested participants, divided in the proper size and location, have been solicited. At that time, this list of participants will be passed on to Cx Associates who will divide the site visits between themselves and their subcontractor, Buro Happold. Any additional interested participants will be retained on a ‘last minute availability list’ in the case of cancellations or “no-shows”.

When the sites have been successfully identified, Cx Associates and Buro Happold will contact the appropriate code official for the building plans of the participating businesses. Cx Associates and Buro Happold will schedule the building plan review (at either the code official’s office or the building site) and the building sitevisit so that the plan review is completed before the on-site visit.

In the event of a cancelation, Cx Associates or Buro Happold will attempt to reschedule the appointment for a later date and/or time that is convenient for the participant or the code official. If rescheduling is not possible, the engineer will attempt to replace this contact by contacting participants on the ‘last minute availability list’. In the event where an engineer arrives at the participant’s location and the participant is not available, the engineer will attempt to find another party at the company that could provide access to the building. If access to the building is denied, these appointments will be deemed ‘no-shows’ and the building will be assessed solely on the plan review at the code official’s office.

Letter to code officials:

Name

Date

Dear Code Official:

In order to comply with the American Recovery and Reinvestment Act (ARRA) funding building energy efficiency prerequisite, the New York State Energy Research and Development Authority (NYSERDA) is conducting an evaluation of the energy efficiency of new construction projects throughout New York State over the past three years. A few projects in your jurisdiction have been randomly selected for this evaluation, and we would greatly appreciate your support in this important study.

This is not an evaluation of individuals, buildings or firms. The information collected will be used solely to assess the current state of energy efficiency in the market, with project findings used only in summary data. Information gathered from these building will form a database of information to create an "average" building across the commercial sector. No persons, firms or specific buildings will be individually evaluated on code compliance. This evaluation is to support the design and construction industries' efforts in meeting the ARRA funding prerequisite that the State of New York meet energy efficiency requirements of new construction building practices by the year 2017. Building data will not be used to identify individual deficiencies to be corrected by the owner.

NYSERDA has contracted with Cx Associates and Buro Happold, two independent research firms, to complete this evaluation. The evaluation work will include a one time, on–site inspection of the selected buildings and a review of the plans submitted to your office. An engineer from Cx Associates or Buro Happold will be contacting you shortly to schedule an office visit at your convenience.

NYSERDA, Cx Associates and Buro Happold will keep your project information private. Again, this is not an evaluation of individuals, buildings or firms. The information collected will be used only in summary of state-wide data intended to improve the state's support of New York State building codes, standards and construction.

Should you have any questions about this study or would like to schedule this office visit, please contact Eveline Killian of Cx Associates at 1-802-861-2715 x-15 or Eveline@cx-assoc.com. If you prefer to speak with a NYSERDA representative, feel free to contact Marilyn Kaplan at 518-862-1090 x3298 or mek@nyserda.org.

Thank you, in advance, for your interest and cooperation.

Sincerely,

Department of State – Energy Services

Letter to building owners:

<Month, Day, Year>

<Participant Name and Address>

Dear <Name of Participant>:

The New York State Energy Research and Development Authority (NYSERDA) is conducting an evaluation of the energy efficiency of new construction projects throughout New York State over the past three years. The <Project Name> project for <"your company"> has been randomly selected for this evaluation, and we would greatly appreciate your participation in this important study. NYSERDA is offering a $150.00 for companies that participate in this research.

The study is being conducted to fulfill the American Recovery and Reinvestment Act (ARRA) funding prerequisite that the State of New York must meet energy efficiency requirements of new construction building practices by the year 2017. NYSERDA is gathering information on the current levels of energy efficiency to support the design and construction industries' efforts in meeting this future milestone.

NYSERDA has contracted with Cx Associates, an independent research firm, to complete this evaluation. The evaluation work will include one time, on–site inspections of the selected buildings and interviews with design firms practicing in New York State. An engineer from Cx Associates will be contacting you shortly to schedule a site visit at your convenience.

NYSERDA and Cx Associates will keep your project information private. *We are not evaluating individuals, buildings or firms.* The information collected will be used solely to assess the current state of energy efficiency in the market, with project findings used only in summary data.

Should you have any questions about this study or would like to schedule this site visit, please contact Eveline Killian of Cx Associates at 1-802-861-2715 x-15 or Eveline@cx-assoc.com. If you prefer to speak with a NYSERDA representative, feel free to contact me at 518-862-1090 x3298 or mek@nyserda.org.

We look forward to working with you on this important research effort. Thank you, in advance, for your interest and cooperation.

