Final Report
Project 11
Code Compliance Baseline Study
Massachusetts Energy Efficiency Programs’
Large Commercial & Industrial Evaluation

Prepared for: Massachusetts Energy Efficiency Program Administrators
Submitted to: National Grid
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Burlington, Massachusetts, August 24, 2012
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1. Executive Summary

This Executive Summary provides a high level review of the results for Project 11 Code Compliance Baseline Study for the evaluation of the large commercial and industrial (C&I) programs operated by the Massachusetts program administrators (PA). In this section, we state the study objectives, summarize the evaluation approach, and present key findings, conclusions and recommendations.

1.1 Overview of Objectives and Approach

The principal research objectives of the study are:

1. Understand the energy code enforcement process
2. Understand the level of compliance with the energy code in recently constructed commercial buildings through plan reviews and site visits
3. Understand the future energy savings potential for recently constructed buildings

The LCIEC Team developed the research approach in collaboration with the Program Administrators (PAs), Energy Efficiency Advisory Council (EEAC) Consultants and National Building Institute (NBI). The research plan was developed in accordance to the methodology and guidance offered in Pacific Northwest National Laboratory’s (PNNL) Measuring State Energy Code Compliance\(^1\) report prepared for the Department of Energy’s (DOE’s) Building Energy Codes Program (BECP).

A high level synopsis of the research approach is as follows:

- **Coordination with C&S Program Team:** Collaborated with the PAs’ Codes & Standards Program Team to understand how this research can most effectively support the C&S Program Team, their goals, and their vision for attainment of those goals.

- **Marketing of Research**: Developed and implemented a marketing plan to promote study participation with building officials, building owners, and architects and engineers to promote study participation.

- **In-Depth Interviews**: Conducted in-depth interviews with over 150 market actors (building owners, design team members, building officials and program implementers) active in the Massachusetts commercial new construction market. Initial interviews focused on the current structure of the new construction marketplace, existing new construction energy efficiency programs and the current energy code enforcement process, project specific interviews focused on access to the site, site plans and contact information for additional players involved in the development and construction of the sampled building.

- **Sample Design**: Developed a randomly generated sample (obtained from the F.W. Dodge Player Database) of commercial building projects constructed since 2009. The LCIEC Team used three years of construction data to get a sample large enough to yield the targeted number of completes. The building size groups, which are consistent with PNNL’s recommended strata boundaries.

As shown in Table 1-1, the LCIEC Team achieved the target of 75 buildings with an overall response rate of 44%. We understand this to be a very high response rate for this type of study. The buildings in the Large and X-Large categories represent 75% of the total area of construction. Therefore the LCIEC Team targeted 45 of the 75 sites from buildings larger than 60,000 square feet.

<table>
<thead>
<tr>
<th>Building Size Strata</th>
<th># Projects (2009-2011)$^a$</th>
<th>% Total Construction Area$^a$</th>
<th>Target</th>
<th>Completed</th>
<th>Response Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small (&lt;=25k ft$^2$)</td>
<td>458</td>
<td>11%</td>
<td>15</td>
<td>19</td>
<td>55%</td>
</tr>
<tr>
<td>Medium (&gt;25k ft$^2$ to 60k ft$^2$)</td>
<td>126</td>
<td>14%</td>
<td>15</td>
<td>17</td>
<td>53%</td>
</tr>
<tr>
<td>Large (&gt;60k ft$^2$ to 250k ft$^2$)</td>
<td>136</td>
<td>50%</td>
<td>35</td>
<td>32</td>
<td>38%</td>
</tr>
<tr>
<td>X-Large (&gt;250k ft$^2$)</td>
<td>21</td>
<td>25%</td>
<td>10</td>
<td>7</td>
<td>37%</td>
</tr>
<tr>
<td>Total</td>
<td>741</td>
<td>100%</td>
<td>75</td>
<td>75</td>
<td>44%</td>
</tr>
</tbody>
</table>

$^a$Source: F.W. Dodge

- **Site Data Collection Methodology**: The LCIEC Team developed tools, and rigorous protocols and procedures to ensure high stratum-level response rates and high quality
site data for the assessment of code compliance. Two custom tools were developed to facilitate site data collection and quality control thereof. The first is a data collection tool developed with Filemaker Pro and Filemaker Go for use with Apple iPad tablets. The second tool is an Excel spreadsheet analysis tool utilized to compile site data and characterize individual project specifics as well as perform overall and sector based baseline analysis.

Senior LCIEC Team experts conducted classroom and field training. Following completion of the Project 11 Training, site surveyors were responsible for recruiting sampled sites for participation in the study, obtaining and reviewing as-built plans, conducting site visits, interviewing market actors associated with project and performing quality control of information entered in iPad database. Site data was submitted to senior staff within 24 hours of completing the site visit for additional quality control and verification.

- **Estimation of Overall Baseline Condition and Code Compliance:** Estimated commercial code compliance rates to determine what trends in baseline methodologies and code compliance rates are evident and what opportunities they offer for programmatic activities to advance practices and improve energy efficiency. Examples of additional compliance rate breakdowns included in the report are: energy code category, building type, geography, individual code provisions, code version and new (advanced code provisions).

To facilitate future comparisons with other states using the same methodology, and to allow the results to be utilized for ARRA funding reporting, we calculated the statewide estimate using the weighting methods and compliance score calculation developed by PNNL.

1.2 **Key Findings and Conclusions**

Figure 1-1 presents the unweighted and weighted overall state-wide estimated compliance rates for Massachusetts commercial buildings. Overall state-wide compliance is estimated to be 80% (unweighted) utilizing the DOE/PNNL tiered impact methodology. Weighted by building size the estimated overall compliance rate improves to 83%. This result does not mean that 80% of commercial buildings comply with the energy code, as we found no buildings fully in compliance. The 83% compliance rate represents the preferred DOE/PNNL methodology for the code compliance requirements associated with Federal ARRA
funding for state energy efficiency programs and projects. The intent of the DOE/PNNL methodology is to calculate the compliance rates based on the energy impacts of individual code provisions, adjusting for building size.

Figure 1-1: Statewide Compliance Rates

Analysis of commercial new construction in Massachusetts and of the responses of multiple new construction market actors, leads us to draw the following conclusions about commercial energy code compliance rates and practices. Conclusions first address findings on building and measure compliance and then address observed barriers to energy code compliance.

1. Overall code compliance for new construction in Massachusetts is estimated at about an 80% compliance rate. However, it is important to consider several factors:

   a. This result does not mean that 80% of commercial buildings comply – as we found no buildings fully in compliance.

   b. The overall number refers to the average provision compliance weighted by energy impacts as proposed by DOE/PNNL.

   c. Because the DOE/PNNL methodology seeks to assess the energy impacts of code provisions, it is more relevant to say that on average, commercial buildings
perform 20% worse than the code requires, and by extension, use 20% more energy than fully compliant buildings. However, there are many uncertainties involved and monitored or modeled data assessing the Energy Use Intensity of the studied buildings would assist in verifying the estimate.

d. Considering that efficiency programs strive for 15-20% performance improvement compared to code, this 20%, if verified, represents a significant increase in the potential savings that could be legitimately claimed, for a variety of measures, if the true standard practice baselines were recognized.

e. With a caveat that the sample is small, compliance is estimated to be somewhat lower for building designed and constructed under the current code (IECC 2009) than under IECC 2006. And, compliance rates were lowest associated with new provisions adopted for IECC 2009. This supports an intuitive conclusion that as energy codes become broader and stricter, more diligence is needed to maintain high compliance rates.

2. Lighting and lighting controls offer major opportunities for efficiency.

3. New daylighting provisions are experiencing low compliance.

4. Mechanical system efficiency levels are at full compliance. However, installation practices are not fully code compliant (for example central heating plants were found to meet required efficiency levels, while pipes and ducts were often left uninsulated or were not properly insulated), and design teams need assistance to understand these practices. A responsibility that design professionals are assigned is to monitor the construction process and assure that a design intent is realized. Assistance with this responsibility could help close the gap between as-designed and as-built performance.

5. Code compliance is somewhat better for larger buildings.

6. Code compliance occurs primarily at the design phase, not the construction phase.

7. Code compliance is a shared responsibility.

8. Code officials require additional staff resources in order to properly address the energy code and/or they need assistance from other sources in order to share the burden of energy code compliance.

9. Constructing and installing energy code compliant materials and equipment does not guarantee proper installation and operation thereof.
10. Energy code training and curriculum development is a key element in increasing market actors’ existing knowledge and improving compliance processes.

   a. Training is needed for all market actor categories on the commercial energy code as well as the Stretch Energy code.

   b. Interview results support the widespread distribution of existing, and the creation of Massachusetts specific, supplementary energy code handbooks which would:
      1) fully explain changes in the new code and why changes they have been made, and
      2) describe design and engineering assumptions behind energy codes and standards.

   c. Stand-alone training of building officials is not a solution.

11. Observed challenges to achieving and documenting energy code compliance for commercial projects range from lack of technical expertise to heavy constraints on building officials staff and their time.

   a. Building officials generally do not feel qualified to determine energy code compliance for complex HVAC systems and their controls, lighting power densities, and the type, quantity, and locations of lighting controls.

   b. Building and inspectional service departments generally report being understaffed and overloaded with code inspections, zoning enforcement, plan reviews and field work.

   c. Use of COMcheck reports to document commercial energy code compliance is sporadic and varies by jurisdiction.

   d. COMcheck reports are often accepted as stand-alone proof of compliance.

   e. Owners and design teams report more challenges in meeting commercial energy code requirements for the building envelope measures than lighting and HVAC requirements.

   f. There is currently no compliance mechanism that requires design engineers to justify their design decisions.

12. The lack of standardization, rules and metrics negatively impact the market actors and determination of energy code compliance.
a. Different compliance documentation is required depending on the building official and the particular jurisdiction.

b. The design community would benefit from the creation of standardized forms and documentation requirements for communicating Stretch Code compliance, especially where compliance is determined through energy modeling.

c. There is a lack of common metrics across industry standards such as LEED rating systems, the Stretch Code, and EPA's Energy Star “Target Finder” for determining energy savings.

1.3 Recommendations

Based on the extensive research of new construction sites and market actors operating in Massachusetts marketplace, the LCIEC offer the following list of recommendations for consideration.

1. Implement a comprehensive plan to provide energy code compliance assistance.
   a. Funding additional staff of energy experts to work with the state’s Board of Building Regulations and Standards and local officials to augment building official knowledge and resources.
   b. Funding and staffing a team of third party experts to verify the compliance for complex HVAC systems, HVAC controls, and lighting power densities and controls.
   c. Provide focused assistance for new provisions.

2. Continue “beyond code” new construction efforts.

3. Consider targeted program support for practices that verify proper installation, testing, and performance of building systems.

4. Develop training opportunities and new energy code curriculum to address the knowledge gaps identified across market segments.
   a. Offer a range of trainings to new construction market actors.
   b. Adopt alternative training approaches.
c. Provide energy code guidebooks and supplementary written materials to building officials that: 1) explain changes from one version of energy code to the next, 2) offer guidance on basic energy principles for building systems, and 3) explain the reasons for the different energy code provisions.

d. Combine internal energy code training efforts with all program implementation staff.

5. Develop energy modeling guidelines and standardized documentation to improve the quality and accuracy of compliance documentation.

a. Develop standard documentation that allows engineers and architects to submit energy models as commercial code compliance documentation.

b. Create standardized forms and documentation for communicating Stretch Code compliance, especially where compliance is determined through energy modeling.

c. Adopt common metrics and standards for energy saving calculations that align with state policy and programs.

d. Develop energy modeling guidelines for capturing baseline energy consumption for energy system types that are not addressed by ASHRAE 90.1 Appendix G, such as combined heat and power or central utility plants.

e. Examine the potential for crediting behavioral design changes, such as higher or lower set points for HVAC equipment, with energy savings.
2. Introduction

The Project 11 Code Compliance Baseline Study is part of a major effort to support the adoption of energy efficiency equipment, design and construction practices that will help address energy and environmental challenges in Massachusetts. The LCIEC Team collaborated with the Massachusetts program administrators (PAs), Energy Efficiency Advisory Council (EEAC) Consultants and the New Buildings Institute (NBI) to determine study goals and to develop a research plan.

This report provides the results for Project 11 Code Compliance Baseline Study for the evaluation of the large commercial and industrial (C&I) programs operated by the Massachusetts program administrators (PAs). In this section we provide a review of the evaluation study objectives, summarize the evaluation approach, and describe the organization of the remainder of the report.

2.1 Evaluation Objectives

The principal research objectives of the study are provided in Table 2-1.

<table>
<thead>
<tr>
<th>#</th>
<th>Primary Objectives</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Understand the energy code enforcement process.</td>
</tr>
<tr>
<td>2</td>
<td>Understand the level of compliance with the energy code in recently constructed commercial buildings through plan reviews and site visits.</td>
</tr>
<tr>
<td>3</td>
<td>Understand the future energy savings potential for recently constructed buildings.</td>
</tr>
</tbody>
</table>

2.2 Overview of Approach

The LCIEC Team developed the research approach in collaboration with the PAs, EEAC Consultants and NBI. Figure 2-1 outlines the research agenda for the Code Compliance Baseline Study. Successful execution of this research required significant planning and stakeholder outreach efforts. A summary of the primary steps undertaken in this study follows the diagram.
Figure 2-1: Research Agenda

- Development of Research Agenda
- Coordination with Codes & Standards Program Team (Ongoing Task)
- Interviews with Market Actors (BBRS, Program Implementers, Code Officials, Retailers/Vendors Design Team)
- Marketing of Research
- Sample Design & Selection
- Development of Tools and Protocols
- Field Staff "Codes" Training
- Interim Results Memo
- Project Specific In-depth Interviews (Building Dept Officials, Design Team and Building Owners)
- Onsite Data Collection
- Analysis (Site Data and In-depth Interviews)
- Final Report
Development of Research Agenda

The development of the research agenda was based on 1) the experience of the LCIEC Team in other jurisdictions; 2) discussions with the PAs, PAs’ Codes & Standards Program Team, NBI, and EEAC Consultants; and 3) review of Pacific Northwest National Laboratory’s *Measuring State Energy Code Compliance*\(^2\) report and the *Massachusetts Baseline Commercial Code Compliance Study* document\(^3\) provided by National Grid. The research agenda was developed to allow for commencement of several research tasks prior to completion and approval of the Final Project 11 Work Plan\(^4\), execution of concurrent tasks and on-going engagement of numerous stakeholders. The final work plan included the final site data collection survey ensuring clear expectations for this significant undertaking.

Coordination with Codes & Standards Program Team

A key driver of the research was to provide the Codes & Standards Program Team with information to assist with the development of a new statewide Codes & Standards Program. The objective of this task was to understand the goals of the Codes & Standards Program Team, their vision for attainment of those goals and how this research could most effectively support the Codes & Standards Program Team.

Marketing of Research

The U.S. Department of Energy’s Building Energy Codes Program (BECP) highlights the need to market code compliance studies to all stakeholders (e.g., building officials, building owners, design team). In an effort to get cooperation from all market actors to participate in the study, the LCIEC Team developed and implemented a Marketing of Research Action Plan in coordination with the PAs, Codes & Standards Program Team and BBRS.

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\(^3\) Massachusetts Baseline Code Compliance Study _110615.doc

Initial In-Depth Interviews with Market Actors

The LCIEC Team conducted 21 in-depth interviews to collect information on the current structure of the new construction marketplace, existing new construction energy efficiency programs and the current energy code enforcement process. The interviews were completed with a BBRS Code Development Manager (1 interview), PA new construction program implementers (6 interviews), building code officials (7 interviews), members of the design community (1 group meeting) and selected wholesale and retail suppliers (6 interviews).

Sample Design & Selection

The Department of Energy's (DOE's) Building Energy Codes Program (BECP) recommends a minimum sample size of 50 for Massachusetts in estimating the statewide building code compliance rate for commercial new construction buildings within a tolerable margin of error when using an average of three years of construction starts data. The LCIEC Team developed a sample plan of new construction buildings with a target of 75 completes. The sample was stratified by building size (square footage).

Development of Tools and Protocols

The LCIEC Team developed several custom instruments and procedures to ensure thorough and accurate site data collection, including:

- A data collection tool developed with Filemaker Pro and Filemaker Go for use with Apple iPad tablets; and
- An Excel spreadsheet analysis tool utilized to compile site data and perform site level and overall analysis.

Field Staff “Codes” Training

Training was conducted with all staff associated with the study in an effort to establish consistent data collection procedures and data accuracy. Classroom training included coverage of all site project-specific surveys as well as the data collection procedures associated with the iPad tool. Staff involved in site data collection also received in-the-field training that included hands-on collection and iPad input of project data for building envelope, mechanical system and lighting system measures.
Interim Results Memo

The interim report memo provided a summary of the Project 11 – Code Compliance Baseline Study research activities conducted through February 2012. The primary purpose of the interim report was to provide the Codes and Standards Implementation Team with information to assist with program development. Preliminary findings reported in this memo report were generated from initial in-depth interviews with market actors and site visits completed to date at newly constructed buildings in Massachusetts.

Project Specific In-Depth Interviews (Building Dept Officials, Design Team and Building Owners)

Whereas the initial in-depth interviews looked at the energy code compliance process in Massachusetts in general, the project-specific interviews focused the code compliance process for specific buildings. The LCIEC Team attempted to administer project-specific interviews with building officials, building owners/owner’s project managers and members of the design team involved in the construction of each the 75 sampled buildings a site visit was conducted. The LCIEC Team conducted 127 project-specific interviews with: 19 building officials, 65 building owners/owner’s project managers and 43 members of the design community. For each project-specific interview that occurred prior to the site visit, the LCIEC Team attempted to gain access to the site, site plans and contact information for additional players involved in the development and construction of the sampled building.

Onsite Data Collection

The onsite data collection undertaking consisted of visiting 75 building sites and using the tools developed during the Development of Tools and Protocols phase of the study to collect data to assess code compliance. Tasks associated with this activity included recruiting sampled sites for participation in the study, obtaining and reviewing as-built plans, conducting site visits and performing quality control of information entered in iPad database.