Sincerely,

Marilyn Kaplan

NYSERDA Project Manager

Telephone Recruitment Language

Hello, my name is _____________________ and I'm calling from ___________ on behalf of the New York State Energy Research and Development Authority (NYSERDA).

Our firm is conducting research for NYSERDA on the efficiency levels of new construction and to improve services to the new construction market. The [Project Name] project for [Owner Name] is one of a small group of projects that has been selected for this evaluation and we would greatly appreciate your participation in this important study. NYSERDA sent you a letter recently telling you that we would be calling and explaining the research we are doing.

As an independent research firm, __________ will not report your responses in any way that would reveal your identity or the identity of your organization. The research will be used solely to assess the current state of the market in general and will in no way be used to evaluate the practices of any individual firms in the state. The project findings will use only summary data and will not identify individual projects or firms

I have you listed as the contact for the new construction project at **[Project name and location].**
Are you the most appropriate person to talk to about this project?

YES ➔ proceed

NO ➔ "May I ask who would be the best person to talk to?" **[Obtain title, name, phone number, email address]**

____

Title Name Phone Email

DOES NOT REMEMBER PROJECT ➔ "Is there someone else there who may be able to provide information regarding this project?" **[Obtain title, name, phone number, email address]**

____

Title Name Phone Email

Has this building been sold, or is it tenant occupied?

YES ➔ [Obtain information on the appropriate contacts and constraints. For buildings that have been sold we have to talk with the new owner to obtain access. For tenanted buildings there are a variety of conditions with which the review engineers will have to contend.]

[Obtain title, name, phone number, email address for additional contacts]

____

Title | Name | Phone | Email

[Obtain title, name, phone number, email address for additional contacts]

____

Title | Name | Phone | Email

[Obtain title, name, phone number, email address for additional contacts]

____

Title | Name | Phone | Email

A sitevisit will take approximately 3-4 hours in which we would like access to the mechanical and electrical rooms, but which otherwise can be unsupervised if it is your preference. Can we schedule a time when we may come out and walk through your building?

YES ➔ [Date:_____________________ Time: ____________________]

NO ➔ [Next Steps:____]

Who is the person we should meet at the site?

Name: ____

Email: ____

Telephone: _______________________________________

Thank you very much for your time in talking with me today. We look forward to meeting you/your staff and we thank you for your participation in this study.

[If they express hesitation, use an appropriate combination of the following.]

Security. All information obtained in this evaluation will be strictly confidential.

Sales concern. I am not selling anything. I simply want to understand the energy efficiency levels of your building.

Contact. If you would like to talk with someone from NYSERDA about this effort, you can call NYSERDA Project Manager: Marilyn Kaplan 518-862-1090 x

Q10. COMMERCIAL PHONE RECRUITMENT SCRIPT

Interviewer Name and Firm:

Participant Name:

Firm Name:

Outreach Date:

Phone Number:

Project Name:

Project Number:

Hello, my name is ____________________ and I'm calling from __________ on behalf of the New York State Energy Research and Development Authority (NYSERDA).

Our firm is conducting research for NYSERDA on the efficiency levels of new construction and to improve services to the new construction market. The [Project Name] project for [Owner Name] is one of a small group of projects that has been selected for this evaluation and we would greatly appreciate your participation in this important study. NYSERDA sent you a letter recently telling you that we would be calling and explaining the research we are doing.

As an independent research firm, __________ will not report your responses in any way that would reveal your identity or the identity of your organization. The research will be used solely to assess the current state of the market in general and will in no way be used to evaluate the practices of any individual firms in the state. The project findings will use only summary data and will not identify individual projects or firms

I have you listed as the contact for the new construction project at **[Project name and location].**

1) Are you the most appropriate person to talk to about this project?

YES ➔ proceed

NO ➔ "May I ask who would be the best person to talk to?" **[Obtain title, name, phone number, email address]**

____

Title *Name* *Phone* *Email*

DOES NOT REMEMBER PROJECT ➔ "Is there someone else there who may be able to provide information regarding this project?" **[Obtain title, name, phone number, email address]**

____

Title *Name* *Phone* *Email*

Has this building been sold, or is it tenant occupied?

YES ➔ **[Obtain information on the appropriate contacts and constraints. For buildings that have been sold we have to talk with the new owner to obtain access. For tenanted buildings there are a variety of conditions with which the review engineers will have to contend.]**

[Obtain title, name, phone number, email address for additional contacts]

____

Title *Name* *Phone* *Email*

[Obtain title, name, phone number, email address for additional contacts]

____

Title *Name* *Phone* *Email*

[Obtain title, name, phone number, email address for additional contacts]

____

Title *Name* *Phone* *Email*

A sitevisit will take approximately 3-4 hours in which we would like access to the mechanical and electrical rooms, but which otherwise can be unsupervised if it is your preference. Can we schedule a time when we may come out and walk through your building?