Analysis and Reporting (Site Data and In-Depth Interviews)

The LCIEC Team analyzed the site data to determine the following:

- Overall rates of compliance
- Compliance by category:
  - Envelope
HVAC

Lighting Power Density (LPD)

Lighting controls (separate as compliance varies greatly from LPD compliance)

- Individual measures with high or low compliance rates
- Compliance by building type (e.g. office, school, big box retail, etc)
- Geographical anomalies
- Discrepancies between relevant measures as detailed on plans and specifications and actual installed conditions
- Quality of installation practices affecting energy performance
- Knowledge of the proper operation of building systems conveyed to owners/operators by design and construction teams
- Knowledge and participation levels regarding efficiency program opportunities
- Opportunities for training, technical assistance and financial incentives

The LCIEC Team also analyzed the qualitative findings from 21 initial and 127 project-specific in-depth interviews. These in-depth interviews with market actors provided a solid foundation for understanding the market structure in regard to the existing energy code and related compliance and enforcement efforts. These findings also provided additional information to support the findings of the site data collection.

## 2.3 Organization of Report

The remainder of this report is organized as follows:

- **Section 3. Methodology.** This section presents LCIEC Team's approach to the following:
  
  - Coordination efforts with the PAs' Codes & Standards Team;
  - Marketing of research to increase study participation;
  - Initial in-depth and project-specific interviews;
  - Sample design and weighting procedures;
  - Site-level data collection; and
- Estimation of commercial code compliance rates.

- **Section 4. Baseline and Code Compliance Trends.** This section presents the results of analysis based on the evaluation of 75 project sites to determine estimates of the following:
  - Statewide energy code compliance rates;
  - Overall code compliance for different building size stratum;
  - Statewide code compliance weighted by building size;
  - Compliance by energy code categories (e.g., building envelope, lighting, HVAC);
  - Code compliance of different building types;
  - Compliance by geographic region and/or utility service territory; and
  - Compliance rates for code provisions that represent opportunities for improvement through compliance support mechanisms.

- **Section 5. In-Depth Interview Findings.** This section presents the results of the 21 in-depth initial interviews and the 127 project-specific interviews.

- **Section 6. Conclusions and Recommendations.** This section integrates the findings from the in-depth interviews and site visits. The LCIEC Team provides recommendations for increasing levels of code compliance for PA consideration.

- **Appendices**
  - A. iPad Site Data Collection Instrument
  - B. Jurisdictional Letter
  - C. Marketing of Research Presentation
  - D. Initial In-Depth Instrument: Program Implementation Staff Interview Guide
  - E. Initial In-Depth Instrument: Building Code Officials Interview Guide
  - F. Initial In-Depth Instrument: Retailers, Wholesalers and Commercial Building Equipment Vendors Interview Guide
  - G. Initial In-Depth Instrument: Design Community Members Interview Guide
I. Project-Specific Instrument: Building Owners and Property Managers Interview Guide

J. Project-Specific Instrument: Design Team Members Interview Guide
3. Methodology

This section describes the process taken to develop the Codes & Standards Baseline Study; the methodologies used to gather market data on new construction buildings; and to determine code compliance rates for commercial buildings in Massachusetts.

This section is organized as follows:

- **Coordination with C&S Program Team**: Collaboration efforts between the LCIEC Team and the PAs’ Codes & Standards Team.
- **Marketing of Research**: Discussion of marketing plan to promote study participation with building officials, building owners, and architects and engineers.
- **In-Depth Interviews**: Overview of the initial and project-specific in-depth interviews the LCIEC Team conducted with market actors – includes description of the market actors interviewed, data collection process and survey instruments.
- **Sample Design**: Description of the rationale used to determine the sample design to conduct onsite visits.
- **Site Data Collection Methodology**: Approach implemented to collect site data and a description of the custom tool developed for baseline and code compliance analysis.
- **Estimation of Overall Baseline Condition and Code Compliance**: Process used for estimating commercial code compliance rates.

3.1 Coordination with C&S Program Team

A central purpose of this study is to inform the PAs’ Codes & Standards (C&S) Team’s development of a statewide program focused on reducing energy usage through the enhanced implementation of codes and standards. Close coordination between the LCIEC Team and the C&S Program Team was needed to understand how this research can most effectively support the C&S Program Team, their goals, and their vision for attainment of those goals. An initial meeting with the LCIEC Team and key members of the C&S Program Team and its consultants was held at National Grid on August 15, 2011. Key discussion items included:

- History of Codes and Standards Program development;
- Program Goals;
• Status and overview of program design and implementation plan;
• Regulatory needs for allowing code assistance savings; and
• Discussion of potential program models.

In developing study materials and tools, the LCIEC Team requested information from the C&S Program Team that would influence the marketing efforts, interviewing guides and data collection processes including feedback on the Marketing of Research Action Plan, the informational letters on the study sent to building officials across the State, and the field data collection tool.

Further coordination continued as the study continued to progress. In accordance with the request from the C&S Program Team during the August 15, 2011 meeting to provide an interim report by March, 2012, the LCIEC team completed a report which summarized findings of the study to that point. No analysis of the field data was included at that point as field data collection was still ongoing. The interim report mainly contained findings from the stakeholders interviews held prior to mid-February. Coordination is planned to continue between the LCIEC Team and the C&S Program Team throughout the summer of 2012, to ensure the study data is utilized to its fullest potential.

3.2 Marketing of Research

The U.S. Department of Energy’s Building Energy Codes Program (BECP) stresses the importance of marketing code compliance studies to all stakeholders (e.g. building department code officials, design community, etc) in order to obtain the necessary data from a representative sample of buildings. To define the necessary marketing activities, the LCIEC Team developed a Marketing of Research Action Plan in close coordination with the PA’s and the C&S Program Team. The action plan identified three key messages that would formulate the marketing strategy, including:

1. **Proper branding of the study would be vital to its success.** Instead of conveying the research as a code compliance study, the LCIEC Team branded the study as an effort to learn about common construction practices in relation to the energy code, removing any reference to the word “compliance.”

2. **Marketing materials would be needed to communicate the intent of the study and alleviate any concerns the market actors may have with this research.** The primary message of the materials conveyed that the information collected through this study
would be used to develop a program that provides financial assistance and training and support to those who work closely with building codes including architects, engineers, construction managers, and building officials.

3. **Focus should be on three primary market actor groups: the design and construction community, building owners, and building code officials.** In order to engage an adequate number of these actors, a multi-pronged approach that has a broad reach was required. The selected communications established credibility, began to gain the markets actors' trust, and conveyed the importance of this study.

The LCIEC team used several approaches to market this study and establish a relationship and trust with participants including:

1. **Electronic Announcements:** email to building officials, and the construction and design community
2. **Jurisdictional Letter:** letter to building officials informing them of the study and encouraging participation
3. **Presentations:** brief in-person presentation to key professional associations

During the process for developing and disseminating the information, the LCIEC drafted the materials and then collected feedback from the PA’s, the C&S Program Team, and the Massachusetts Board of Building Regulations and Standards (BBRS). The LCIEC Team and representatives from the PA’s and C&S Program Team met with BBRS on September 29, 2011 to obtain input and guidance on the materials. Feedback that was collected for the electronic announcement and letter was incorporated and then sent to the various stakeholders. The activities are summarized in Figure 3-1 below.
The presentation was designed to be 10-15 minutes in length and intended to provide a brief overview of the study; describe how market actors might be asked to participate; and provide insight into how the information collected would be used. The presentation is included in Appendix C. Recruitment for the presentation proved to be challenging, but the LCIEC team did make a presentation to the Massachusetts Building Commissioners and Inspectors Association (MBCIA) and participants of two of the Center for Ecological Technology’s High Performance Building Training Sessions which included both building officials and residential and commercial contractors. The LCIEC team was also able to provide information on the study at a U.S. Green Building Council Massachusetts Chapter Board of Directors Meeting.

The marketing campaign communicated the potential benefits of such a program to the target market and alleviated concerns that market actors may have had with participating in the research. The LCIEC Team believes that these marketing efforts resulted in achievement of higher data collection response rates across the State.
3.3 In-Depth Interviews

This section discusses Initial and Project-Specific in-depth interviews the LCIEC Team conducted with market actors. A description of the market actors interviewed and a summary of the data collection process and survey instruments is provided for both initial and project-specific in-depth interviews.

3.3.1 Initial In-Depth Interviews

In the early part of the study period (beginning November 2011), the LCIEC Team conducted 21 initial in-depth interviews with market actors to collect information on the current structure of the new construction marketplace, existing new construction energy efficiency programs and the current energy code enforcement process. Market actors interviewed for this part of the research included:

- Code Development Manager for the Massachusetts Department of Public Safety, Board of Building Regulations and Standards;
- PA new construction program implementers;
- Building code officials;
- Selected wholesale/retail suppliers; and
- Members of the design community.

3.3.1.1 Initial In-Depth Interview Data Collection

Senior Massachusetts-based members of DNV KEMA’s Sustainable Buildings and Communities (SBC) practice conducted the initial in-depth interviews. Some interviews with building officials and wholesale/retail suppliers were completed by other DNV KEMA staff under the direct supervision of the SBC team. DNV KEMA’s SBC division provides green building consulting and sustainable building portfolio services. The interviewers used their professional familiarity with energy code compliance in commercial building design and operation to elicit important details and resolve inconsistencies in respondents’ answers.

Table 3-1 presents an overview of the initial in-depth interviews including a brief description of the market actors’ organizations and their positions. These interviews were conducted between November 2011 and February 2012 and averaged 52 minutes in length, with a range of 18 minutes to two hours.
Table 3-1: Summary of Initial In-Depth Interviews

<table>
<thead>
<tr>
<th>Market Actor</th>
<th>Number of Interviews</th>
<th>Interview Format</th>
<th>Rationale for Selected Market Actor</th>
<th>General Description of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>BBRS Code Development Manager</td>
<td>1</td>
<td>In-person</td>
<td>Inform the marketing of research plan and gather input that may be helpful in reaching market actors.</td>
<td>Market Actor Interviewed • Head of the building code development process</td>
</tr>
<tr>
<td>PA Program Implementers</td>
<td>6</td>
<td>In-person</td>
<td>Gain understanding of the impact of the commercial energy code on energy efficiency program implementation</td>
<td>Market Actors Interviewed • Implementation staff for Massachusetts commercial energy efficiency programs</td>
</tr>
<tr>
<td>Building Code Officials</td>
<td>6</td>
<td>Phone and In-person</td>
<td>Gain understanding of the compliance practices in regard to the current building energy code.</td>
<td>Market Actors Interviewed • State building inspector • Upper level building commissioners for three cities and three towns</td>
</tr>
<tr>
<td>Wholesale/ Retail Suppliers</td>
<td>6</td>
<td>Phone</td>
<td>Gain understanding of the market actors’ knowledge of and supply strategies based on the building energy code.</td>
<td>Market Actors Interviewed • Two lighting manufacturer representatives • Lighting distributorship • Industrial HVAC equipment vendor • HVAC manufacturer representative • Lumber yard (i.e., windows, doors, insulation)</td>
</tr>
<tr>
<td>Design Community</td>
<td>1 group interview discussion</td>
<td>1 group interview discussion</td>
<td>Focus group Gain understanding of the design community’s experience complying with the Massachusetts commercial energy code, identify barriers that impede code compliance and solicit suggestions to improve code compliance.</td>
<td>Market Actors Interviewed • Four mechanical engineers • Architect • Operations manager for non-profit building organization</td>
</tr>
</tbody>
</table>

Range of FTEs in Mass
- 2 to 40
- 4 to 110
Table 3-2 presents a summary of the key research topics covered in each of the initial market actor interviews. All topics may not have been covered in each interview. The focus of each initial in-depth interview was guided by the experience and availability of the interviewees.

Table 3-2: Initial In-Depth Interview Research Topics

<table>
<thead>
<tr>
<th>Key Research Topics</th>
<th>PA Program Implementers</th>
<th>Building Officials</th>
<th>Wholesale/Retail Suppliers</th>
<th>Design Team</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Information</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Job Responsibilities</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Specialization in Particular Building Types</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Energy Code Awareness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Familiarity of Recent Energy Code Updates</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Impact of Recent Energy Code Updates</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>How Learn about Energy Code</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Building Systems Impacted by Energy Code</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Interaction with Others Involving Energy Code</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Familiarity with Stretch Code</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Impact of Stretch Code</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Energy Code Compliance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Code Documentation Reviewed</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Process for Complying with Energy Code</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Challenges to Meeting Energy Code Requirements</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Suggestions to Improve Energy Code Compliance</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
3.3.2 Project-Specific In-Depth Interviews

In addition to the initial market actor interviews that solicited general feedback on energy code compliance in Massachusetts, 127 project-specific interviews were conducted that focused on energy code compliance for projects that received site visits. Project-specific interviews were conducted with the following market actors:

- Building Officials
- Building Owners or Owner’s Project Managers
- Design Community

3.3.2.1 Project-Specific In-Depth Interview Data Collection

Similar to the initial in-depth interviews, senior Massachusetts-based members of DNV KEMA’s SBC practice oversaw the administration of project-specific interviews. DNV KEMA and ERS field staff were responsible for all market actor data collection (i.e., interviews with building owners, building officials and design teams) for each of their assigned sites. The process allowed the LCIEC Team to review the code compliance process in the context of an actual project that was being reviewed. Project participants were able to describe in substantial detail their interactions with code officials and their understanding of how code provisions applied to the building. This protocol also provided continuity between the field staff and the building owners and design team in order to establish a relationship and increase the probability of success in completing the data collection and in-depth interviews. The SBC team provided training for all staff involved in conducting project-specific interviews to ensure familiarity with the survey instruments. While administering the interviews field staff used their professional familiarity with energy code compliance in commercial building design and operation to elicit important details and resolve inconsistencies in respondents’ answers.

The following tables present an overview of the project-specific interviews. Table 3-3 includes a brief description of the market actors’ organizations and the rationale for conducting the interviews. The project specific interviews were conducted between December 2011 and May 2012 and averaged 23 minutes in length, ranging in length from 15 to 73 minutes. Some market actors interviewed provided feedback on multiple projects from the sample. For example, the sample contained a number of chain stores in different locations throughout the state. In an effort to honor the time constraints of market actors being interviewed, field staff often asked building owners and design team members affiliated with multiple chain stores from the sample...
to discuss their overall experience with the building energy code rather than administering separate interviews for each unique site.

Table 3-3: Summary of Project-Specific In-Depth Interviews

<table>
<thead>
<tr>
<th>Market Actor</th>
<th>Number of Interviews</th>
<th>Interview Format</th>
<th>Rationale for Selected Market Actor</th>
<th>General Description of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Code Officials</td>
<td>19</td>
<td>Phone and in-person</td>
<td>Gain understanding of the energy code compliance practices in regard to specific building projects.</td>
<td><strong>Market Actors Interviewed</strong>&lt;br&gt;• 1 State building inspector&lt;br&gt;• Upper level building commissioners for 6 cities and 12 towns&lt;br&gt;<strong>Range of FTEs in Mass</strong>&lt;br&gt;1 to 40</td>
</tr>
<tr>
<td>Building Owners/Owner’s Project Managers</td>
<td>65</td>
<td>Phone and in-person</td>
<td>Gain understanding of building owner awareness of energy code and PA-sponsored new construction programs in regard to specific building projects.</td>
<td><strong>Market Actors Interviewed</strong>&lt;br&gt;• 34 Owners&lt;br&gt;• 9 Owner’s Project Managers&lt;br&gt;• 8 Developers&lt;br&gt;• 8 Facility Managers&lt;br&gt;• 3 Construction Managers&lt;br&gt;• 1 Consultant&lt;br&gt;• 1 Property Manager&lt;br&gt;• 1 Real Estate Representative</td>
</tr>
<tr>
<td>Design Community</td>
<td>43</td>
<td>Phone and in-person</td>
<td>Gain understanding of the design community’s experience complying with the Massachusetts commercial energy code in regard to specific building projects.</td>
<td><strong>Market Actors Interviewed</strong>&lt;br&gt;• 26 architects&lt;br&gt;• 12 engineers&lt;br&gt;• 5 general contractors</td>
</tr>
</tbody>
</table>
Table 3-4 presents a summary of the key research topics covered in each of the project-specific market actor interviews. All topics may not have been covered in each interview. The focus of each interview was guided by the experience and availability of the interviewees.

Table 3-4: Project-Specific In-Depth Market Actor Interview Research Topics

<table>
<thead>
<tr>
<th>Key Research Topics</th>
<th>Building Official</th>
<th>Owners and Owners’ Project Managers</th>
<th>Design Team Members</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Information</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Job Responsibilities</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Role in New Construction Project</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Previous Energy Code Experience</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Energy Code Awareness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How Learn about Energy Code</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Knowledge of Energy Code</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Energy Code Compliance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Code Documentation Prepared/Requested</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Process for Complying with/Enforcing Energy Code</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Interaction with Building Officials Involving Energy Code</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time/Effort Energy Code Plan Reviews &amp; Field Inspections</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Challenges to Meeting Energy Code Requirements/ Barriers to Enforcing Code</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>New Construction Program Support</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Efficiency Goals Established</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Contact w/ MA Efficiency Programs</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Building Testing &amp; Performance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfaction w/Building Performance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Testing &amp; Balancing/Commissioning Completed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identified Problems w/ Building Operation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LCIEC 3-10 August 24, 2012
### 3.4 Sample Design and Weighting Procedures

This section discusses the sample design and post-survey weighting.

#### 3.4.1 Sample

##### 3.4.1.1 Target Population

The target population for the Code Compliance Baseline Study was the commercial and industrial buildings constructed between 2009 and 2011 in the state of Massachusetts that fall under the commercial energy code.

##### 3.4.1.2 Sample Frame

The sample frame was the Dodge Players Database for 2009-2011. This database is developed using information from the F.W. Dodge New Construction Reporting system. The Dodge Players Database is designed to furnish information on the market actors associated with individual new construction projects, including owners, architects, engineers, and other market actors.

The sample frame was restricted to the projects that were anticipated to fall under the commercial energy code.

The original sample frame had 779 new construction projects in 2009-2011. After excluding the ineligible projects, 741 projects remained. Based on the frame, the estimated total new construction square footage was 34.9 million square feet. However, that estimate was further adjusted as a result of screening and interviewing the sampled cases.

---

### Key Research Topics

<table>
<thead>
<tr>
<th>Improving Compliance Process</th>
<th>Building Officials</th>
<th>Owners and Owners’ Project Managers</th>
<th>Design Team Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suggestions to Improve Energy Code Compliance</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Training Needs</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
3.4.1.3 Sample Selection

The sample frame was stratified into four strata based on the square footage of a project reported by Dodge:

- Small – Up to 25,000 ft$^2$
- Medium – Larger than 25,000 ft$^2$ and up to 60,000 ft$^2$
- Large – Larger than 60,000 ft$^2$ and up to 250,000 ft$^2$
- X-Large – Larger than 250,000 ft$^2$

Table 3-5 shows the number of projects, the total square footage, and the percent of total square footage for each stratum.