YES ➔ **[Date:_____________________ Time: ____________________]**

NO ➔ **[Next Steps:____]**

Who is the person we should meet at the site?

Name: ____

Email: ____

Telephone: ______________________________________

Thank you very much for your time in talking with me today. We look forward to meeting you/your staff and we thank you for your participation in this study.

[If they express hesitation, use an appropriate combination of the following.]

Security. All information obtained in this evaluation will be strictly confidential.

Sales concern. I am not selling anything. I simply want to understand the energy efficiency levels of your building.

Contact. If you would like to talk with someone from NYSERDA about this effort, you can call

NYSERDA Project Manager: Marilyn Kaplan 518-862-1090 x

[Please document contacts and save hard and/or electronic copies of outreach results. Log in contacts database as appropriate.]

Q88

Q11. COMMERCIAL CHECKLIST ASHRAE 90.1-2007

Table 24. Commercial Building Data Collection Checklist

Commercial Building Data Collection Checklist

ANSI/ASHRAE/IESNA Standard 90.1-2007

Date:______________ Name of Evaluator(s): ____

Building Name & Address:____ Conditioned Floor Area:_____________ft²

Building Contact: Name:__________________________ Phone:____________ Email:__________________________

Compliance Approach: ☐ Prescriptive ☐ Trade-Off (Section 5.6) ☐ Performance (ECB Section 11)

State:______________ Jurisdiction: ____

Building Use: ☐ Office ☐ Retail ☐ Storage ☐ Education ☐ Lodging ☐ Dining ☐ Public ☐ Health ☐ Residential ☐ Other

Project Type: ☐ New Construction ☐ Addition ☐ Renovation Valuation (If Renovation): $_______________

Item Number	Plan Review	Complies			Comments/Notes/Findings
		Y	N	N/A	
PR1 [4.2.2][1]	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.	☐	☐	☐	
PR2 [4.2.2][1]	Plans and/or specifications 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.	☐	☐	☐	
PR3 [4.2.2][1]	Plans and/or specifications 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.	☐	☐	☐	
PR4 [4.2.2][1]	Plans and/or specifications 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.	☐	☐	☐	
PR5 [6.4.2][1]	HVAC load calculations submitted.	☐	☐	☐	
PR6 [7.4.01][1]	Service water heating load calculations submitted.	☐	☐	☐	
PR7 [6.7.2.4][1]	Detailed instructions for HVAC systems commissioning included on the plans or specifications.	☐	☐	☐	
PR8 [6.7.2.1][1]	Construction documents require HVAC "as-built" drawings submitted within 90 days of system acceptance.	☐	☐	☐	
PR9 [8.4.1.1, 8.4.1.2][1]	Feeder and branch circuit load and sizing calculations provided that allow verification of voltage drop.	☐	☐	☐	
PR10 [8.7.1 8.7.2][1]	Construction documents require as-built drawings for electric power systems and O&M manual for electrical power systems and equipment.	☐	☐	☐	

Additional Comments: ____

Page 1

General building information only required if different than above

Date:____________ Name of Evaluator(s): ____

Building Name & Address:____ Conditioned Floor Area:____________ ft^2

Building Contact: Name:________________________ Phone:____________ Email:________________________

Compliance Approach: ☐ Prescriptive ☐ Trade-Off (Section 5.6) ☐ Performance (ECB Section 11)

Item Number	Footing / Foundation Inspection	Verified Value	Complies Y	Complies N	Complies N/A	Comments/Notes/Findings
FO1 [5.8.1.7][1]	Exterior insulation protected against damage, sunlight, moisture, wind, landscaping and equipment maintenance activities.		☐	☐	☐	
FO2 [5.8.1.7.3][1]	When contacting ground insulation has ≤0.3% water absorption (ASTM C272).		☐	☐	☐	
FO3 [6.3.2, 6.4.4.1 6.4.4.2][1]	Piping, ducts and plenum are insulated and sealed when installed in or under a slab.	R-	☐	☐	☐	
FO4 [6.5.8.2, 7.4.3][1]	Any SWH piping in or under slab is insulated.	R-	☐	☐	☐	
FO5 [5.5.3.3, 5.8.1.2][2]	Below-grade wall insulation R-value. Installed per manufacturer's instructions.	R-	☐	☐	☐	
FO6 [5.5.3.5, 5.8.1.2][2]	Slab edge insulation R-value, depth/length. Installed per manufacturer's instructions.	R- ft -	☐	☐	☐	
FO7 [6.4.3.8][3]	Freeze protection and snow/ice melting system sensors for future connection to controls.		☐	☐	☐	