Table 3-5: New Construction Sample Stratification

<table>
<thead>
<tr>
<th>Stratum</th>
<th># Projects</th>
<th>Total Square Footage (in 1000 ft$^2$)</th>
<th>% Total Square Footage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>458</td>
<td>3,840</td>
<td>11%</td>
</tr>
<tr>
<td>Medium</td>
<td>126</td>
<td>5,036</td>
<td>14%</td>
</tr>
<tr>
<td>Large</td>
<td>136</td>
<td>17,352</td>
<td>50%</td>
</tr>
<tr>
<td>X-Large</td>
<td>21</td>
<td>8,718</td>
<td>25%</td>
</tr>
<tr>
<td>Total</td>
<td>741</td>
<td>34,946</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: F.W. Dodge

The sample design reflects the share of total square footage each size group represents with an oversample of buildings in small and medium groups. The sample included 151 buildings in Replicate 1 and 53 buildings each in Replicate 2 and Replicate 3. Replicate 3 was not released because an adequate response rate was achieved from Replicates 1 and 2.
### Table 3-6: Sample Design - Number of Buildings Sampled by Stratum

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Replicate 1</th>
<th>Replicate 2</th>
<th>Replicate 3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>30</td>
<td>10</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Medium</td>
<td>30</td>
<td>10</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Large</td>
<td>70</td>
<td>33</td>
<td>33</td>
<td>136</td>
</tr>
<tr>
<td>X-Large</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>151</strong></td>
<td><strong>53</strong></td>
<td><strong>53</strong></td>
<td><strong>257</strong></td>
</tr>
</tbody>
</table>

#### 3.4.2 Data Collection

##### 3.4.2.1 Field Visits

The LCIEC Team completed 71 site visits with the sampled projects. Table 3-7 shows the sample disposition by stratum.

### Table 3-7: Sample Disposition by Stratum

<table>
<thead>
<tr>
<th>Disposition</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
<th>X-Large</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>Complete</td>
<td>16</td>
<td>17</td>
<td>31</td>
<td>7</td>
</tr>
<tr>
<td>Complete</td>
<td>40%</td>
<td>43%</td>
<td>30%</td>
<td>33%</td>
</tr>
<tr>
<td>Refused</td>
<td>10</td>
<td>9</td>
<td>27</td>
<td>7</td>
</tr>
<tr>
<td>Refused</td>
<td>25%</td>
<td>23%</td>
<td>26%</td>
<td>33%</td>
</tr>
<tr>
<td>Quota Met</td>
<td>5</td>
<td>4</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Quota Met</td>
<td>13%</td>
<td>10%</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>Could Not Schedule</td>
<td>3</td>
<td>6</td>
<td>24</td>
<td>5</td>
</tr>
<tr>
<td>Could Not Schedule</td>
<td>8%</td>
<td>15%</td>
<td>23%</td>
<td>24%</td>
</tr>
<tr>
<td>Not Contacted</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Quota Met</td>
<td>3%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Excluded</td>
<td>5</td>
<td>3</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Not Eligible</td>
<td>13%</td>
<td>8%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>40</td>
<td>40</td>
<td>103</td>
<td>21</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 3-8 shows the number of eligible sampled cases, the number of completed interviews, and the response rate by sample stratum. The overall eligibility rate was 90%. The overall survey response rate was 44%.
An additional four site visits were completed with buildings that were not part of the original sample to reach the target of 75 completed sites. These four sites are assigned to additional strata and are considered to represent themselves in the post-survey processing.

### 3.4.2.2 Sample Eligibility Status

The estimated total square footage of eligible new construction projects based on information from the Dodge database was 34.9 million square feet. During the interviewing, additional sampled cases were found to be ineligible. Based on the sample eligibility rates, we estimate that in 2009 through 2011, about 31.5 million square feet of new construction area fell under the commercial energy code.

This estimate is further adjusted to account for the differences in square footage between the Dodge records and the values recorded by field technicians for the completed sites. The revised population estimate is 31.1 million square feet of new construction.

### 3.4.3 Data Processing

#### 3.4.3.1 Weights

The Department of Energy's (DOE's) Building Energy Codes Program (BECP) recommends that the average individual scores from the completed sites be weighted by building size strata according to the proportion of total square footage constructed in the population that each size stratum represents in order to derive an overall state compliance metric for commercial new construction buildings.

Table 3-9 shows the proportion weights developed for each stratum excluding the additional four completes that were not part of the sample.
Table 3-9: Proportion Weights by Stratum, 71 Completes

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Total Eligible Square Footage (in 1000 ft²)</th>
<th>Stratum Proportion Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>3,498</td>
<td>0.111</td>
</tr>
<tr>
<td>Medium</td>
<td>4,615</td>
<td>0.146</td>
</tr>
<tr>
<td>Large</td>
<td>15,640</td>
<td>0.496</td>
</tr>
<tr>
<td>X-Large</td>
<td>7,773</td>
<td>0.247</td>
</tr>
<tr>
<td>Total</td>
<td>31,526</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Table 3-10 shows the proportion weights developed for each stratum including the additional four completes that were not part of the sample. Since these four sites represent themselves in the stratum they were assigned to, the proportion weights for their strata are significantly smaller than others.

Table 3-10: Proportion Weights by Stratum, 75 Completes

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Total Eligible Square Footage (in 1000 ft²)</th>
<th>Stratum Proportion Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>3,498</td>
<td>0.110</td>
</tr>
<tr>
<td>Medium</td>
<td>4,615</td>
<td>0.146</td>
</tr>
<tr>
<td>Large</td>
<td>15,640</td>
<td>0.494</td>
</tr>
<tr>
<td>X-Large</td>
<td>7,773</td>
<td>0.245</td>
</tr>
<tr>
<td>Small–Additional Sites</td>
<td>37</td>
<td>0.001</td>
</tr>
<tr>
<td>Large–Additional Sites</td>
<td>120</td>
<td>0.004</td>
</tr>
<tr>
<td>Total</td>
<td>31,683</td>
<td>1.000</td>
</tr>
</tbody>
</table>

In addition to stratum proportion weights, site-level weights are developed to be used in the subgroup analysis. The site level square footage weight (SFW) is based on two factors – the stratum factor and the square footage of each site.

The formula for the stratum factor (SF) is $SF = \frac{\text{Sum of Stratum Square Footage}}{\text{Sum of Square Footage for Stratum Respondents}}$. 
The formula for the Square Footage Weight for each completed site is \( SFW = SF \times \text{Square Footage of the Site} \).

These weights are then normalized so that they add up to 75, the total number of completed sites by multiplying each weight by \( 75/31,683 \). The normalized (relative) weights reflect the relative importance of each completed site, which is based on the total square footage each site represents in the population, in the estimation of compliance rates.

Table 3-11 presents information on the computation of site-level relative square footage weights.

**Table 3-11: Relative Square Footage Weights by Stratum, 75 Completes**

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Total Eligible Square Footage (in 1000 ft(^2))</th>
<th>Total Respondent Square Footage (in 1000 ft(^2))</th>
<th>Stratum Factor</th>
<th>Average Weight</th>
<th>Average Relative Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>3,498</td>
<td>191</td>
<td>18.31</td>
<td>218.62</td>
<td>0.52</td>
</tr>
<tr>
<td>Medium</td>
<td>4,615</td>
<td>725</td>
<td>6.37</td>
<td>271.47</td>
<td>0.64</td>
</tr>
<tr>
<td>Large</td>
<td>15,640</td>
<td>3,603</td>
<td>4.34</td>
<td>504.52</td>
<td>1.19</td>
</tr>
<tr>
<td>X-Large</td>
<td>7,773</td>
<td>2,346</td>
<td>3.31</td>
<td>1110.43</td>
<td>2.63</td>
</tr>
<tr>
<td>Small–Additional Sites</td>
<td>37</td>
<td>37</td>
<td>1.00</td>
<td>12.33</td>
<td>0.03</td>
</tr>
<tr>
<td>Large–Additional Sites</td>
<td>120</td>
<td>120</td>
<td>1.00</td>
<td>120.00</td>
<td>0.28</td>
</tr>
<tr>
<td>Total</td>
<td>31,683</td>
<td>7,022</td>
<td>4.51</td>
<td>422.44</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**3.4.3.2 Weight Adjustments**

For the final report, the weights are further adjusted to account for the differences in square footage between the Dodge records and the values recorded by field technicians for the completed sites. In some case, the difference was large enough to re-classify the project under a different size group than originally assigned based on the Dodge record.
Table 3-10 presents information on the reclassification of sites in the size stratum based on the square footage recorded by the field technicians.

**Table 3-12: Stratum Reclassification, 75 Completes**

<table>
<thead>
<tr>
<th>Revised Stratum</th>
<th>Original Stratum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
</tr>
<tr>
<td>Small</td>
<td>14</td>
</tr>
<tr>
<td>Medium</td>
<td>0</td>
</tr>
<tr>
<td>Large</td>
<td>2</td>
</tr>
<tr>
<td>X-Large</td>
<td>0</td>
</tr>
<tr>
<td>Small–Add.</td>
<td>0</td>
</tr>
<tr>
<td>Large–Add.</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

Table 3-10 shows the adjusted proportion weights developed for each stratum after reclassifying the projects based on the recorded square footage by the field technicians.

**Table 3-13: Adjusted Proportion Weights by Stratum, 75 Completes**

<table>
<thead>
<tr>
<th>Revised Stratum</th>
<th># Completes</th>
<th>Total Eligible Square Footage (in 1000 ft²)</th>
<th>Stratum Proportion Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>16</td>
<td>3,328</td>
<td>0.107</td>
</tr>
<tr>
<td>Medium</td>
<td>19</td>
<td>4,636</td>
<td>0.149</td>
</tr>
<tr>
<td>Large</td>
<td>31</td>
<td>17,810</td>
<td>0.573</td>
</tr>
<tr>
<td>X-Large</td>
<td>5</td>
<td>5,162</td>
<td>0.166</td>
</tr>
<tr>
<td>Small–Additional Sites</td>
<td>3</td>
<td>37</td>
<td>0.001</td>
</tr>
<tr>
<td>Large–Additional Sites</td>
<td>1</td>
<td>120</td>
<td>0.004</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>75</strong></td>
<td><strong>31,093</strong></td>
<td><strong>1.000</strong></td>
</tr>
</tbody>
</table>

In addition to stratum proportion weights, site-level weights are also adjusted to be used in the subgroup analysis. The cases retained their original sample selection weights but the original site-level square footage weights are multiplied by an adjustment factor, which is equal to the recorded square footage divided by Dodge reported square footage for the site.
Table 3-11 presents information on the computation of site-level relative square footage weights.

**Table 3-14: Adjusted Relative Square Footage Weights by Stratum, 75 Completes**

<table>
<thead>
<tr>
<th>Revised Stratum</th>
<th># Completes</th>
<th>Total Eligible Square Footage (in 1000 ft²)</th>
<th>Average Adjusted Weight</th>
<th>Average Adjusted Relative Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>16</td>
<td>3,328</td>
<td>208.00</td>
<td>0.50</td>
</tr>
<tr>
<td>Medium</td>
<td>19</td>
<td>4,636</td>
<td>244.01</td>
<td>0.59</td>
</tr>
<tr>
<td>Large</td>
<td>31</td>
<td>17,810</td>
<td>574.53</td>
<td>1.39</td>
</tr>
<tr>
<td>X-Large</td>
<td>5</td>
<td>5,162</td>
<td>1032.44</td>
<td>2.49</td>
</tr>
<tr>
<td>Small–Additional Sites</td>
<td>3</td>
<td>37</td>
<td>12.33</td>
<td>0.03</td>
</tr>
<tr>
<td>Large–Additional Sites</td>
<td>1</td>
<td>120</td>
<td>120.00</td>
<td>0.29</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>75</strong></td>
<td><strong>31,093</strong></td>
<td><strong>422.44</strong></td>
<td><strong>1.00</strong></td>
</tr>
</tbody>
</table>

### 3.5 Site Data Collection Methodology

This section presents the methodology implemented to collect data regarding specific project sites. It also describes the custom tool developed for baseline and code compliance analysis. Figure 3-2 illustrates the process employed to collect and verify the site data.
Figure 3-2 Site Data Collection Process

3.5.1 Data Collection Tool Development and Quality Control

In order to assure thorough and accurate site data collection, the project team developed two custom tools. The first is a data collection tool developed with Filemaker Pro and Filemaker Go for use with Apple iPad tablets. The second tool is an Excel spreadsheet analysis tool that is utilized to compile site data and characterize individual project specifics as well as perform overall and sector based baseline analysis.

- **Data Collection Tool** – ERS modified the data collection instrument utilized for the Maine Code Baseline study for use as the basis the Massachusetts study. Modifications included coverage of the provisions of the Massachusetts amendments as well as the Stretch Code. In addition the instrument was modified to be fully consistent with the DOE/PNNL compliance methodology, as Maine does not yet have in place a mandatory...
energy code. DNV KEMA and ERS worked together to develop the iPad application that provides for a step-by-step data collection process that prompts the user for responses to each baseline measure and/or energy code requirement. Drop-down menus are utilized to facilitate accurate data collection, and comment fields for every measure assure the ability to fully describe site details.

- **Data Analysis Tool** – ERS senior engineers developed a spreadsheet tool that accepts uploaded data from the iPad Filemaker tool, populating a spreadsheet for each project surveyed. The tool automatically determines code compliance for any measures identifiable with a yes/no response, or a specific threshold value. For all compliance measures it facilitates analysis of code compliance and performance levels relative to code provisions. Sorting functions facilitate compliance by measure, measure category, and overall. In addition the tool will be used to gauge compliance across various sectors as allowed by the size of the sample.

Training was conducted with all staff associated with the study to ensure consistent data collection procedures and ensure high levels of data accuracy. Classroom training included coverage of all site survey questions as well as the data collection procedures associated with the iPad tool. In addition, all staff involved in site data collection received in-the-field training that included hands-on collection and iPad input of project data for building envelope, mechanical system, and lighting system measures.

Following the above training exercises, the entire survey instrument was reviewed with the trained staff covering all questions and concerns regarding possible obstacles to obtaining accurate information while on-site. Following this exercise, final modifications were made to the iPad tool and the associated spreadsheet tool.

In order to provide for on-going quality control, a follow-up debriefing session was conducted after the initial round of site visits. Staff discussed challenges presented by their initial visits/interviews, sought clarifications, and recommended methodologies developed both by peers and senior staff. Minor modifications were made to the data collection tool in response to staff feedback generated during this initial round of site data collection.

### 3.5.2 Site Data Collection Procedures

Utilizing the methodologies developed during the above described process, the project staff scheduled and conducted site surveys and interviews in a manner consistent with data collection best practices. The procedure is outlined as follows:
• **Site Scheduling** – In order to assure proper coordination, each project team member scheduled their own site visits. Working from their assigned projects from the sample, initial information regarding the status of the project (i.e. fully complete, under construction, design stage, etc.) was recorded. Upon identification of viable sites, the site visits were scheduled.

• **Obtaining Project Documentation** – At the time of initial site scheduling, the team member arranged for access to project documentation, including architectural/mechanical/electrical plans and project specifications including “sequence of operation” documents.

• **Assuring Valuable Data Collection** – Prior to visiting the site, team members requested that key personnel be available for interviews. This typically included project owners, design team members, and facility managers. In addition, a facility tour with adequate time to perform project assessment and data collection was scheduled.

• **On-Site Interviews** – Although flexibility was maintained in order to accommodate project participants, each site visit began with an interview, or a series of interviews, in order to gather as much project data as possible. These interviews assisted in:
  - Obtaining key features of the project related to energy efficiency
  - Identifying owner and design team relative awareness of energy code mandates and procedures, energy efficiency best practices, energy efficiency programmatic offerings, etc.
  - Assuring access to as much of the project site as possible
  - Establishing safe and constructive procedures for the rest of the visit

• **Project Document Review** – Depending on the size and scope of the facility, as well as the results of the scheduling procedure, project documents were reviewed on-site in conjunction with the site survey, or were reviewed independent of the site work. Depending on the detail presented in the available documents the following project information was gathered and then verified through the facility tour:
  - Comprehensiveness of the documents in terms of energy code compliance issues
  - Adequacy of document details for facilitating compliance and instructing construction personnel
  - Required system testing and facility training procedures
Envelope details, including, but not limited to:

- Air barriers and air sealing
- Insulation levels and materials
- Thermal breaks
- Vapor retarders for cavity insulation
- Fenestration specifications
- Facility specific details such as loading docks, vestibules, etc.

Mechanical system details:

- Model numbers and/or efficiency levels of equipment
- Thermostatic controls
- Fan and pump controls
- Heat recovery ventilation as applicable
- Duct and pipe insulation
- Control sequences

Lighting system details:

- Lighting power density (LPD) of space types
- Manual controls
- Automatic timer and/or occupancy based controls
- Daylighting zones
- Exterior lighting efficacy requirements

Facility Tour—A comprehensive facility tour was performed at each site in order to field verify the information collected from the design documents and to collect additional data not available in the documents. For a small percentage of the sites, the project team was not provided access to design documents but was invited to tour the facility. For these sites, as much data as possible was collected through physical inspection. In all cases, the iPad data collection tool was fully completed with each measure addressed. “Not
verifiable” (NV) and “not applicable” (NA) were utilized to avoid confusion as to possible missing data.

- **Data Submission** - To ensure that proper procedures were followed, site survey personnel uploaded completed data collection files within 24 hours of completing the site survey.

### 3.5.3 Data Upload and Analysis Procedure

The project team developed a data transfer protocol that is highly automated, yet allows for quality control at every step. The user interface allows for the entry of comments and adjustments at any juncture, and every baseline measure was recorded or is referenced as “not applicable” or “not verifiable.” The procedure the LCEIC Team utilized is as follows:

- **Data Upload** – Upon assurance that collected data is complete and accurate, the individual facility data collected was uploaded from the Filemaker tool to the custom analysis spreadsheet tool.

- **Data Quality Assurance Review** – Following the upload of the data, project management reviewed the spreadsheet inputs for completeness and conflicts, referring all questions and concerns back to the project staff assigned to the site.