Additional Comments: ____

General building information only required if different than above

Date:____________ Name of Evaluator(s): ____________________________________

Building Name & Address:______________________________ Conditioned Floor Area:____________ ft^2

Building Contact: Name:__________________ Phone:__________ Email:__________________

Compliance Approach: ☐ Prescriptive ☐ Trade-Off (Section 5.6) ☐ Performance (ECB Section 11)

Item Number	Framing / Rough-In Inspection	Verified Value	Complies Y	N	N/A	Comments/Notes/Findings
FR1 [5.8.2.2][1]	Fenestration products are certified as to performance labels or certificates provided.		☐	☐	☐	
FR2 [5.5.3.1, 5.8.1.2][1]	Roof insulation R-value provided. Installed per manufacturer's instructions.	R-	☐	☐	☐	
FR3 [5.5.4.2.1, [5.5.4.2.2][1]	Performance compliance approach submitted for vertical fenestration area >40% or skylight area >5%.		☐	☐	☐	
FR4 [5.5.4.3a][1]	Vertical fenestration U-Factor.	U-	☐	☐	☐	
FR5 [5.5.4.3b][1]	Skylight fenestration U-Factor.	U-	☐	☐	☐	
FR6 [5.5.4.4.1][1]	Vertical fenestration SHGC value.	SHGC -	☐	☐	☐	
FR7 [5.5.4.4.2][1]	Skylight SHGC value.	SHGC -	☐	☐	☐	
FR8 [5.8.2.1][2]	Fenestration products rated in accordance with NFRC.		☐	☐	☐	
FR9 [5.8.1.8][3]	Roof insulation not installed on a suspended ceiling with removable ceiling panels.		☐	☐	☐	
FR10 [5.4.3.2][3]	Fenestration and doors meet maximum air leakage requirements.		☐	☐	☐	
FR11 [5.4.3.3][3]	Loading dock weatherseals installed on loading dock doors.		☐	☐	☐	
FR12 [5.4.3.4][3]	Vestibules installed per approved plans.		☐	☐	☐	

Additional Comments: ____

General building information only required if different than above

Date:__________ Name of Evaluator(s): __________

Building Name & Address:__________ Conditioned Floor Area:__________ ft^2

Building Contact: Name:__________ Phone:__________ Email:__________

Compliance Approach: ☐ Prescriptive ☐ Trade-Off (Section 5.6) ☐ Performance (ECB Section 11)

Item Number	Plumbing Rough-In Inspection	Complies			Comments/Notes/Findings
		Y	N	N/A	
PL1 [7.4.4.4][1]	Pump controls installed to limit operation of recirculating pumps	☐	☐	☐	
PL2 [7.4.4.2][1]	Automatic time switches installed to automatically switch off the recirculating hot-water system or heat trace.				
PL3 [7.4.6][3]	Heat traps installed on non-circulating storage water tanks	☐	☐	☐	

Additional Comments: __________

General building information only required if different than above

Date:____________ Name of Evaluator(s): ______________________________

Building Name & Address:______________________________ Conditioned Floor Area:____________ ft^2

Building Contact: Name:____________________ Phone:____________ Email:____________________

Compliance Approach: ☐ Prescriptive ☐ ENVSTD (Section 5.6) ☐ Building Performance (ECB Section 11)