- **Automatic Code Compliance/Baseline Determination** – There are many code provisions that are prescriptive across all commercial building types and others that are prescriptive, but are segregated by building type and/or building size. For these provisions, upon uploading of the Filemaker data, the spreadsheet tool recorded the baseline information, the building type/size when appropriate, and made a code compliance determination automatically. This determination verifies that individual provisions are met. COMcheck and “Total Building Performance” methodologies allow for some tradeoffs within building envelope measures. The DOE/PNNL compliance methodology does not allow for trade-off determinations. However, our field assessments did not identify envelope assemblies that significantly outperform code provisions, allowing such trade-offs. Where we encountered assemblies that fell short of code requirements, they had not been offset by corresponding beyond code envelope practices elsewhere in the building.

Determinations made in this fashion, include:

- Air barriers and air sealing
- Insulation levels
- Fenestration performance
- HVAC efficiency levels
- VFD fan and pump controls
- Lighting controls

**Semi-Automatic Code Compliance/Baseline Determination** – Other provisions do not lend themselves to automatic determinations and require user judgment. For these provisions the Filemaker data was uploaded to the spreadsheet in the same fashion, but dropdown menus prompted the user for inputs in order to make a final code provision determination. Provisions handled in this fashion include:

- Daylighting zones
- Control of complex HVAC systems
- Economizing
- Demand Control Ventilation
- Prevention of simultaneous heating and cooling

**Calculated Code Compliance/Baseline Determination** – In some cases, a calculation was needed to determine compliance with a specific provision. An obvious example is lighting power density (LPD) which is the main avenue of lighting compliance. The steps followed are as follows:

- Site surveyor determined if the project consisted of repeated lighting layouts with similar fixtures, as is common with commercial buildings, and determined a survey approach accordingly.
- Site surveyor selected areas of the project that represented the variety of space types encountered, or in some cases, surveyed the entire facility.
- The dimensions of each selected space were entered in the iPad tool.
- The lighting fixture technologies were selected from drop-down menus.
- The fixture quantity was recorded in the tool.
- The tool assigned the appropriate fixture wattage from an extensive database of lamp/ballast combinations and calculated the LPD.

- Upon uploading the Filemaker data to the spreadsheet tool, the LPD calculation was repeated and the result checked against the lighting power allowance (LPA) for the space or building area type.

**Final Quality Control of Data Inputs**—Following the above procedures, the LCIEC Team reviewed all finalized facility spreadsheets for consistency and completeness. Incomplete data produced an automatic inquiry to the site surveyor who then reviewed the site data. In nearly all cases the result of such inquiries was the recognition that a portion of the baseline information was not verifiable due to the stage of project completion. All staff was instructed to record only baseline conditions that were verifiable without causing damage to the structure.

### 3.6 Estimation of Overall Baseline Conditions and Code Compliance

One of the advantages of spreadsheet tools is that they allow data to be viewed and analyzed in many differing ways. One of the goals of this project is to determine what trends in baseline methodologies and code compliance rates are evident and what opportunities they offer for programmatic activities to advance practices and improve energy efficiency.

#### 3.6.1 Estimation of Overall Commercial Code Compliance Rates

Through the comparison of actual practice baseline conditions with energy code provisions the LCIEC Team has constructed an analysis of the recent and current energy code compliance rates in Massachusetts. The purposes for doing this include:

- The establishment of an overall code compliance rate for commercial buildings for Massachusetts in accordance with the guidelines established for compliance with the American Recovery and Reinvestment Act (ARRA) for codes-related project activities at the state and local levels. These guidelines include the measurement of the compliance rate associated with the commercial energy code identified (IECC 2009/ASHRAE 90.1 2007) in the ARRA legislation. For projects permitted before IECC 2009 went into effect, code compliance was based on Massachusetts Building Code Chapter 13/IECC 2006.

- The identification of overall needs for increased energy code awareness and education.
The identification of compliance categories and individual provisions that represent lower than average compliance rates associated with significant energy impacts.

Identifying opportunities for Massachusetts efficiency programs to offer assistance and incentives in support of code compliance and advancing standard practice.

The process utilized to determine overall compliance rates meets or exceeds all of the requirements of the ARRA legislation and will assist Massachusetts in reaching the mandated goal of 90% energy code compliance by the year 2017.

The process the LCEIC Team utilized is as follows:

1. Assess energy code compliance via interviews with market actors, a review of available construction documents, and site visits at a representative sample of 75 newly constructed commercial buildings in Massachusetts.

2. Calculation of an average rate of compliance across each compliance category: envelope; HVAC; lighting; and procedural (design documents, operational testing, owner training, etc.). For some categories this consists of a compliance/non-compliance rating. For others, such as LPD achieved, the percentage of the differential to code is identified in addition to the pass/fail basis.

3. Calculation of the overall percentage of code provision compliance for the sample of facilities, utilizing the energy impact weighted “Tier” methodology established by the DOE for compliance with ARRA program guidelines.

ARRA Weighted “Tier” Methodology - The methodology recommended by the DOE for establishing code compliance rates utilizes a system that establishes a weighted value for each code provision. This methodology correctly recognizes that individual code provisions have different impacts. In order to assess the relative impacts with reasonable accuracy, the provisions are cataloged in three tiers: High, Medium, and Low Impact. A point system is utilized to compile the results with three points assigned to High, two to Medium, and one to Low Impact provisions. As such a High Impact provision contributes three times as much to the overall compliance percentage as does a Low Impact provision.

Enhanced Weighted “Tier” Methodology – As stated, the methodology utilized in this project complies with the ARRA guidelines but is being enhanced in several important ways:
The DOE/PNNL methodology requires only yes/no determinations on code compliance. Because this project seeks to inform in regards to baseline practices, the actual level of efficiency is recorded in addition to compliance/non-compliance.

The project team has identified a number of instances where the DOE/PNNL methodology does not correctly identify code provision impacts. These will be identified, although the overall compliance rate will reflect the DOE/PNNL methodology in order to be consistent with ARRA requirements and to allow comparisons with other states utilizing this methodology. Examples where we would recommend adjusted impact assessments include:

- Bi-level switching of lighting is assigned a higher impact value than is the ability to turn lights fully off manually or automatically. The relative impacts are likely the opposite.
- The DOE/PNNL methodology scores the impact of SHGC to be greater than the impact of fenestration air leakage. In our climate zone the impact of SHGC is quite minimal and is in fact negative on the south façade for many projects. On the other hand the impact of fenestration air leakage is likely greater.
- Lighting Power Density requirements are incorrectly assessed as “lighting installed per the approved lighting plan.” The team understands from the interviews with code officials and design professionals that “approved lighting plans” are rarely checked for code compliance by code officials. As such we are calculating actual achieved LPDs and quantifying performance against code level Lighting Power Allowances (LPAs).
- For HVAC, the project team recorded what systems and controls have been installed, not simply attempting to assess, in the field, whether or not they are code compliant.

Massachusetts has adopted several amendments to the base (IECC 2009) code. The LCIEC Team assessed those amendments and included compliance information. There is no ARRA requirement that state specific amendments be met; only that the base IECC 2009 provisions be assessed. As such the amendments are not included in the overall compliance score.

For projects permitted prior to the adoption of IECC 2009 we measured compliance in accordance with IECC 2006. This is consistent with ARRA requirements.
• For jurisdictions impacted by the Stretch Code, we investigated whether or not the Stretch Code provisions were followed. Because the Stretch Code is only now being introduced by a significant number of communities, we did not encounter facilities built to Stretch Code provisions.

This enhanced process results in both a statewide compliance rate that is fully compliant with ARRA guidelines as well as compliance information that recognizes the unique characteristics of the Massachusetts climate zone and energy code amendments.

It is important to note the results of this calculated compliance rate does not represent the percentage of commercial buildings that fully comply with the energy code. Although informative there are notable limitations to a single statewide compliance estimate. For example, very few buildings fully comply with the energy code. In fact none of the buildings in our sample were fully compliant. Based on this research, it is clear that some code provisions are misunderstood by both market actors and code officials. Code officials are allowed some leeway in interpreting and applying code provisions, and ongoing code amendments and corrections impact construction projects to a varying degree. It is also clear that implementing an “international” energy code results in some provisions that are insignificant in some climate zones, and some provisions are not fully followed in Massachusetts for this reason.

In addition to providing the overall compliance rates, the LCIEC Team established categories of compliance rates that will allow the sponsors to easily view the potential for improving standard practice, by measure as well as overall compliance. The impacts are weighted using the DOE/PNNL methodology. Additionally both above and below code performance were recorded by category, and with direction from the project sponsors, the data can be evaluated to further assess energy impacts and programmatic opportunities.

In addition, our analysis procedure facilitated making overall judgments regarding design and construction practices. The LCIEC Team assessed the gaps between standard baseline practices and code compliant/best practices. These determinations, along with other code related work sponsored by the Massachusetts utilities, will allow program administrators to target specific areas where education and implementation programs can best effect positive change in new construction practices.
4. **Baseline and Code Compliance Trends**

In this section, the LCIEC Team presents the results of the analysis applied to the site collected “as-built” data for the estimation of overall code compliance rates and compliance rates by subcategories. The compliance results presented include:

1. An estimate of statewide overall energy code compliance rate for commercial buildings, utilizing the DOE/PNNL tiered energy impact procedures developed in support of ARRA funded energy efficiency programs.

2. An estimate of overall energy code compliance within each building size stratum identified for the project.

3. An estimate of statewide overall energy code compliance weighted by building size.

4. Estimates of compliance by energy code category: envelope; lighting; lighting controls; HVAC; and design documentation.

5. Estimates of compliance by commercial building type.

6. Estimates of compliance by geographic region. The regions include inside (east) of Route 95; Route 95 west to Route 495; and areas outside of Route 495.

7. Compliance rates for individual code provisions that represent opportunities for improvement through educational and/or compliance support mechanisms.


9. Compliance trends by permit date to determine if code compliance is trending in any significant pattern as codes become stricter.

10. Code compliance for newly added 2009 measures only.

4.1 **Determining Code Compliance Rates**

Determining new construction practices for completed buildings is not a trivial task. Many elements such as construction materials, equipment, and practices are no longer discoverable once the building is completed. Although design documents (plans and specifications) are often available for review, they may not represent the final “as-built” specifications, and it’s not always certain that contractors follow all details as specified. For larger projects “as-built” plan sets are often produced, yet even those documents cannot be relied upon to fully represent actual construction practice.
The LCIEC Team developed and executed a methodical approach in identifying construction practice, recording design document information and verifying design intent on site through a rigorous inspection process. Data that could not be verified to a reasonable degree of certainty was not included in the final data analysis. Thus, absence of that data does not skew the results in any direction, as it does not contribute to either compliance or non-compliance, as each site is calculated for compliance only on verified data.

4.1.1 DOE/PNNL Compliance Methodology

The compliance rates presented were calculated utilizing the methodology developed by the DOE/PNNL ARRA Team for use in determining current compliance rates and for establishing a plan for participating states to reach 90% compliance with IECC 2009. The methodology weights the impact of compliance with various provisions based on the predicted energy impacts of provision compliance/non-compliance. The weighting is applied in a tiered fashion utilizing three tiers. Tier 3 is weighted at three-times the energy impact of Tier 1, and Tier 2 is twice the impact of Tier 1. A final step provides impact weighting based on building size.

Although the methodology is valid, it is important to recognize some important factors in considering the results:

- The methodology assumes that several visits can be made to construction sites at key construction phases to verify provision compliance. Indeed, this is the best practice code enforcement methodology. However, post-construction evaluation does not provide the same opportunities.

- It is assumed that code officials actually site verify the myriad of energy code provisions. The interviews with code officials that were conducted for this project make it clear that it is not possible for code officials to do so. Code officials have many other code responsibilities and cannot allocate unlimited time to site and/or plan review. Our interviews with both code officials and design professionals suggest that many code officials rely on the design professional statements of energy code compliance. This is not inappropriate, as code compliance, including energy provisions, is a responsibility of professional, registered architects and engineers, and licensed construction practitioners, as well as code officials.

- It is also assumed that code officials would record non-compliance with individual provisions and that recorded information could be utilized to determine code compliance
rates. As it is the code officials responsibility to enforce compliance it is counterintuitive that they would record non-compliance.

- The tiered system may or may not be accurate for any particular climate zone or building type. It generates an overall compliance value that is useful for ARRA program compliance. However, it is much more useful for program administrators to look at individual provisions and provision categories when assessing efficiency improvement opportunities.

- It tends to undervalue, or ignore, the importance of proper installation and proper commissioning. Both are code compliance issues, and both can have a much greater impact than the actual efficiency level of an installed piece of equipment.

In summary, the DOE/PNNL methodology is valid and useful for determining overall compliance rates. However, when looking to develop programmatic opportunities for advancing the efficiency levels of construction practices, it is important to disaggregate the information in order to identify specific areas to address.

### 4.2 Estimated Overall Energy Code Compliance

To facilitate future comparisons with other states using the same methodology, and to allow the results to be utilized for ARRA funding reporting, we calculated the statewide estimate using the proportion (P) weights and compliance score calculation developed by PNNL. These are provided as Equation 1 and Equation 2.

As discussed in section 3, in developing the building scores we assessed compliance/non-compliance only when the combination of design documents, building surveys, and project design team and owner interviews provided a reasonable certainty as to the actual installed condition. This reduces the probability of granting credit for provisions not installed to design intent.

**Equation 1: Calculation of P by size stratum**

\[
P_{\text{size stratum}} = \frac{\text{Total constructed building space for size stratum of building (ft}^2\text{)}}{\text{Total constructed building space for all commercial buildings (ft}^2\text{)}}
\]
**Equation 2**: Calculation of average state compliance score, weighted by building size

\[
P_{\text{small}} \times \left( \frac{\text{sum of building scores in small strata}}{n_{\text{small}}} \right) + \quad P_{\text{medium}} \times \left( \frac{\text{sum of building scores in medium strata}}{n_{\text{medium}}} \right) + \\
P_{\text{large}} \times \left( \frac{\text{sum of building scores in large strata}}{n_{\text{large}}} \right) + \quad P_{\text{Xlarge}} \times \left( \frac{\text{sum of building scores in X-large strata}}{n_{\text{Xlarge}}} \right) + \\
P_{\text{small–additional sites}} \times \left( \frac{\text{sum of building scores in small–additional sites}}{n_{\text{small–additional sites}}} \right) + \\
P_{\text{large–additional sites}} \times \left( \frac{\text{sum of building scores in large–additional sites}}{n_{\text{large–additional sites}}} \right) = \text{Average Compliance Score}
\]

where \( P_i \) = the small, medium, large, X-large, small–additional sites, or large–additional sites proportion weight

\( n_i \) = the number of samples evaluated within the respective size stratum

Figure 4-1 presents the unweighted and weighted overall state-wide compliance rates for Massachusetts commercial buildings. Overall state-wide compliance is estimated to be 80% (unweighted) utilizing the DOE/PNNL tiered impact methodology. **Weighted by building size the overall compliance rate improves to 83%**. This represents the preferred DOE/PNNL methodology for the code compliance requirements associated with Federal ARRA funding for state energy efficiency programs and projects.
The lowest compliance rate calculated for individual projects was approximately 33%, with the highest being 96%. No evaluated projects achieved 100% code compliance. The largest buildings evaluated had compliance rates at the upper end of range; therefore, when weighted by building size, the overall compliance rate improves from 80% to 83%. However, program administrators may wish to focus on smaller buildings where the design teams need more assistance in complying with ever increasing energy code provisions.

Although the compliance rates between various size strata, do not vary greatly, it is clear that smaller commercial buildings experience lower rates of compliance. The reasons for this will be discussed in the conclusions and recommendations section of this report, but are likely associated with the fact that smaller buildings are less likely to be designed by professionals trained in energy code provisions, and/or are constructed under design/build arrangements that do not engage an energy code knowledgeable professional. Code officials tend to be more familiar with small building systems, therefore it is not logical to attribute the lower compliance rates to code enforcement approaches.
4.3 Estimated Compliance Subgroup Analysis

This section provides estimated compliance rates for selected subgroups of the population. As with all statistical analysis, results from small sample sizes and corresponding lower statistical precision should be viewed with caution. Due to the small sample sizes, the LCIEC Team found that applying the site-level weights to the subgroup analysis created results that were unduly influenced by a small number of outlier projects. As such, the subgroup analysis presents the data as collected in the field, without being adjusted by the site-level weights. The LCIEC Team contends these findings in conjunction with the findings of the in-depth interviews with 150 market actors offer valuable insights of code compliance practices in Massachusetts.

4.3.1 Estimated Compliance by Energy Code Category

We disaggregated the site data by code compliance category to help inform the sponsors regarding relative compliance improvement opportunities across the categories. Table 4-1 presents the estimated compliance by energy code categories: building envelope; mechanical systems (HVAC); lighting; lighting controls.

<table>
<thead>
<tr>
<th>Energy Code Category</th>
<th>Building Size</th>
<th>Overall Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less than 25,000 ft²</td>
<td>25,000 to 60,000 ft²</td>
</tr>
<tr>
<td>Total Compliance</td>
<td>75%</td>
<td>80%</td>
</tr>
<tr>
<td>Compliance Weighted by Size</td>
<td>77%</td>
<td>80%</td>
</tr>
<tr>
<td>Documentation Compliance</td>
<td>82%</td>
<td>72%</td>
</tr>
<tr>
<td>Envelope Compliance</td>
<td>78%</td>
<td>87%</td>
</tr>
<tr>
<td>HVAC Compliance</td>
<td>75%</td>
<td>79%</td>
</tr>
<tr>
<td>Lighting Compliance</td>
<td>68%</td>
<td>69%</td>
</tr>
<tr>
<td>Lighting Controls Compliance</td>
<td>76%</td>
<td>86%</td>
</tr>
<tr>
<td>Counts per Stratum</td>
<td>19</td>
<td>19</td>
</tr>
</tbody>
</table>

Again, we observe no dramatic variations, but it is clear that smaller buildings remain low in compliance across the code categories. In addition, lighting provisions remain at the lower end of compliance. This is significant as it is a category easily addressed by efficiency program
administrators. It also raises questions about code enforcement, as the lighting provisions are clearly defined in code documents and the calculations can be readily performed by both design professionals and many code officials.