Item Number	Mechanical Rough-In Inspection	Verified Value	Complies Y	N	N/A	Comments/Notes/Findings
ME1 [6.5.6.1][1]	Exhaust air energy recovery on systems ≥ 5,000 cfm and 70% of design supply outside air.		☐	☐	☐	
ME2 [6.5.7.2][1] C	Fume hoods exhaust systems ≥15,000 cfm have VAV hood exhaust and supply systems, direct make-up air or heat recovery.		☐	☐	☐	
ME3 [6.5.9][1] C	Hot gas bypass limited to: ≤24 kBtu/h – 50% >24 kBtu/h – 25%		☐	☐	☐	
ME4 [6.4.3.9][1]	Demand control ventilation provided for spaces >500 ft^2, >40 people/1000 ft^2 occupant density and served by systems with air side economizer, auto modulating outside air damper control or design airflow >3,000 cfm.		☐	☐	☐	
ME5 [6.5.1, 6.5.1.1.1, 6.5.1.1.2, 6.5.1.1.3, 6.5.1.3][1]	Air economizers provided where required, meet the requirements for design capacity, control signal, and high-limit shut-off and integrated economizer control.		☐	☐	☐	
ME6 [6.5.1.1.5][1]	Means provided to relieve excess outside air.		☐	☐	☐	
ME7 [6.4.4.1.1][1]	Insulation exposed to weather to be protected from damage. Insulation outside of the conditioned space and associated with cooling systems is vapor retardant.		☐	☐	☐	
ME8 [6.5.1.2, 6.5.1.2.1, 6.5.1.2.2, 6.5.1.3][1] C	Water economizers provided where required, meet the requirements for design capacity, maximum pressure drop and integrated economizer control and heating system impact.		☐	☐	☐	
ME9 [6.5.1.4][1]	Economizer operation will not increase heating energy use during normal operation.		☐	☐	☐	
ME10 [7.4.2][2] C	Service water heating equipment meets efficiency requirements.		☐	☐	☐	
ME11 [7.5.1][2] C	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.		☐	☐	☐	
ME12 [7.5.2][2] C	Service water heating equipment used for space heating complies with the service water heating equipment requirements.		☐	☐	☐	
ME13 [6.4.1.4][2]	HVAC equipment efficiency verified.	Eff -	☐	☐	☐	

Item Number	Mechanical Rough-In Inspection	Verified Value	Complies Y	N	N/A	Comments/Notes/Findings
ME14 [6.4.1.5][2]	Non-NAECA HVAC equipment labeled as meeting 90.1.		☐	☐	☐	
ME15 [6.4.4.1.2][2]	HVAC ducts and plenums insulated.	R-	☐	☐	☐	
ME16 [6.4.4.1.3][2]	HVAC piping insulated.	R-	☐	☐	☐	
ME17 [6.4.4.2.1][2]	Ducts and plenums sealed based on static pressure and location.		☐	☐	☐	
ME18 [6.5.1.1.4][2]	Return air and outdoor air dampers meet minimum air leakage requirements.		☐	☐	☐	
ME19 [6.5.2.2.3][2] C	Hydronic heat pump systems connected to a common water loop meet heat rejection and heat addition requirements.		☐	☐	☐	
ME20 [6.5.7.1][2]	Kitchen hoods >5K cfm have make up air ≥50% of exhaust air volume.		☐	☐	☐	
ME21 [6.5.3.2.1][2] C	VAV fan motors ≥10 hp to be driven by mechanical or electrical variable speed drive, or have a vane-axial fan with variable pitch blades, or have controls or devices to limit fan motor demand to ≤30% of design wattage at 50% design air volume at static pressure of 1/3 total rated static pressure of the fan.	*Circle One:* VSD Vane axial fan Other	☐	☐	☐	
ME22 [6.5.3.2.2][2] C	VAV fans have static pressure sensors positioned so setpoint ≤1/3 total design pressure.		☐	☐	☐	
ME23 [6.5.3.2.3][2] C	Reset static pressure setpoint for DDC controlled VAV boxes reporting to central controller based on the zones requiring the most pressure.		☐	☐	☐	
ME24 [6.5.3.1.2][2]	HVAC fan motors not larger than the first available motor size greater than the bhp.	bhp -	☐	☐	☐	
ME25 [6.4.3.4.1][3]	Stair and elevator shaft vents have motorized dampers that automatically close.		☐	☐	☐	
ME26 [6.4.3.4.5][3] C	Ventilation fans >0.75 hp have automatic controls to shut off fan when not required.		☐	☐	☐	
ME27 [6.4.3.4.2, 6.4.3.4.3, 6.4.3.4.4][3]	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.		☐	☐	☐	
ME28 [6.4.1.5.2][3]	PTAC and PTHP with sleeves 16 in by 42 in. labeled for replacement only.		☐	☐	☐	
ME29 [6.4.4.2.2][3] C	Ductwork operating >3 in. water column requires air leakage testing.		☐	☐	☐	
ME30 [6.5.2.1][3]	Zone controls can limit simultaneous heating and cooling and sequence heating and cooling to each zone.		☐	☐	☐	
ME31 [6.5.2.4][3] C	Water economizer specified on hydronic cooling and humidification systems designed to maintain inside humidity at > 35 ºF dewpoint if an economizer is required.		☐	☐	☐	
ME32 [6.5.2.3][3]	Dehumidification controls provided to prevent reheating, recooling, mixing of hot and cold airstreams or concurrent heating and cooling		☐	☐	☐	