### 4.3.2 Estimated Compliance by Commercial Building Type

The Team disaggregated the data by building type in order to identify any discernible patterns. Table 4-2 presents the overall compliance rates by the identified building types in the sample. Although the results should be viewed with caution due to small sample sizes, it is interesting to note the low compliance rate for retail establishments. This may underscore the need to further investigate the state of new construction and renovation related to retail buildings.

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Total Compliance</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hotel</td>
<td>76%</td>
<td>3</td>
</tr>
<tr>
<td>Office Building</td>
<td>87%</td>
<td>10</td>
</tr>
<tr>
<td>Restaurant</td>
<td>86%</td>
<td>1</td>
</tr>
<tr>
<td>Retail Store</td>
<td>77%</td>
<td>14</td>
</tr>
<tr>
<td>Education</td>
<td>85%</td>
<td>17</td>
</tr>
<tr>
<td>Hospital</td>
<td>82%</td>
<td>3</td>
</tr>
<tr>
<td>Multi-Family</td>
<td>72%</td>
<td>8</td>
</tr>
<tr>
<td>Residential Hall/Dormitory</td>
<td>80%</td>
<td>16</td>
</tr>
<tr>
<td>Warehouse</td>
<td>68%</td>
<td>3</td>
</tr>
</tbody>
</table>

### 4.3.3 Estimated Compliance by Geographic Region

We also investigated whether there were differences in compliance rates based on geographic location. Table 4-3 presents the compliance rates disaggregated by the region inside (East) of Route 95; the Routes 95-495 region; and areas outside of Route 495.

<table>
<thead>
<tr>
<th>Geographic Region</th>
<th>Total Compliance</th>
<th>Documentation Compliance</th>
<th>Envelope Compliance</th>
<th>HVAC Compliance</th>
<th>Lighting Compliance</th>
<th>Lighting Controls Compliance</th>
<th>Count of Geographic Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside 95</td>
<td>80%</td>
<td>80%</td>
<td>82%</td>
<td>77%</td>
<td>62%</td>
<td>84%</td>
<td>19</td>
</tr>
<tr>
<td>95 -&gt; 495</td>
<td>80%</td>
<td>85%</td>
<td>79%</td>
<td>81%</td>
<td>72%</td>
<td>88%</td>
<td>29</td>
</tr>
<tr>
<td>Outside 495</td>
<td>80%</td>
<td>75%</td>
<td>83%</td>
<td>79%</td>
<td>83%</td>
<td>81%</td>
<td>27</td>
</tr>
</tbody>
</table>
It is perhaps a surprising result that compliance in the greater Boston area (inside Route 95) tends to be lower than within the other two regions. This is noteworthy because the region is represented by more code officials, and those code officials have more experience with commercial buildings. In addition, the same can be said for design teams in the Boston area. In contrast, in more rural areas of the Commonwealth, municipalities often employ part-time officials and/or share the expense of a single official with other municipalities. These officials tend to be most familiar with residential construction as they are often part-time builders, or were previously contractors before taking on code enforcement duties. A possible conclusion is that design teams in the more rural areas focus on fewer projects at a time, and are able to make more thorough code assessments.

4.3.4 Estimated Compliance Rates for Selected Individual Code Provisions

The analysis process allows us to identify some code provisions and compliance rates that present particular opportunities for program administrators to explore for enhancing compliance and harvesting savings through educational and/or compliance support mechanisms. Table 4-4 presents this data. The opportunities or code provision that are listed were those that have a significant response percentage, are estimated to have a relatively low compliance rate, and represent a measure that is often addressed by efficiency program efforts.
Table 4-4: Statewide Compliance Rates by Selected Individual Code Provisions

<table>
<thead>
<tr>
<th>Code Provision</th>
<th>Prevision Description</th>
<th>Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>03.2.7 [ME8]2</td>
<td>HVAC ducts and plenums insulated.</td>
<td>67%</td>
</tr>
<tr>
<td>303.2 [FO4]2</td>
<td>Slab edge insulation installed per manufacturer’s instructions.</td>
<td>62%</td>
</tr>
<tr>
<td>5.5.4.2.1, 5.5.4.2.2 [FR7]1</td>
<td>Performance compliance approach submitted for vertical fenestration area &gt;40% or skylight area &gt;3%.</td>
<td>52%</td>
</tr>
<tr>
<td>502.2.5 [IN8]2</td>
<td>Floor insulation R-value.</td>
<td>75%</td>
</tr>
<tr>
<td>502.2.6 [FO3]2</td>
<td>Slab edge insulation R-value.</td>
<td>72%</td>
</tr>
<tr>
<td>502.4.7 [FR4]3</td>
<td>Vestibules installed per approved plans.</td>
<td>74%</td>
</tr>
<tr>
<td>503.2.10.1 [ME40iecc]1</td>
<td>HVAC fan systems &gt;5 hp meet fan power limitation.</td>
<td>26%</td>
</tr>
<tr>
<td>503.2.4.1.1 [FI5]3</td>
<td>Heat pump controls prevent supplemental electric resistance heat from coming on when not needed.</td>
<td>68%</td>
</tr>
<tr>
<td>503.2.7 [FO8]1</td>
<td>Piping, ducts and plenum are insulated and sealed when installed in or under a slab.</td>
<td>75%</td>
</tr>
<tr>
<td>503.2.8 [ME9]2</td>
<td>HVAC piping insulation thickness.</td>
<td>80%</td>
</tr>
<tr>
<td>504.5 [FO10]1</td>
<td>Any recirculating SWH piping in or under slab is insulated.</td>
<td>86%</td>
</tr>
<tr>
<td>504.5 [PL1]2</td>
<td>Piping for recirculating and non-recirculating service hot-water systems insulated.</td>
<td>73%</td>
</tr>
<tr>
<td>505.2.2.1 [EL10iecc]1</td>
<td>Lighting controls installed to uniformly reduce the lighting load by at least 50%.</td>
<td>70%</td>
</tr>
<tr>
<td>303.2 [IN7]1</td>
<td>Above-grade wall insulation installed per manufacturer’s instructions.</td>
<td>58%</td>
</tr>
</tbody>
</table>

From this data it can be assumed that there are opportunities for program administrators to enhance compliance and harvest savings associated with:

- Buildings with a high percentage of glazed areas
- Fan power limitations
- Lighting controls
- Control of daylit areas
- Insulation of various HVAC ducts and pipes

In addition, we often found that installed lighting power density levels did not meet code. Program administrators could consider adjusting savings calculations to recognize the standard practice baseline, rather than utilizing code mandates as the baseline.
4.3.5 Compliance by Code Version and Trends Over Time

Although the DOE/PNNL methodology applies only compliance related to IECC 2009, we adapted the procedure to allow for a similar calculation for projects constructed under IECC 2006. We tested all applicable building against IECC 2009, and additionally tested buildings built prior to the adoption of IECC 2009 against IECC 2006. Table 4-5 presents the code compliance rates for the projects associated with the two different applicable time periods. (We did visit three buildings that were designed under IECC 2000. The changes between IECC 2000 and 2006 were subtle, so we included those buildings in the 2006 category. Removing the three buildings from the calculation does not significantly affect the result.)

Table 4-5: Statewide Compliance Rates by Code Version/Time Period

<table>
<thead>
<tr>
<th>Project Year</th>
<th>Applicable Code</th>
<th>Total Compliance</th>
<th>Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009 - 2010</td>
<td>IECC2006</td>
<td>82%</td>
<td>48</td>
</tr>
<tr>
<td>2011 - 2012</td>
<td>IECC2009</td>
<td>76%</td>
<td>27</td>
</tr>
</tbody>
</table>

The results presented in Table 4-5 illustrate compliance trends associated with changes in codes, standard practice, knowledge, equipment availability, etc. over the last few years. (For projects where construction dates were not clearly defined or spanned long time periods, the data were not included.) As codes have advanced and become more challenging, compliance rates have deteriorated. This is further discussed in the conclusions section.

4.3.6 Estimated Compliance for Advancing Code Provisions

In order to further refine the compliance rate effects of advancing codes, we disaggregated the compliance results for identified new or significantly strengthened code provisions. Table 4-6 presents the estimated compliance rate for several advancing code provisions.
Table 4-6: Estimated Compliance for Advancing Code Provisions

<table>
<thead>
<tr>
<th>Code Provision</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
<th>% Verifiable*</th>
<th>Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are doors and other access openings leading to shafts, chutes, stairwells and</td>
<td>25</td>
<td>4</td>
<td>29</td>
<td>39%</td>
<td>86%</td>
</tr>
<tr>
<td>elevator lobbies connected to the air barrier or equipped with weatherseals?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below-grade wall insulation R-value.</td>
<td>29</td>
<td>9</td>
<td>38</td>
<td>51%</td>
<td>76%</td>
</tr>
<tr>
<td>Slab edge insulation R-value.</td>
<td>7</td>
<td>28</td>
<td>35</td>
<td>47%</td>
<td>20%</td>
</tr>
<tr>
<td>Wall Above-grade wall insulation R-value=</td>
<td>51</td>
<td>5</td>
<td>56</td>
<td>75%</td>
<td>91%</td>
</tr>
<tr>
<td>Roof Assembly Verified Value. R =</td>
<td>38</td>
<td>12</td>
<td>50</td>
<td>67%</td>
<td>76%</td>
</tr>
<tr>
<td>Are any daylit zones controlled separately? (manual or auto)</td>
<td>33</td>
<td>29</td>
<td>62</td>
<td>84%</td>
<td>53%</td>
</tr>
</tbody>
</table>

*To be verifiable the measure needs to be included in the facility and must be field verifiable

Of the above provisions, below grade insulation levels and the control of daylit zones offer particular opportunities for improved performance. Secondary roof assemblies also represent lower compliance, but the sample is low providing less certainty about the result.

The control of daylit zones within buildings is a new provision and is not well understood by code officials or design teams. By contrast, program administrators often provide design assistance and financial incentives for automated controls that are responsive to daylight. There is a distinct opportunity for the redefinition of the baseline associated with this provision, and or compliance assistance that will produce additional energy savings.

4.3.7 Estimated compliance for Massachusetts Air Barrier Provision

Massachusetts has adopted an additional significant requirement for a “continuous air barrier.” This air barrier must connect all building envelope elements and must seal all envelope penetrations. Although difficult to impossible to determine compliance after construction is completed, we have done our best effort to estimate compliance with this code requirement.
Table 4-7 presents the compliance rates for buildings where there was a reasonable opportunity to gauge compliance with this provision.
Table 4-7: Estimated Compliance for MA Air Barrier Provision

<table>
<thead>
<tr>
<th>Code Provision</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
<th>% Verifiable</th>
<th>Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does air barrier connect: Foundation, Walls, Windows, Roof, Envelope &amp; Penetrations</td>
<td>25</td>
<td>4</td>
<td>29</td>
<td>39%</td>
<td>86%</td>
</tr>
</tbody>
</table>

*To be verifiable the measure needs to be included in the facility and must be field verifiable

Compliance appears to be quite high. However, we caution that air barrier performance is very dependent up proper installation/detailing. Only visiting multiple construction sites would produce results that could be fully relied upon.

It should be noted that the team developing the new proposed Massachusetts Stretch Code is exploring a strengthening of the air barrier provision by requiring testing of the air sealing performance through blower door and other testing procedures.

4.3.8 Stretch Code Comments

The number of projects in our data collection sample for which the stretch code was applicable was not significant. To date, 121 Massachusetts communities have adopted the stretch code, but many of these only became effective in 2012, some will start in 2013, others started 2011, and only two started in 2010 (Buckland and Newton). Sample projects that might have stretch code applicability are too small to draw defensible conclusions regarding code compliance.

Energy efficiency programs in Massachusetts have not penalized projects in stretch code communities by changing to a baseline more stringent than the standard code. This facilitates great opportunities for savings and incentives for projects that are mandated by the “local” energy code. In the future, as the stretch code becomes more entrenched in the communities that have adopted it, it would be valuable to study the levels of code compliance of projects with both the base code (IECC 2009) and with the specific stretch code provisions.

4.4 General and Administrative Observations and Comments

Code Compliance – There are many general observations that can be readily viewed for inspection of the preceding tables and graphs. Some key observations include:

- Code compliance is worse for smaller buildings despite the fact that code officials know the systems that typically installed in small buildings better. Likely contributing factors are that design professionals with code expertise are less likely to be involved in the
smaller projects. In addition, there are contractor driven issues, including less code knowledge and perceived responsibility.

- Most efforts associated code compliance occurs during the design phase, not during site visits during construction as the DOE/PNNL methodology assumes. Designers represent the aspect of the new buildings and construction market that is most aware of the detailed code provisions and the associated technologies. In contrast, contractors and code officials have less knowledge and understanding of the technical code details. Design-side compliance is particularly true for larger facility projects.

- In addition to the above point, code compliance for commercial buildings is performed primarily by the design team, rather than through code official enforcement. Code officials accept that design professionals build to code regulations. Many accept a signed statement or affidavit as proof of energy code (and general building code) compliance.

- Although many code officials accept COMcheck as evidence of code compliance, the tool is often misunderstood since it does not represent sole evidence of proof of compliance. Data entry in COMcheck must be checked against the plans and specs for compliance, and installation techniques are beyond the scope of COMcheck.

- Overall code compliance is relatively high at an estimated 80%.
  - This does not mean that 80% of buildings comply – as we found no buildings fully in compliance.
  - It refers to the average provision compliance weighted by energy impacts as proposed by DOE/PNNL.
  - It is more relevant to say that on average, commercial buildings perform 20% worse (from an energy perspective) than the code requires.
  - Considering that efficiency programs strive for 15-20% performance improvement compared to code, this 20% is a significant number and represents an opportunity that can be addressed through programs.

- PA’s should not place a singular focus on improving enforcement; rather, they should continue to focus on beyond code measures. Such a focus fulfills the goal of improving compliance rates while also harvesting additional savings for performance above code compliance. Such efforts promote improved compliance rates through a better understanding of basic code requirements, but do not neglect the potential for further improvement. Further, considering there is an average energy gap between observed
levels of practice and fully code-compliant projects, we believe programs should seek the ability to utilize “standard practice” baselines, for measures that often fall below code requirements, and claim savings on projects for the delta from standard practice to code compliance in addition to the delta from code compliance to the installed project.

- Design professionals tend to become increasingly interested in new or recently strengthened code provisions. PA’s should focus on these measures to gain traction and to achieve greater impacts.

- Code officials should be taught basic building science, HVAC principals, and the use of controls systems, rather than being taught to memorize energy code provisions. In the effort to just push towards memory of provisions, code officials tend to just focus on a few provisions that they have keyed into or grasped, neglecting consideration of many other requirements. A broader base of insights associated with a deeper understanding of energy use and concepts should enable a more energy-intensive set of focus areas.

**Design Documentation** – Amongst the collection of administrative requirements stated in the code, the code requires that project plans and specifications include enough detail to identify performance levels and to verify compliance with code provisions. In most cases the project documentation is adequate, but there are many cases where the documentation does not reflect the as-built condition or where information is missing. Some identified lack of plans data include:

- Window and door specifications are often missing model #s and/or performance data. Nevertheless, as required, labeling on those installed products is generally left in place for code official inspection even though there are some comments that information is seldom checked.

- Lighting fixture details are often missing or are incorrectly listed with nominal lamp wattage data, rather than the rated luminaire wattage, which is dictated by the lamp/ballast combination in fluorescent and HID luminaires.

- Incomplete data regarding HVAC model numbers, however field verification is typically obtainable and advisable as equipment substitution is common.

- Service water heating data is often missing from plans/specifications.

In addition to code requirements for documentation is the concurrent requirement for labeling of products. As stated, this information is typically clear and available and enables the code officials to fully assess installed systems.
4.5 Building Envelope Observations and Comments

- Continuous Air Barriers – As previously discussed, this is not an IECC requirement, but is a Massachusetts Code Amendment. Air barriers are very difficult to verify unless the construction project can be visited at the appropriate time. Although we attempted to visit as many construction sites as possible, we rarely had the opportunity to field verify air barriers. However, we did review plans carefully and discussed the air barrier with building design teams and owners, gathering as much data as possible. We found that a continuous air barrier was typically specified, but that the design documents often lacked the detail to assure that the barrier would effectively connect all building components. It was also impossible for the field team to determine if installation was in accordance with the design documents. The results of our findings for air barriers should be considered to have a high margin of error.

- Air Sealing – In nearly all cases, exposed penetrations of the envelope were observed to be or were seemingly properly sealed. As with air barriers, much air sealing is enclosed within envelope assemblies and difficult to field verify after construction is complete or past a certain point.

- Below Grade Insulation – For all projects reviewed to date, some below grade insulation was specified. However, in approximately 50% of the cases, the R-value of the specified insulation was somewhat below current code levels, but did meet the provisions of the previous code that was in effect through June 2010. It is reasonable to conclude that the construction industry and code officials have not yet adjusted to the increased insulation requirements of IECC 2009 for below grade insulation.

- Above Grade Wall Insulation – For most projects, the above grade wall insulation levels meet code standards. Insulation levels were verified on design documents and field verified whenever possible. This is an area that is often checked by code officials according to our interviews. As code officials are generally most familiar with residential construction, insulation materials and techniques are well within their areas of expertise.

- Roof Insulation – Approximately 20% of the projects evaluated were specified or constructed with roof insulation R-values below current code levels for the primary roof assembly. When a secondary roof assembly represented a different construction detail, we found that compliance was even lower. This is a smaller sample, but likely is associated with difficulty of designing some assembly types to code compliant levels.
4.6 Lighting System Observations and Comments

In contrast with envelope provisions which are difficult to evaluate post-construction, we were able to assess lighting system compliance for all evaluated buildings. When full sets of design documents were available, our team of field evaluators calculated lighting power density levels from electrical/lighting plans, and then field verified that the lighting was installed as designed, noting any discrepancies. When there was a lack of available lighting plans, we measured spaces, recorded fixture types and counts, calculating and recording the result. The following observations relate to the site data collected regarding lighting measures:

- **Lighting Power Density** – In what represents a significant opportunity for efficiency programs, we often field calculated lighting power density levels significantly higher than code allows for a building area or space type. This is especially true of some space types such as performance centers and dining halls, where LPD was found to be as high as twice the code allowance. The high density levels for these space types is attributed to the fact that incandescent lighting is still a favored technology for certain spaces, as fluorescent lighting has failed to reach acceptance for some space types due to performance issues related to color rendering and “punch.” LED lighting for these space types has, until recently, not met cost-effectiveness criteria for efficiency program support. With recent performance and cost improvements, LED lighting represents a significant opportunity to install quality lighting systems at low power density levels.