Item Number	Mechanical Rough-In Inspection	Verified Value	Complies			Comments/Notes/Findings
			Y	N	N/A	
C	of the same airstream.					
ME33 [6.5.8.1] [3]	Unenclosed spaces that are heated use only radiant heat.		☐	☐	☐	
ME34 [6.5.4.1] [3] C	HVAC pumping systems >10 hp designed for variable fluid flow.		☐	☐	☐	
ME35 [6.5.4.2] [3] C	Reduce flow in pumping systems >10 hp. to multiple chillers or boilers when others are shut down.		☐	☐	☐	
ME36 [6.5.4.3] [3] C	Temperature reset by representative building loads in pumping systems >10 hp for chiller and boiler systems > 300,000 Btu/h.		☐	☐	☐	
ME37 [6.5.4.4] [3] C	Two-position automatic valve interlocked to shut off water flow when hydronic heat pump with pumping system >10 hp is off.		☐	☐	☐	
ME38 [6.5.5.2] [3] C	Fan systems with motors ≥7.5 hp associated with heat rejection equipment to have capability to operate at 2/3 of full-speed and auto speed controls to control the leaving fluid temp or condensing temp/pressure of heat rejection device.		☐	☐	☐	
ME39 [7.4.4.1] [3] C	Temperature controls installed on service water heating systems (≤120 °F to max temp for intended use).		☐	☐	☐	
ME40 [6.5.6.2, 6.5.6.2.1, 6.5.6.2.2] [3] C	Condenser heat recovery system that can heat water to 85 °F or provide 60% of peak heat rejection is installed for preheating of service hot water in 24/7 facility, water cooled systems reject >6 MMBtu, SHW load ≥1 MMBtu.		☐	☐	☐	

Additional Comments: ______________________________

General building information only required if different than above

Date:_____________ Name of Evaluator(s): ____

Building Name & Address:____ Conditioned Floor Area:____________ ft^2

Building Contact: Name:______________________ Phone:__________ Email:______________________

Compliance Approach: ☐ Prescriptive ☐ Trade-Off (Section 5.6) ☐ Performance (ECB Section 11)

Item Number	Rough-In Electrical Inspection	Complies			Comments/Notes/Findings
		Y	N	N/A	
EL1 [9.4.1.4] [1]	Verify separate lighting control devices for specific uses installed per approved lighting plans.	☐	☐	☐	
EL2 [9.4.3] [1]	Exit signs do not exceed 5 watts per face.	☐	☐	☐	
EL3 [9.4.4] [1]	Exterior ground lighting over 100 W provides >60 lm/W unless on motion sensor or fixture is exempt from scope of code or from external LPD.	☐	☐	☐	
EL4 [9.6.2] [1]	Additional interior lighting power allowed for special functions per the approved lighting plans and is automatically controlled and separated from general lighting.	☐	☐	☐	
EL5 [8.4.1.1] [2]	Feeder connectors sized in accordance with approved plans.	☐	☐	☐	
EL6 [8.4.1.2] [2]	Branch circuits sized for maximum drop of 3%.	☐	☐	☐	
EL7 [9.4.1.1] [2]	Automatic lighting control to shut off all building lighting installed in buildings >5,000 ft^2.	☐	☐	☐	
EL8 [9.4.1.2] [2]	Independent lighting control installed per approved lighting plans and all manual control readily accessible and visible to occupants.	☐	☐	☐	
EL9 [9.4.1.3] [2]	Automatic lighting controls for exterior lighting installed.	☐	☐	☐	
EL10 [10.4.1] [2]	Electric motors meet requirements where applicable.	☐	☐	☐	
EL11 [9.4.2] [3]	Ballasted one and three lamp fixtures with >30 W/lamp have two lamp tandem wired ballasts when $\geq$2 fixtures in same space on same control.	☐	☐	☐	

Additional Comments: ____

General building information only required if different than above

Date:_____________ Name of Evaluator(s): ______________________________

Building Name & Address:______________________________ Conditioned Floor Area:____________ ft^2

Building Contact: Name:______________________ Phone:____________ Email:______________________

Compliance Approach: ☐ Prescriptive ☐ Trade-Off (Section 5.6) ☐ Performance (ECB Section 11)