- **“Manual” Lighting Controls** – In nearly all cases, the requirements for manual control for each controlled space are met. This may seem trivial, but prior to energy code adoption, it was common for commercial buildings to control lighting at circuit panels, resulting in lighting that was powered during all operating hours.

- **Bi-Level and Automatic Controls** – The requirement that many space types have bi-level manual or automatic controls installed is not often complied with, and the code includes many exceptions for this provision. The requirements for automatic occupancy or timer controls are being met on average in 75-90% of the projects. The fact that we found occupancy sensors installed and functioning is a positive sign, as early versions of sensors experienced reliability and operational problems often leading to early retirement of the controls.

- **Exterior Lighting Control** – For exterior lighting, the provision that a timer or photocell control be installed was nearly always met.
• Daylighting Zone Controls – The separate control of daylit zones is a new provision introduced with IECC 2009. It requires that daylit zones within commercial buildings be recognized and be controlled separately. The design community and code officials have not yet embraced the new requirements for separate control of daylit zones, as we found low compliance rates with this measure. This represents a significant opportunity as, with the exception of retail space, modern commercial buildings are typically designed with 25-40% of their occupied areas receiving enough daylight to allow the electric lighting to be dimmed or turned off for a majority of the workday. School designers are recognizing this as they often control lighting close to classroom windows separate from the remaining lighting in the room.

4.7 HVAC System Observation and Comments

HVAC measures and requirements contained in the energy code address a myriad of aspects of HVAC components, including specific primary equipment efficiencies (for unitary, boiler, furnace, chillers, and other equipment), size limitations for fans and pumps, speed control capabilities for fans and pumps, temperature and pressure control equipment, and distribution system insulation and sealing. Compliance was observed to be highly variable among these categories.

• System Rated Efficiency Levels – The majority of the equipment installed on site and specified in the drawings met or exceeded the code. The energy code adopted by Massachusetts is nearly identical to the code adopted throughout the Northeast. Manufacturers, their sales representatives, and distributors, do not normally stock or provide equipment that does not meet the minimum criteria to pass the code requirements. For this reason, HVAC equipment efficiency levels are complied with essentially by default.

• HVAC System Insulation Measures – Basic measures such as duct insulation and sealing and pipe insulation were observed to be in compliance less than equipment efficiency levels. Many of these requirements have been in place for multiple code versions, yet compliance is still relatively low.

• Auxiliary System Sizing and Control Requirements – The code presents many specific requirements for sizing of HVAC auxiliaries and for the overall control of the HVAC systems. These systems presented lower levels of compliance, perhaps due to the complexity of such requirements and the associated lack of understanding by the design and construction communities. Some of these requirements involve application of
calculations to arrive at appropriate size or flow controls, and this might be a factor in achieving higher levels of compliance.

- **Control Measures and Efficiency Programs** – While code requirements mandate the existence and basic capabilities of controls (rather than the setup and continued operation of controls), there seems to be an opportunity for programs to support both better compliance with control installation and then enhanced operation of those controls. Leveraging commissioning, retro-commissioning, and continuous commissioning program efforts, it should be possible to achieve higher levels of code compliance while also moving projects to better operation after the project is completed.

- **HVAC Compliance and Building Size** – The stratum for the largest buildings has the highest HVAC compliance, whereas the smallest buildings have the lowest compliance. In fact, the largest buildings complied with HVAC requirements 20% more than the smallest stratum. This could be representative of the amount of effort put forth in the design of the large building projects. The larger buildings obviously have a larger design budget and may benefit from extra time spent on details. It may also be indicative of time spent on site scrutinizing the building construction techniques.

- **HVAC Compliance Variation with Code Versions** – Overall, the HVAC compliance IECC 2009 projects was lower than those that had to comply with IECC 2006. Again, considering the complexity of HVAC systems and the associated code requirements, this compliance difference seems to suggest the struggles of the design and construction community to better understand the new code requirements. Training that addresses these communities should facilitate a progressively higher level of compliance with the new code and with future code introductions.

- **Geographic Variation in HVAC Compliance** – The urban area inside the I-95 belt had only a slight difference in compliance levels than that for projects outside I-495, which contains more suburban and rural areas. In contrast, the areas between I-95 and I-495 had the highest HVAC compliance. It is not clear whether the driver for this higher level of compliance is associated with the types of communities, the types of projects, or a greater code awareness of the firms and code officials that work in these areas.
5. In-Depth Interview Findings

This section provides the findings of the initial and project specific in-depth interviews. Twenty-one market actors were interviewed during the initial in-depth interviews and 127 interviews were conducted as part of the project specific interviews. In addition, one design community focus group session was conducted as part of initial in-depth interviews. Table 5-1 provides a breakdown of the various parties interviewed for each effort.

Table 5-1: In-Depth Interviews Respondent Breakdown

<table>
<thead>
<tr>
<th>Market Actor</th>
<th>Number of Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial In-Depth Interviews</strong></td>
<td></td>
</tr>
<tr>
<td>BBRS Code Development Manager</td>
<td>1</td>
</tr>
<tr>
<td>PA New Construction Program Implementers</td>
<td>6</td>
</tr>
<tr>
<td>Building Code Officials</td>
<td>7</td>
</tr>
<tr>
<td>Wholesale/Retail Suppliers</td>
<td>6</td>
</tr>
<tr>
<td>Design Community (focus group)</td>
<td>1</td>
</tr>
<tr>
<td><strong>Project Specific In-Depth Interviews</strong></td>
<td></td>
</tr>
<tr>
<td>Building Code Officials</td>
<td>19</td>
</tr>
<tr>
<td>Building Owners/ Owner’s Project Managers</td>
<td>65</td>
</tr>
<tr>
<td>Design Community</td>
<td>43</td>
</tr>
</tbody>
</table>

The findings from these interviews provide an understanding of the market structure for assessing energy code compliance and related enforcement efforts as well as an understanding of challenges and opinions market actors have of the energy code. The responses have been categorized according to overarching themes. The key findings associated with each theme are included in the sections to follow. The identified themes include:

1. **Commercial Code Compliance General Practices.** This section summarizes the basic methods that building officials use to determine compliance including what documentation they require as well as the resources they use.

2. **Commercial Energy Code Implementation Barriers.** This section focuses on the practice of implementing the energy code and what challenges are faced. Interviewees report a variety of barriers to code implementation ranging from lack of knowledge across market actor segments to lack of resources available to provide code
clarifications. Staffing levels of municipal and state inspection offices appear to be greatly mismatched given the number of projects, non-energy code related inspections, and responses to permit violations that each is required to track, manage, and address.

3. **Commercial Energy Code Knowledge and Training Needs.** This section examines market actors’ current understanding of the commercial energy code, highlights knowledge gaps, and identifies training needs. Due to the rapid changes in the energy codes, introduction of the Stretch Energy Code, an increase of non-energy related building regulations, a majority of interviewees across market segments have not mastered the new energy codes and desire comprehensive training opportunities.

4. **Commercial Energy Code Technical Challenges and Opportunities.** This section provides a summary of the on-going technical challenges that design teams, contractors, and owners face when trying to meet or exceed the energy code using more energy efficient equipment and materials. Energy modeling is a key topic of conversation indicating its importance as a tool for architects and engineers in assessing building performance.

5.1 **Commercial Energy Code General Compliance Practices**

This section presents key findings related to commercial energy code compliance practices.

**Building officials rely heavily on Construction Control regulations (780 CMR 116.0) to ensure energy code compliance.** Documentation practices for commercial energy code compliance differ per jurisdiction although virtually all jurisdictions require architects and engineers to follow Construction Control methods (780 CMR 116.0). Construction Control regulations apply to all projects requiring a registered architect or professional engineering services above a small size, such as one and two family dwellings, and mandate the following: 1) stamped plans, computations, and specifications, 2) submittal review, 3) regular field inspections by members of design team, i.e. field visits and reports, and 4) stamped final compliance documentation. In practice, Construction Control documentation is referred to as design affidavits, field reports, and final affidavits.

**About half of the building officials interviewed request U.S. DOE software COMcheck to help judge compliance.** COMcheck compares baselines from 2006 or 2009 IECC / ASHRAE 90.1-2004 or 2007 codes and standards to the proposed building design. COMcheck offers four compliance modules including envelope insulation, interior lighting power densities, exterior
lighting power densities, and HVAC equipment efficiencies, with the ability to generate compliance reports. Fourteen of the 26 building officials interviewed use COMcheck reports to help them determine compliance. Further, based on the interview findings, when building inspectors and commissioners request COMcheck reports, they are usually referring to COMcheck *envelope* reports. However, a small number of code officials do also ask for the COMcheck lighting and HVAC reports. Interviews for this study revealed that a few jurisdictions are also accepting narratives, results of energy modeling studies, and commissioning reports. One Stretch Code city official we spoke with has developed a specific compliance form exclusively for Stretch Code projects.

**Building officials report that their code reviews are made easier when architects and engineers prepare a code page in project drawings, and for complex projects, narratives of how their designs meet the commercial energy code.** Preparation of code summary pages and energy code compliance narratives help facilitate reviews by building commissioners, inspectors and plan reviewers. The code page cites the version of the energy code under which the project is permitted. A narrative offers a detailed explanation of energy code compliance and serves as a guide for plan and specification review.

**Because the Stretch Energy Code is relatively new and adopted on a voluntary basis, few building officials, designers, or owners are very familiar with the commercial portion of this code.** As with any code update, lag time exists before new projects are designed and permitted to the new code. This lag time, and the economic recession that began in 2008, has further slowed the introduction of commercial projects in Stretch Code municipalities. The Stretch Energy Code or “Stretch Code,” adopted as an appendix to the Massachusetts Building Code on July 24, 2009, is designed to allow municipalities to “stretch” beyond the state residential and commercial energy codes. Even though Stretch Code adoption has been relatively rapid - approximately 30% of municipalities have adopted it to date- few designers, owners, or building officials have worked on a commercial Stretch Code project from schematic design to final occupancy.

**Architects and engineers are primarily responsible for documenting compliance with the Massachusetts commercial energy code during the building design.** Forty-eight of 66 owners and owner’s project managers (OPM) respondents indicated their engineers or architects handled compliance. For 6 of the 48 projects, the owner or OPM also contributed to the compliance process. In five cases, the contractor was noted as primarily being responsible for documenting energy code compliance.
Projects that did not use design professionals to prepare compliance documentation appeared to be small design-build projects, but not always. The general contractor for a new university lab building reportedly prepared energy code compliance documentation. In a few cases, owners themselves claimed responsibility for code documentation, notably a large commercial retail respondent, a biotech firm, and a multi-family project, but some of this subset received help from electrical/mechanical subs, construction managers, and in one case, from Conservation Services Group.

The project’s consulting design engineer is the ultimate decision-maker/expert on equipment specifications. The sales engineer typically does not try to influence product selection based on efficiency. Consulting design engineers typically specify the cooling/heating loads, run bin analyses, and prepare system optimization calculations for sales engineers who, in turn, will track the manufacturing and delivery process, especially where large, costly, and sophisticated equipment is specified. For new construction, the HVAC equipment vendor will sometimes work with the design engineers and owners to assess different equipment types.

Owner involvement and understanding of commercial energy code depends on the type of commercial project and established energy goals. Owners typically depend on the architects and engineers to coordinate permitting issues and compliance; however, for many public school projects, college and university projects and for some national retailers, the owner or owner’s project manager regularly interact with and conduct walkthroughs with the building officials. In one case, a major national retail chain stated that they have their own process in place to deal with code compliance. This indicates that the building owner segment does play an active role in the code compliance process for certain customer types.

Among the design and building official communities, there is a basic misunderstanding that achieving LEED certification and meeting the Massachusetts Building Code are equivalent. LEED certification can be achieved by outperforming ASHRAE 90.1-2007 baseline requirements by a percentage established by the USGBC. Meeting or exceeding ASHRAE 90.1-2007 is also a pathway for Massachusetts’ commercial energy code compliance. However, Massachusetts’ energy code is augmented by amendments including the mandate for a continuous air barrier. Based on the data collected, achieving LEED certification does not necessarily mean that a building meets all requirements of the Massachusetts commercial energy code.
Out of 43 project specific interviews with design team members, 30 respondents indicated that their projects had established energy goals. The goals range from formal rating systems such as LEED, MA-CHPS, MA-LEED Plus, to performance goals such as Zero-Net Energy (ZNE), and to a percentage performance better than code. Other goals mentioned were mainly related to enhanced equipment efficiencies, although in the case of one major national retail chain, the company has set its own aggressive energy efficiency goals that align with its corporate sustainability policies.

Figure 5-1 below depicts the range of energy goals reported by building type based on the responses from the 43 design team members interviewed for the 48 buildings they represented.

Figure 5-1: Energy Goals by Building Type
Table 5-2 provides sample of direct quotes from owners and design team members that explain why they set energy performance goals for their new constructions. Each response represents one building project.

**Table 5-2: Owner/Designer Motivations for Setting Energy Performance Goals**

<table>
<thead>
<tr>
<th>Stated Energy Performance Goal Motivations</th>
<th>(Building Type)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• We have a company-wide policy and awareness towards sustainability (Biotechnology Company)</td>
<td></td>
</tr>
<tr>
<td>• The town building commission has knowledgeable members with HVAC, construction, and electrical experience. They understand the importance of energy and are financially savvy. (Public School)</td>
<td></td>
</tr>
<tr>
<td>• The state mandates [MA-LEED Plus]⁵ and we abide by the President's Climate Commitment⁶ to reduce greenhouse gases. In addition, we were comfortable with going for Zero Net Energy (ZNE) because our architect was on the State ZNE task force. (College Academic Building)</td>
<td></td>
</tr>
<tr>
<td>• We're always trying to find new cost effective technology. Our corporate plan is to be perceived as a green retailer. (Commercial Retail Chain)</td>
<td></td>
</tr>
<tr>
<td>• It is in our corporate standard practice; for example, we have ongoing recycling programs and have another building that is LEED platinum. (Biotechnology Company)</td>
<td></td>
</tr>
<tr>
<td>• We wanted a state of the art building. We own and operate the building and understand the benefits of a LEED building pretty well. The City of Boston also has requirements for being at least LEED Silver certifiable as well as EnergyStar certified. (Multi-family)</td>
<td></td>
</tr>
<tr>
<td>• Extra incentive points through the Massachusetts School Building Authority. We get points for CHPS certification or LEED Silver certification. (Public School)</td>
<td></td>
</tr>
<tr>
<td>• Quality. Building the most cost effective project has lower operating and maintenance costs over the long run. (University Recreational/Lab Building)</td>
<td></td>
</tr>
<tr>
<td>• The owner required LEED Silver, and the Advanced Building Program made good business sense. (Owner-Hospital; Project – Residential Care Facility)</td>
<td></td>
</tr>
<tr>
<td>• We, as a construction company, apply certain principles to our practice. On every job we do, we try to insulate the exterior, and depending on the budget size, we may increase the insulation level. We include efficient windows, condensing boilers, install lighting sensors. We do our best to at least meet the minimum Massachusetts baseline. (Assisted Living Facility)</td>
<td></td>
</tr>
<tr>
<td>• [Utility] rebate money and marketing of affordable housing units. (Multi-family)</td>
<td></td>
</tr>
<tr>
<td>• Goals were put in place to save money for the tenant and owner. Owner pays utility costs for certain common spaces that are metered separately. (Medical Center)</td>
<td></td>
</tr>
</tbody>
</table>

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⁵ On April 18, 2007 Governor Deval Patrick signed Executive Order 484 – Leading by Example: Clean Energy and Efficient Buildings. The order directs that all newly constructed state facilities over 20,000 square feet must meet Mass LEED Plus requirements. All new construction less than 20,000 square feet must meet the Mass LEED Plus, achieve 20% more efficiency than the Mass. Building Energy Code, or meet the Core Performance Advanced Buildings energy criteria. The Mass LEED Plus standard is the same as LEED for New Construction but imposes additional prerequisites on Massachusetts state projects:

- Twenty percent for efficiency than the Mass. Building Energy Code baseline
- Reduction of outdoor water consumption by 50% and indoor water consumption by 20% relative to standard baseline projects.
- Conformance with at least 1 of 4 smart growth criteria from LEED’s Sustainable Sites category.

⁶ The President’s Climate Commitment refers to the president of a college or university who has signed a pledge to work toward climate neutrality as part of an effort known as the American College & University President’s Climate Commitment.
5.2 Commercial Energy Code Implementation Barriers

This section presents key findings related to barriers that were identified to energy code implementation.

Building officials consistently reported their departments to be understaffed and under budgeted. Lack of money, lack of time and lack of staff were frequently mentioned as limitations that impede officials’ abilities to enforce the energy code. Some building officials reported an additional consumer of their time—i.e. the time needed to educate builders and contractors on code issues – contributing to the resource constraints on their departments.

Building officials in general feel overloaded with responsibilities. Building officials reported that a wide range of responsibilities including: code and zoning enforcement, annual code inspections, addressing permit violations, performing plan reviews, and completing multiple site visits of construction and renovation projects. Building officials frequently stated that they do not have enough time to do all of what is expected of them.

Regular code inspections of existing buildings can use a lot of building officials’ staff time and resources. By law, building officials are required to conduct periodic inspections of particular building use groups such as assembly (restaurants, theaters, places of worship), educational (schools and daycares) group care (hospitals, nursing homes), residential (hotels, summer camps, multi-family) and bars7. In addition to checking fire safety and egress, they are mandated to enforce 521 CMR (Architectural Access) and may have to enforce local building-related or zoning bylaws or ordinances. One inspector, from a metropolitan Boston city, said that in addition to overseeing commercial building projects, he completes annual inspections for life safety and egress of colleges, hotels, motels, daycares, and churches. He noted that there are at least 100 academic buildings alone in his jurisdiction, each of which requires a site visit.

Most building officials agree that code provisions such as life safety and structure take precedence over energy code related items. Items related to life safety (e.g. functionality of alarms, emergency systems, and sprinkler systems; establishing means of egress), structure (e.g. ensuring that the building has structural integrity and meets seismic code); and

7 Refer to 780 CMR Chapter 1 Section 110 Table 110 – Schedule for Periodic Inspections of Existing Buildings
accessibility (i.e. ensuring compliance with Americans with Disabilities Act (ADA) requirements) would likely be prioritized over energy code items if they had to choose which codes to enforce.