Item Number	Insulation Inspection	Verified Value	Complies			Comments/Notes/Findings
			Y	N	N/A	
IN1 [5.5.3.1] [1]	Roof insulation R-value. Installed per manufacturer's instructions. Blown or poured loose-fill insulation is installed only where the roof slope is ≤3 in 12.	R-	☐	☐	☐	
IN3 [5.5.3.2] [1]	Above-grade wall insulation R-value. Installed per manufacturer's instructions.	R-	☐	☐	☐	
IN12 [5.4.3.1] [1]	All sources of air leakage in the building thermal envelope are sealed, caulked, gasketed or weather stripped to minimize air leakage.		☐	☐	☐	
IN4 [5.8.1.1] [2]	Building envelope insulation is labeled with R-value or insulation certificate providing R-value and other relevant data.		☐	☐	☐	
IN5 [5.8.1.4] [2]	Eaves are baffled to deflect air to above the insulation.		☐	☐	☐	
IN6 [5.8.1.5] [2]	Insulation is installed in substantial contact with the inside surface separating conditioned space from unconditional space.		☐	☐	☐	
IN7 [5.8.1.6] [2]	Recessed equipment installed in building envelope assemblies does not compress the adjacent insulation.		☐	☐	☐	
IN8 [5.8.1.7] [2]	Exterior insulation is protected from damage with a protective material.		☐	☐	☐	
IN9 [5.8.1.7.1] [2]	Foundation vents do not interfere with insulation.		☐	☐	☐	
IN10 [5.8.1.7.2] [2]	Insulation in contact with the ground has ≤0.3% water absorption rate per ASTM C272.		☐	☐	☐	
IN11 [5.8.1.7.3] [2]	Attics and mechanical rooms have insulation protected where adjacent to attic or equipment access.		☐	☐	☐	
IN13 [5.5.3.4] [2]	Floor insulation R-value. Installed per manufacturer's instructions.	R-	☐	☐	☐	
IN2 [5.5.3.1] [3]	Skylight curbs insulated to the level of roofs with insulation above deck or R-5.	R-	☐	☐	☐	
IN14 [5.5.3.1.1] [3]	High-albedo roofs meet solar reflectance of 0.70 and thermal remittance of 0.75 or SRI of 82.	SR - SRI -	☐	☐	☐	
IN15 [5.8.1.8] [3]	Roof Insulation not installed on suspended ceiling with removable panels.		☐	☐	☐	

Additional Comments: ______________________________

General building information only required if different than above

Date:____________ Name of Evaluator(s): ____

Building Name & Address:_____________________________________ Conditioned Floor Area:_____________ft^2

Building Contact: Name:________________________ Phone:____________ Email:____________________________

Compliance Approach: ☐ Prescriptive ☐ Trade-Off (Section 5.6) ☐ Performance (ECB Section 11)

Item Number	Final Inspection	Complies			Comments/Notes/Findings
		Y	N	N/A	
FI1 [6.7.2.3] [1] C	An air and/or hydronic system balancing report is provided for HVAC systems serving zones >5,000 ft^2 of conditioned area.	☐	☐	☐	
FI2 [6.7.2.4] [1] C	Verify HVAC control systems have been tested to ensure proper operation, calibration and adjustment of controls.	☐	☐	☐	
FI3 [9.1.3] [1]	Installed lamps and fixtures are consistent with what is shown on the approved lighting plans.	☐	☐	☐	
FI4 [5.4.3.3] [1]	Weatherseals installed on all loading dock cargo doors in Climate Zones 4-8.	☐	☐	☐	
FI5 [5.8.2.3, 5.5.3.6] [2]	U-factor and air leakage of opaque doors associated with the building thermal envelope meets requirements.	☐	☐	☐	
FI6 [6.4.3.1.1] [2]	Heating and cooling to each zone is controlled by a thermostat control.	☐	☐	☐	
FI7 [6.4.3.1.2, 6.4.3.2, 6.4.3.3, 6.4.3.3.1, 6.4.3.3.2] [2]	Temperature controls have the following features: dead band controls, setpoint overlap restrictions, off-hour controls, automatic shutdown, setback controls.	☐	☐	☐	
FI8 [6.4.3.3.3] [2]	Systems with air capacity >10,000 cfm include optimum start controls.	☐	☐	☐	
FI9 [7.4.5.2] [2] C	Pool covers are provided for heated pools and pools heated to >90°F have a cover ≥R-12.	☐	☐	☐	
FI10 [6.4.3.5] [3]	Heat pump controls prevent supplemental electric resistance heat from coming on when not needed.	☐	☐	☐	
FI11 [6.4.3.7] [3] C	When humidification and dehumidification is provided to a zone simultaneous operation is not possible.	☐	☐	☐	
FI12 [7.4.4.3] [3]	Public lavatory faucet water temperature not greater than 110°F.	☐	☐	☐	
FI13 [7.4.4.4] [3]	Controls are installed that limit the operation of a recirculation pump installed to maintain temperature of a storage tank.	☐	☐	☐	
FI14 [7.4.5.1] [3] C	Pool heaters are equipped with on/off switch and no continuous burning pilot light	☐	☐	☐	
FI15 [7.4.5.3] [3] C	Time switches are installed on all pool heaters and pumps.	☐	☐	☐	

Additional Comments: ____

Key: [1] – Tier One [2] – Tier Two [3] – Tier Three C – Complex

APPENDIX R: RECOMMENDATION FOR ENHANCING RESCHECK/COMCHECK TO COMPUTE 90% COMPLIANCE SCORE

Currently, when compliance documentation is filed for residential buildings, the most common form is the REScheck report. On the commercial side, COMcheck is required prior to obtaining a building permit. REScheck and COMcheck are widely used and provide a common user-friendly interface to demonstrate code compliance. These tools, however, do not quantify all aspects of the code and are unable to produce an overall building compliance score to demonstrate 90% as required by ARRA. PNNL created the residential and commercial checklists to provide the 90% scoring capability. These checklists, as found during the on-site visits conducted for this report, are problematic when using during a post-construction study. Additionally, they introduce not only a new concept of calculating code compliance, but introduce a new compliance tool as well. The limitations of REScheck and COMcheck, as well as the issues with introducing a new tool to the code compliance community can be overcome by combining the functionality of the two tools into enhanced REScheck and COMcheck tools.

The VEIC Team recommends the current REScheck and COMcheck tools be enhanced to enable a Certified Energy Inspector (CEI), as described in the Recommendations Section to verify code compliance during each phase of the new construction process. The current REScheck and COMcheck tools would need to be modified considerably to enable compliance scoring per the new BECP Protocol, but would provide the advantage of being a single compliance tool that is already familiar to the building construction community. The following section illustrates how the current REScheck tool might be modified to enable 90% compliance scoring per the ARRA requirements as well as enhance compliance enforcement by inserting a third party CEI into the compliance verification process.

Conceptually, REScheck would be modified to perform the same calculations as the PNNL checklists do, behind the scenes. In some cases new input fields would need to be created, mostly in the form of checkbox style "yes or no" inputs, to enable quantification of the basic (or mandatory) requirements of the code that are currently only printed in a REScheck compliance checklist report. While the basic code requirement checklists should be checked and signed off on by the builder, the code office visits found this is often not the case but more importantly, they are not currently quantified in any way. Additional inputs will need to be created to assess code requirements that are currently not captured at all by REScheck, such as insulation installation quality, HVAC sizing requirements, and other less direct (Tier 2 or 3) energy impact requirements.

The PNNL checklists are divided into the following five sections to mirror the phases of construction in addition to plan review:

Pre-inspection/Plan review

Foundation in
spection
Framing/Rough in inspection
Insulation Inspection
Final Inspection

As described in the Recommendations Section, REScheck, primarily in its current form, would be completed, or signed off on, by the CEI during the design/construction permit phase and would fulfill the requirements of the Pre-inspection/Plan review portion of the PNNL checklists. A checklist item for HVAC sizing would need to be included during this phase. A Plan Review report should generated, similar to the current REScheck Compliance Certificate, that can be signed off on by the builder and CEI.

After the Plan Review phase, the 'Construction Phase' of REScheck would be turned on. In this phase, the additional code requirements found in the remaining sections of the PNNL checklist would be visible to the user. These would include additional checklist items pertaining to the quality of insulation installation and the remaining code requirements not currently captured by REScheck. As these code requirement inputs (envisioned as checkboxes) are completed, a compliance score is generated based on the same scoring methodology currently used by the PNNL checklists. For example, if the building envelope meets the overall UA code requirements, all of the envelope R-value requirements would receive a score of three points as they currently do in the PNNL checklists. But if the insulation installation requirements are not met, the envelope component scores would change to zero if the Overall UA is no longer compliant. The introduction of insulation quality will require REScheck to adjust its calculation of U-Factor values based on recorded insulation quality (similar to how HERS software currently does this). As each code requirement checkbox is completed, the 90% compliance score tallies in a similar way that the Overall UA compliance in REScheck does currently.

This enhanced version of REScheck may need to be utilize the current PNNL checklists in some fashion as some CEI's may not have access to a computer with the software loaded in order to complete the electronic tool at the time of inspection. Compliance data will need to be captured on paper and later transferred to the REScheck tool.

Enhancements to COMcheck would be similar, but specific to the commercial approach and tools.

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