Building officials, inspectors, and plan reviewers state that energy code provisions receive a limited amount of time when reviewed concurrently with other Massachusetts building codes, both during plan reviews and field inspections. When asked to separate out the range of time devoted energy code compliance during plan reviews and field inspections, the overall ranges provided were 10 minutes to 2 hours for plan reviews and 15 minutes to 4 hours for field inspections. When asked what percentage of time is spent on energy code items versus other items, most building officials estimated around 10%.

Numerous factors affect the time devoted to plan reviews and field inspections – chief among these are size and complexity of building projects. Nineteen of the twenty-six building officials interviewed reported that the size and complexity of the buildings are key factors in determining length of time devoted to a project. Additional factors include depth of knowledge of the design team, and the level of detail provided on the design documentation, as well as limited staffing resources, and numbers of projects officials have to attend to at one time.

The levels of sophistication of HVAC systems and their controls exceed the abilities of building officials and inspectors to evaluate them. This finding is a common theme across jurisdictions, regardless of size or location of jurisdiction, years of staff experience, or urban versus rural environments. Today’s HVAC equipment is often controlled by onboard computers or by central computer systems referred to as building automation systems (BAS) or building management systems (BMS). As one building official lamented, it is hard enough “just understanding the mechanics of the building; none of our building inspectors is trained in these complicated systems (e.g. HVAC systems); everything is software operated (BMS).”

5.3 Commercial Energy Code Knowledge and Training Needs

This section presents key findings related to commercial energy code knowledge and training.

Additional education and training on the commercial energy code was repeatedly cited as a need across all market actor categories. The number of new regulations from all chapters of the building code, coupled with rapid energy code updates (2008, 2009, 2010), and the introduction of the Stretch Energy Code have made it difficult for the design community, code officials, vendors, and program implementers to keep track of energy code provisions.
Respondents from all market sectors requested more frequent and in-depth training on the energy code.

**Education, training, and third party compliance verifications were cited as necessary for compliance improvements.** Members of the design community felt that building inspectors need to be better trained, noting that the inspectors may not have the technical backgrounds needed to enforce energy code provisions. Building officials typically claimed that training and education for contractors is vital. Many relayed that they spend too much time trying to educate contractors and installers. Additionally, building officials felt that having third parties involved in assessing energy code compliance and energy modeling accuracy would be beneficial.

**For commercial projects, building inspectors tend to focus their plan reviews and inspections on envelope measures such as building insulation, air sealing at joints and seams, and continuity of the air barrier.** Most inspectors indicate an awareness of energy code provisions that address interior and exterior lighting power densities (LPD’s) and HVAC system design and control provisions, but feel they are beyond their training and technical expertise to verify compliance.

**Respondents indicated that they rely heavily on consulting design engineers as the experts in code-related issues.** Based on information provided by the respondents, wholesale/retail suppliers, program implementation staff and the building officials utilize consulting design engineers to: 1) learn about what constitutes efficient equipment, 2) verify that heating, ventilating and air conditioning systems are installed and operate as designed, and 3) understand energy code updates. The finding indicates the important role designer engineers play in teaching code content and context to multiple types of market actors.

**Of the three HVAC and two lighting vendors interviewed, all said that they are “a little familiar” with the MA energy code.** Most vendors were quick to point out that they have in-house staff (e.g. engineers) who learn the portions of the code that apply to their particular trade. One lighting distributor interviewed relies primarily on his clients and on the program implementers’ energy efficiency programs to learn about new levels of efficiency.

**Program implementers learn the commercial energy code primarily by self-teaching or participating in MASS-SAVE committees.** Only one PA mentioned that his team utilizes a technical assistance vendor to summarize and present the changes from one iteration of the energy code to the next. Altogether, the LCIEC Team interviewed six program implementers representing six different PA’s. For half of the respondents, it appears that the energy code is learned on an as-needed basis to update program efficiency thresholds,
predicted measure savings, and incentives. The program implementation teams may benefit from holistic training that covers the entire code and provides a detailed summary of energy code changes from one code version to the next.

For code officials and design professionals, learning new commercial energy codes would be enhanced by access to supplemental energy code information and resources. Several respondents requested materials that would: 1) fully explain the changes in the new code and why changes were made, and 2) describe what the code is trying to accomplish in certain instances. For the latter, there are published handbooks provided by ICC and ASHRAE that could describe the theories and engineering assumptions for code provisions.

Energy code training influences enforcement practices by increasing awareness of energy code requirements. Increased awareness often translates to greater effort to determine code compliance through plan reviews, field inspections, and COMcheck reports. Interview results indicate that training is not only helpful but alters enforcement practices. One challenge noted was the lag between the initial training and the time it takes for new commercial projects to be permitted under the new code. As was noted, by that time, the initial training on the new energy code may not be well-retained. Some code officials feel that initial training coupled with follow-up training – for example 6 months to 1 year later – would improve their enforcement abilities.

Architect and engineering professionals are expected to be well versed in new versions of the energy code, but opportunities to comprehensively learn new code provisions depend on the firm’s approach to code education. As noted from interview responses, some firms offer in-house training and encourage staff to view ASHRAE/AEE webinars while other firms expect their staff to absorb new codes as they work on client projects. Between these two approaches is what one architect described as an “organic” process: “All of us learn collaboratively. We will use each other as resources based on our individual experiences on the projects. Learning the code many times is project specific. I might be working on one project that is working from the 7th edition; another colleague of mine might be working on a newer edition.”

Most building officials and design professionals prefer to receive training by classroom learning rather than in the field or online/via webinar. Among building officials, 21 out of 23 indicated that they preferred classroom learning while just under half also prefer in-the-field training. Only 5 of 23 indicated preference for online/webinar training delivery. Among design teams, 22 out of 30 indicated that they prefer classroom settings; fifteen also prefer
online/webinars, and an additional seven answered that they also like in-the-field training. Because design professionals often must maintain accreditation for their professional licenses or for the American Institute of Architects (AIA) or the Green Building Certification Institute (GBCI), training that offers continuing education hours is likely to result in increased attendance.

For vendors of commercial lighting and HVAC products, familiarity with the energy code is often supplemented by or wholly informed by the program implementers’ efficiency metrics for prescriptive measures. For example, one lighting distributor learns about which fixtures are considered energy efficient from EE program staff and the prescriptive incentive forms.

Opportunities may exist for building materials suppliers to offer code related training classes. One company representative stated that her company offers codes training to the public. According to the contact, “Lots of businesses are small operations and don’t have time to review 500 page documents of regulations. [We] offer 2 classes per year for builders on Stretch Code (Had about 40 people attend each training.) Most customers are not familiar with energy code or Stretch Code.”

5.4 Commercial Energy Code Technical Challenges and Opportunities

Lighting design and envelope construction are the most commonly cited challenges that design teams and contractors face with the energy code. Some architects expressed concern that lighting power density requirements are too difficult to meet or that they conflict with their design. In one case, an architect wanted to use incandescent bulbs for a nursing home facility because the “vibration and [lack of] brightness of CFLs may cause issues with the residents”. Regarding the building envelope, several respondents expressed that meeting the continuous air barrier requirements takes considerable effort as does maintaining continuous insulation between different building materials (e.g. between wood and CMUs).

Design engineers and energy modelers expressed a common desire for informed third party reviews of their work. While most report confidence in their abilities to model complicated projects, they recognize that their modeling assumptions and design documentation needs third party review just like any complex engineering discipline. An engineer working on a variety of MA-LEED Plus projects noted that he submits an energy model to the state at every phase of design but has never received any feedback. As he put it, “I have
never gotten so much as a phone call, email or contact about my results. Either what I do is perfect, or no one is looking at it.”

**Using different metrics such as energy cost and site energy to represent predicted energy savings introduces confusion for design engineers and their clients for new construction projects.** This was a concern expressed by several of the attendees of the design team focus group session. A savings goal of 20% more efficient than ASHRAE 90.1-2007, may be easy or quite difficult to attain depending on the metric used. LEED uses energy cost savings percentages which does not necessarily correlate with site or source energy savings. The Stretch Code uses site energy as its benchmark. Therefore, it is highly likely that owners who want to achieve LEED energy credits and satisfy Stretch Code will be looking at two different savings percentages for their new construction projects.

**Using site energy versus source energy is another example of how different metrics introduce confusion for new construction projects.** The design team focus group also noted that measuring savings using site energy can result in counter-intuitive conclusions than when site energy is used. Site energy does not take into account the energy lost to generation and distribution of different fuel types. An energy modeler from a prominent Boston architectural firm stated this about the subject, “We increase gas usage a bit, and reduce electricity, which is great environmentally, but with site energy as a metric, it looks like we’re being less energy efficient. It’s not as good as [using] source energy.” Consequently, site energy may not accurately represent the full energy savings offered by different building designs and equipment.

**Due to the inflexibility of modeling rules, building energy modelers are not rewarded for innovative designs that ultimately save energy.** According to ASHRAE 90.1 Chapter 11 and Appendix G, “All conditioned spaces in the proposed design shall be simulated as being both heated and cooled even if no heating or cooling system is to be installed, and temperature and humidity control set points and schedules shall be the same for the proposed and baseline

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8 Design engineers attending the focus group noted that for federal projects, such as buildings designed for the Bureau of Overseas Buildings Operations or the Veteran’s Administration, modeling assumptions and engineering calculations are reviewed by third parties. Engineers are asked to justify their energy modeling results and justify their design assumptions that impact energy consumption.
building design”. This means that innovative designs that change temperature and humidity parameters to save energy do not necessarily receive credit for them.

As an example, the benefits of specifying a high efficiency chiller are not as large when the proposed design includes an expanded thermal range – e.g. cooling setpoint of 76 compared to 70 deg F. Yet, establishing a higher cooling setpoint ultimately saves more energy than dropping the cooling setpoint to 70 deg F. However, ASHRAE 90.1 modeling guidelines do not account for behavioral changes such as the changing temperature setpoints and as a result, innovative design is not rewarded by LEED or the Stretch Code.

**Process loads are not well-addressed by the Stretch Code, and therefore, savings calculations may overstate energy efficiency in new construction.** Building modelers note that process loads vary greatly according to building type and function. One engineer summed up the problem by stating, “With building energy modeling, we can make the software do whatever we want it to. The amount of process loads is so different. In dorms, it is a bunch of kids and TVs. In labs, there is a huge amount of outside air, which minimizes the effect of a well insulated envelope. But there are going to be some buildings that are 70% process loads and some buildings that are much less than 25% process loads. When you make the calculation of your energy savings, you remove the process loads from the denominator.” The result is that absolute energy consumption can be quite high (or low), but calculations that remove process loads do not necessarily reflect actual building consumption – just relative consumption for regulated loads.

**For owners and design team respondents, challenges in meeting the commercial energy code baseline typically relate to the building envelope.** Among 33 owners and design team members interviewed, 18 owners and 8 designers reported challenges involving some aspect of the building envelope. Six mentioned HVAC equipment and four commented on lighting. Based on feedback provided by building officials, design engineers may have encountered fewer difficulties for lighting and HVAC due to the building officials’ reliance on signed affidavits to verify compliance rather than using a tool or an independent third party to check designs and installations.

Owners and designers were asked to detail any issues, if any, in meeting the commercial energy code during design phases and during actual construction. Table 5-3 below presents the combined responses from 18 owners and 8 designers for both design and construction phase problems.
<table>
<thead>
<tr>
<th>Compliance Barrier Category</th>
<th>Types of Problems Encountered Meeting Commercial Energy Code</th>
<th>Building Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Envelope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Barriers</td>
<td>More effort than anticipated to meet the continuous air barrier requirements. Complex buildings may require mock-up tests to get details right. Time investment makes it costly to comply.</td>
<td>Recreation/Lab, Public School, Multi-family, Healthcare</td>
</tr>
<tr>
<td>Slab Insulation</td>
<td>Difficult to design the thermal separation between the ground floor slab and the earth. The slab has to “float”.</td>
<td>Multi-family</td>
</tr>
<tr>
<td>Insulation</td>
<td>Cost of products to meet code updates more expensive. Wall and roof insulation more expensive than batt insulation or masonry, used under previous codes.</td>
<td>Multi-family Commercial Retail, Public School</td>
</tr>
<tr>
<td>Continuous Insulation</td>
<td>Difficulty maintaining continuity for: foundations, concrete to wood, attic spaces, peaked roofs, architectural features (like cupolas).</td>
<td>Public Safety Building, Multi-family,</td>
</tr>
<tr>
<td>Roof/Wall Assembly</td>
<td>Determining the best way to assemble roofs and walls so the insulation values meet the Stretch Code requirements. Also, cost of extra insulation more expensive than anticipated.</td>
<td>Multi-family</td>
</tr>
<tr>
<td>Lighting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lighting Levels</td>
<td>Difficulty achieving code maximum lighting power densities</td>
<td>Office Building Health Care Facility</td>
</tr>
<tr>
<td>Lighting Controls</td>
<td>Installing daylighting and motion sensors at correct locations</td>
<td>Office Building</td>
</tr>
<tr>
<td>HVAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Efficiency and High Air Changes</td>
<td>Maintaining energy efficiency in a machine shop that has large exhaust fans</td>
<td>Electronics Lab</td>
</tr>
<tr>
<td>Lack of Controls</td>
<td>Lack of interface between GSHP controls and Building Management System</td>
<td>Public Safety Building</td>
</tr>
<tr>
<td>Problems with Heat Wheels</td>
<td>Difficulty balancing pressure and air flow; lack of proper heat transfer to the heating coil</td>
<td>Public Works Building University Lab</td>
</tr>
</tbody>
</table>
Eighteen out of 62 owners and owners’ project managers communicated to the LCIEC Team that they had experienced performance problems with their new construction projects. Table 5-4 presents the problems experienced by building owners according to type of building system. Some owners experienced problems over several building system types which is why the total number of problems is greater than 18. Likewise, similar problems occurred over multiple building types. Building types are captured in parentheses after the problem is stated.

**Table 5-4: Reported Performance Problems in New Construction**

<table>
<thead>
<tr>
<th>Building System Type</th>
<th>Reported Problem (Building Types)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Building Management Systems</strong></td>
<td>• Some EMS system programming bugs still being worked out. (Medical Center)</td>
</tr>
<tr>
<td></td>
<td>• Difficulty programming BMS system and getting it to coordinate with the controls for the ground source heat pump system. (Public Safety Building)</td>
</tr>
<tr>
<td></td>
<td>• Energy management system problems (Senior Living Center)</td>
</tr>
<tr>
<td><strong>HVAC Distribution &amp; Air Balancing</strong></td>
<td>• Portion of the building overcooled - perhaps a balancing issue (Multi-family, School, Office Complex)</td>
</tr>
<tr>
<td></td>
<td>• HVAC system not well balanced (Musical Performance Center)</td>
</tr>
<tr>
<td></td>
<td>• Problem with distribution of air (University Science Lab)</td>
</tr>
<tr>
<td></td>
<td>• Air flow problems (Senior Living Center)</td>
</tr>
<tr>
<td></td>
<td>• Improper balance of air from air handling equipment (Hotel)</td>
</tr>
<tr>
<td><strong>HVAC System Design &amp; Operation</strong></td>
<td>• Unable to reduce unoccupied static pressures to anticipated levels (University Science Building).</td>
</tr>
<tr>
<td></td>
<td>• Some HVAC coils in the VAV boxes were undersized causing electric relays to burn out. (Office Building with Lab spaces)</td>
</tr>
<tr>
<td></td>
<td>• Poor design of the auditorium/meeting space and functioning of HVAC system – people at the top of room get too warm. (Public Safety Building)</td>
</tr>
<tr>
<td></td>
<td>• HVAC sensors never installed so offices get cold when doors are closed (Mechanic’s Shop)</td>
</tr>
<tr>
<td></td>
<td>• We have a boiler issue that hasn’t been diagnosed - bizarre problem with the flue. (College Dormitory)</td>
</tr>
<tr>
<td></td>
<td>• Issues with starting up geothermal systems and PVs. Metering issue with PVs. Equipment manufacturers not being able to match our sequence of operations. (College Academic Building)</td>
</tr>
</tbody>
</table>

LCIEC 5-15 August 24, 2012
<table>
<thead>
<tr>
<th>Building System Type</th>
<th>Reported Problem (Building Types)</th>
</tr>
</thead>
</table>
| Temperature Control & Thermostats | • Some rooms are too hot. Occupants have problems operating the thermostats. (Apartment Building)  
• Digital thermostats are not user friendly - they malfunction quickly and they have faulty control settings. (Senior Living Center)  
• Thermostats located in living room of suite and when bedroom doors are closed, the rooms get hot. (College Dormitory) |
| Lighting Controls             | • Owner wonders why an expensive lighting controls system was installed when only about 15% of the lights are connected to it (Long Term Care Facility)  
• Motion sensors in closets not working properly (Hotel)                                                                                                                                           |
| Building Envelope             | • Customer lounge overheating due too much window area and sun pouring into the room. The thermostat would tell the RTU to cool the lounge, but it made nearby Service Advisor area way too chilly. We had to add a heat pump system to cool the customer lounge separately. (Commercial Retail)  
• Windows are a little drafty. (Hotel)  
• We need curtains for dock doors. (Warehouse)                                                                                                                                                      |
6. Conclusions and Recommendations

This section integrates the findings from the document review and site visits at 75 newly constructed commercial buildings in Massachusetts and the in-depth interviews with over 150 market actors (building owners, design team members, and building officials). Based on this comprehensive research effort, we offer the LCIEC Team’s collective conclusions and recommendations.

The LCIEC Team’s conclusions and recommendations recognize the cooperative nature of code compliance. They are not narrowly focused on improving enforcement, but are focused on improving the understanding of code provisions and providing additional code assistance across both the market actor and code official communities.

6.1 Conclusions

Analysis of commercial new construction in Massachusetts and of the responses of multiple new construction market actors, leads us to draw the following conclusions about commercial energy code compliance rates and practices. Conclusions first address findings on building and measure compliance and then address observed barriers to energy code compliance.

1. Overall code compliance for new construction in Massachusetts estimated to be at about an 80% compliance rate. However, it is important to consider several factors:

   a. This result does not mean that 80% of commercial buildings comply – as we found no buildings fully in compliance.

   b. The overall number refers to the average provision compliance weighted by energy impacts as proposed by DOE/PNNL.

   c. Because the DOE/PNNL methodology seeks to assess the energy impacts of code provisions, it is more relevant to say that on average, commercial buildings perform 20% worse than the code requires, and by extension, use 20% more energy than fully compliant buildings. However, there are many uncertainties involved and monitored or modeled data assessing the Energy Use Intensity of the studied buildings would assist in verifying the estimate.
d. **Considering that efficiency programs strive for 15-20% performance improvement compared to code, this 20%, if verified, represents a significant increase in the potential savings that could be legitimately claimed, for a variety of measures, if the true standard practice baselines were recognized.**

2. **Lighting and lighting controls offer major opportunities for efficiency.** Despite the ease of calculating LPD values, the calculation is often not completed, or incorrect values are utilized. COMcheck is the most popular methodology for calculating LPD and checking against code lighting power allowances (LPA). However, COMcheck relies on user inputs. Incorrect fixture wattage is often entered into the tool, and building or space area is often improperly entered. Including auxiliary spaces, such as basements and mezzanines, in calculations often leads to artificially low reported LPDs. The lighting control provisions have become more complicated and assistance is needed. In addition, many electrical contractors ignore lighting control specifications as they fear call-backs to adjust controls that were never properly commissioned.

3. **New daylighting provisions are experiencing low compliance.** The daylighting zone provisions are new with the introduction of IECC 2009 and will become stricter with IECC 2012. They are little understood by electrical engineers or code officials. Lighting designers generally understand these provisions, but they are rarely members of design teams for smaller buildings. Efficiency program assistance would harvest significant savings.

4. **Mechanical system efficiency levels are at full compliance.** Because manufacturers and distributors only stock code compliant equipment, compliance with efficiency levels occurs by default. At this point, code compliant HVAC equipment is the lowest efficiency level available in the local marketplace. However:

   a. **Installation practices are not fully code compliant (for example, proper duct sealing is not always carried out even when high efficiency HVAC units are installed).** Design teams and construction managers need assistance to understand these practices. Design professionals are charged with the responsibility of monitoring the construction process, but there is a large degree of variability in this area, providing an opportunity to close the gap between as-designed and as-built compliance and performance.
5. **Code compliance is somewhat better for larger buildings.** Despite the fact that code officials better understand the typical systems associated with smaller buildings, smaller buildings have a lower compliance rate. Likely contributing factors are that design professionals with code expertise are more likely to be involved in the design of larger buildings, and that some materials and techniques utilized in residential construction are being utilized without checking for their acceptance for the commercial code.

6. **Code compliance occurs primarily at the design phase, not the construction phase.** One of the items that stood out in the DOE/PNNL compliance methodology was the assumption that code compliance is primarily determined through construction phase site visits. That is certainly true for residential construction. Our interviews and site visits confirm that most compliance verification is done during the design phase. And, as previously stated, it is performed primarily by the design professionals, not by code officials.

7. **Code compliance is a shared responsibility.** Our interviews with code officials and members of the design community reveal that design and construction professionals share the responsibility of code compliance with building officials. In fact, the regulations surrounding code implementation state that design professionals and licensed construction trades people share code compliance responsibility with code officials. It has never been assumed by the developers of codes that officials (building inspectors) would carry full responsibility for energy code compliance. Rather, it is intended that design professionals will understand and design to code and that they will oversee the construction of their code compliant designs, ensuring that the design intent is adhered to. Especially for the commercial sector, code officials' primary duties associated with the energy code are to work with the design/construction communities assisting them in understanding and complying with code provisions. In terms of overall effort, the design team assumes more burden for code compliance than do code officials. However, final authority for code enforcement is assigned to the code officials.

8. **Code officials require additional staff resources in order to properly address the energy code.** And/or they need assistance from other sources in order to share the burden of energy code compliance.

9. **Constructing and installing energy code compliant materials and equipment does not guarantee proper installation and operation thereof.** Problems recorded in Table 5-3 in Section 5, such as poor installation, missing sensors, and difficulties
programming and controlling HVAC equipment, show that performance issues can hurt energy performance. In the experience of the project team, improper installation techniques and inaccurate controls programming can negate the efficiencies designed into a building.

10. Energy code training and curriculum development are key elements in increasing market actors’ existing knowledge and improving compliance processes.

   a. Training is needed for all market actor categories on the commercial energy code as well as the Stretch Energy code. Respondents from all market sectors – including the design community, building officials, vendors, program implementers - request more frequent and in-depth training on the energy code to master energy code provisions and documentation. Current training offerings are either too brief, too superficial, or both for the market actors interviewed for this study.

   b. Interview results support the widespread distribution of existing, and the creation of Massachusetts specific, supplementary energy code handbooks which would: 1) fully explain changes in the new code and why changes they have been made, and 2) describe design and engineering assumptions behind energy codes and standards. Building officials want to understand the design theory or practice behind energy codes, and they want to be able to refer to documents that will quickly show them differences between code versions.

   c. Stand-alone training of building officials is not a solution. The fact that code officials do not have the available time to adequately address the energy code clearly informs that additional training of code officials, without adding other resources and/or assistance will not result in improved compliance rates.

11. Observed challenges to achieving and documenting energy code compliance for commercial projects range from lack of technical expertise to heavy constraints on building officials staff and their time.

   a. Building officials generally do not feel qualified to determine energy code compliance for complex HVAC systems and their controls, lighting power densities, and the type, quantity, and locations of lighting controls. Instead, they rely heavily on design team signed documents (Construction Control
regulations: 780 CMR 116.0) as the primary compliance mechanism for commercial construction.

b. **Building and inspectional service departments generally report being understaffed and overloaded with code inspections, zoning enforcement, plan reviews and field work.** Energy code enforcement is not a top priority when building official time and staff resources are constrained. As a result, officials prioritize the enforcement of life safety, structural, egress, and Architectural Access codes for new construction projects.

c. **Use of COMcheck reports to document commercial energy code compliance is sporadic and varies by jurisdiction.** When requested by building officials, COMcheck reports are primarily submitted to demonstrate envelope compliance, although some jurisdictions do require COMcheck reports for interior/exterior lighting and HVAC systems. The lack of uniformity may indicate a lack of familiarity of the COMcheck tool or lack of shared understanding of its value in compliance documentation, or both.

d. **COMcheck reports are often accepted as stand-alone proof of compliance.** COMcheck is a tool that compiles and calculates compliance from user inputs, but the inputs to COMcheck are intended to be checked against the design documents and site conditions to verify the compliance with code provisions. Instead, COMcheck is typically accepted as stand-alone proof of compliance.

e. **Owners and design teams report more challenges in meeting commercial energy code requirements for the building envelope measures than lighting and HVAC requirements.** It is hypothesized that multiple factors contribute to this finding. The universe of envelope construction materials and techniques is much larger than that for lighting and HVAC. Applying the code to the variety of envelope assembly options can be a daunting task, as can be the learning process involved in adopting newly introduced construction materials. In addition, building officials tend to focus on envelope compliance when they do have time to devote to the energy code. Many building officials do not feel qualified to assess the compliance of electrical and mechanical designs and installations, and more often rely on signed affidavits to verify compliance.

f. **There is currently no compliance mechanism that requires design engineers to justify their design decisions.** HVAC and lighting systems are increasingly complex, and more often than not, computer-controlled. Building officials do not typically have the engineering expertise to judge energy code
compliance or to push back on engineers’ designs and specification practices. Additional expertise is needed for complex systems, particularly HVAC, to assess energy code compliance. However, improved compliance for complex systems likely relies on improving the understanding of code requirements by mechanical engineers who design the systems, rather than anticipating that code officials will have the time to learn the operational aspects of complex HVAC systems.

12. **The lack of standardization, rules and metrics negatively impact the market actors and determination of energy code compliance.**

   a. **Different compliance documentation is required depending on the building official and the particular jurisdiction.** Some officials rely on Construction Control affidavits and field reports to verify energy code while others require additional materials such as COMcheck reports, energy narratives, or even commissioning reports. Design professionals, contractors, and owners who work on projects across the state don’t know what energy compliance documentation to expect from building officials, and it can send a signal that energy code compliance is more of an afterthought than a priority.

   b. **The design community would benefit from the creation of standardized forms and documentation requirements for communicating Stretch Code compliance, especially where compliance is determined through energy modeling.** In Stretch Code municipalities, energy modeling is required in order to verify compliance for commercial new construction over 100,000 ft², and over 40,000 ft² for some building types. Design engineers and architects need clear guidelines for modeling baselines for complex heating and cooling systems—such as combined heat and power and central utility plants. ASHRAE 90.1 Appendix G does not provide guidance for these complex systems, although the U.S. Green Building Council has developed guidelines that address baseline systems for some complex heating and cooling system types.

   c. **There is a lack of common metrics across LEED rating systems, the Stretch Code, and EPA’s Energy Star “Target Finder” for determining energy savings.** The means for determining savings for each system mentioned above are energy cost savings, site energy savings, and source energy savings, respectively. Energy modelers find the different metrics to be confusing, and in certain cases, counterintuitive. LEED uses energy cost savings percentages which does not necessarily correlate with site or source energy savings. The
Stretch Code uses site energy as its benchmark, and Energy Star's Target Finder applies source energy to calculate savings. Sometimes designers are able to shave energy from their designs only to find that metrics like energy cost savings and site energy make it appear as if their buildings are consuming more energy not less. Source energy takes into account the total energy consumed to deliver energy to end users.

6.2 Recommendations

Based on the extensive research of new construction sites and market actors operating in Massachusetts marketplace, the LCIEC Team offers the following list of recommendations for consideration.

1. Implement a comprehensive plan to provide energy code compliance assistance. Assuming that there is no possibility of dramatically increasing staffing budgets for code officials, a comprehensive plan for providing third-party energy code assistance should be implemented. Because there are unrealized savings to be harvested, the assistance effort could potentially be funded through existing efficiency program administrations that would coordinate their efforts with the BBRS. Such a plan should focus on assigning energy efficiency practitioners to assist design teams and code officials in interpreting code provisions and identifying equipment and techniques utilized to meet those provisions. Methods to accomplish this may include:

   a. Funding additional staff of energy experts to work with the state’s Board of Building Regulations and Standards and local officials to augment building official knowledge and resources. As noted in the Section 5, market actors of all types rely on consulting engineers to explain the content and nuances of the energy codes and the Massachusetts amendments to the codes. It is recommended that staff with strong engineering and energy modeling background be added to BBRS staff to answer questions on energy code and compliance processes.

   b. Funding and staffing a team of third party experts to verify the compliance for complex HVAC systems, HVAC controls, and lighting power densities and controls. The team would supplement building official plan and specification review and provide independent engineering assessments for energy code compliance. Third party experts would also be able to review and
assess energy models and question modeling assumptions and techniques. Their assessments would provide much needed feedback for design engineers who are rarely, if ever, challenged on their modeling approaches.

c. **Provide focused assistance for new provisions.** Newly adopted code provisions are often misunderstood or ignored. With each code introduction, program administrators should assess the new provisions and develop an approach for technical assistance that combines code compliance with the promotion of above code measures. Again, savings should be harvested referencing actual standard practice.

2. **Continue “beyond code” new construction efforts.** Program administrators rather than developing code compliance strategies, should continue to focus on beyond code efforts such as those represented by the Stretch Code, LEED, and Advanced Buildings. In addition, as they engage on code compliance issues, it is recommended that they always promote a beyond code measure(s) as the preferred alternative. As they expand these efforts, code compliance improvement becomes a supplemental benefit, rather than the sole focus, and the total savings associated with the project should be the total of the delta from standard practice to code compliance in addition to the delta from code compliance to the actual installed premium measures.

3. **Consider targeted program support for practices that verify proper installation, testing, and performance of building systems.** Owners as well as design professionals report ongoing problems even when construction is complete. Reported problems often involve incorrect BMS programming, unbalanced air distribution, difficulties controlling temperature, and lack of coordinated communication among different control systems (e.g. between a BMS and geothermal system controls). Targeted support for commissioning of controls, sequences of operations, and testing and balancing would help ensure efficiencies are achieved.

4. **Develop training opportunities and new energy code curriculum to address the knowledge gaps identified across market segments.**
   a. **Offer a range of trainings to new construction market actors.** Table 6-1 offers a thorough list of training topics based on respondent suggestions and knowledge gaps observed during the course of the study. Training topics are prioritized according to identified needs where 1 is the highest priority, 2 is medium and 3 is lowest. N/A stands for not applicable and is used in cases where certain training would be inappropriate.
Table 6-1: Recommended Training Topics for New Energy Code Training

<table>
<thead>
<tr>
<th>Key Training Topics</th>
<th>Design Community</th>
<th>Contractors &amp; Subcontractors</th>
<th>Building Officials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Priority Highest = 1, Medium = 2, &amp; Lowest = 3. N/A = Not Applicable.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009 IECC and ASHRAE 90.1-2007 for commercial buildings</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2012 IECC and ASHRAE 90.1-2010 for commercial buildings</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Identify and explain the changes between 2009 IECC and 2012 IECC and why changes occurred.</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Stretch Energy Code for commercial buildings Review 8th edition code and introduce 2012 Stretch Energy Code</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Utilization of COMcheck software for lighting, HVAC, and envelope compliance. Include supplemental data and inspections needed to verify COMcheck reports.</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Training on better energy code inspection processes for lighting and lighting controls</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Daylighting – identifying areas where separate switching is required. Importance of daylight system calibration and commissioning.</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Building science: the movement of air and moisture through building assemblies, with focus on detailing and envelope materials such as insulation, air barriers, vapor retarders</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Basic HVAC systems including control strategies and ASHRAE guidelines for system sizing</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Air sealing for multi-family applications</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>An overview of the overlapping standards including MA-LEED Plus, Stretch Energy Code, and regular code.</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>How to achieve continuous insulation in attics, roofs, walls, and slabs for multi-family construction and similar building types</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Connecting and sealing air barriers across joints and seams for multiple commercial building types</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Basic training on energy modeling software (such as eQuest and Energy Plus)</td>
<td>1</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Advanced training on difficult-to-model building systems (such as eQuest and Energy Plus)</td>
<td>1</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
b. **Adopt alternative training approaches.** It is suggested that energy code training should not focus solely on “what” is in the new code, but “why” a code or standard exists and “how” it is calculated. Building officials indicate that they would like to understand the context of energy code provisions and not simply the rules. We also suggest the employing different training approaches, such as:

- Design code compliance charrettes that walk the participants through sets of rough plans and help them make code compliance decisions as they go.

- Reintroduce building official and design team circuit riders focused on actual projects. The circuit riders would visit individual jurisdictions to review current projects and answer questions in real-time. This approach was adopted in Massachusetts between 2001-2002 for design professionals and received a positive response.

c. **Provide energy code guidebooks and supplementary written materials to building officials that:** 1) explain changes from one version of energy code to the next, 2) offer guidance on basic energy principles for building systems, and 3) explain the reasons for the different energy code provisions. Suggested publications include:


- Another publication that may provide additional reference and curriculum development is: *2012 International Energy Conservation Code Study Companion*

d. **Combine internal energy code training efforts with all program implementation staff.** When the energy code is updated, we recommend that the program implementers invest in third-party training for a holistic understanding of the energy code and detailed summary of changes from one code version to the next. If this approach is accepted, staff from all implementation programs could contribute more fully to worksheet committees.
and other program initiatives in which all program implementation staff participate.

5. **Develop energy modeling guidelines and standardized documentation to improve the quality and accuracy of compliance documentation.**

   a. **Develop standard documentation that allows engineers and architects to submit energy models as commercial code compliance documentation.** There is currently no uniform documentation which energy modelers can use to submit results of energy models or energy models themselves for code compliance. This documentation should be developed by the state and promulgated across all jurisdictions.

   b. **Create standardized forms and documentation for communicating Stretch Code compliance, especially where compliance is determined through energy modeling.** Similar to the comment above, there is no standard documentation for the submission of energy models or their results to demonstrate code compliance. Documentation should also address any compliance measures needed to confirm Stretch Code compliance.

   c. **Adopt common metrics and standards for energy saving calculations that align with state policy and programs.** Determine whether site energy or source energy best represents the savings captured by the Stretch Code or other state initiatives as appropriate.

   d. **Develop energy modeling guidelines for capturing baseline energy consumption for energy system types that are not addressed by ASHRAE 90.1 Appendix G, such as combined heat and power or central utility plants.** The U.S. Green Building Council has developed standards on the aforementioned system types to assist energy modelers. Developing guidelines will allow apples-to-apples comparisons of building performance across jurisdictions, which is important for understanding efficacy of energy efficiency measures and designs.

   e. **Examine the potential for crediting behavioral design changes with energy savings.** As mentioned in Section 5, energy modelers do not get energy savings “credit” for innovative designs that incorporate an expanded thermal comfort range, for example. We believe that behavior change coupled with verifiable passive design strategies merit consideration for energy savings in building energy models.
A. iPad Site Data Collection Instrument
Final Site Data Collection Instrument
Massachusetts Commercial Building Data Collection
2011-2012 Commercial Baseline Study

Note: Each iPad to be uploaded with:
- An electronic version of this survey instrument
- A copy of IECC 2009
- A copy of a system/equipment identification guide

Building ID:___  Climate Zone:_______

Date:_______  Name of Evaluator(s):______________________________

Building Contact: Name:_________  Phone:_______  Email:___________

Building Name & Address:_________

Conditioned Floor Area:_________ ft²

State:_______  County:_______

Building Use:  □ Office Building  □ Retail Store  □ Warehouse  □ K-12 School  □ Hotel
□ Restaurant  □ Grocery Store  □ Banking/Financial Institute  □ Residential
Hall/Dormitory
□ Other ________________________________

Building Ownership:  □ State-owned  □ Local government-owned  □ National
account/Franchise
□ Speculative  □ Private  □ Other ________________________________
**Instructional Note:** Do not assume that items specified in the plans are necessarily installed in the building as specified. In general, “as built” drawings are more reliable than design drawings, but measures should be field verified as much as possible, and not based solely on the available documents.

**Instructional Note:** N/A may be used to describe “not available” “not accessible” or “not applicable.” When selecting N/A; always enter a comment as to why you were unable to obtain the data. Where possible use the dropdown menu for N/A comments.

<table>
<thead>
<tr>
<th>2009 IECC Section #</th>
<th>Plan Review</th>
<th>Y</th>
<th>N</th>
<th>N/A</th>
<th>Comments/Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>103.2 [PR1]</td>
<td>Plans available: Envelope, HVAC, Electrical, Service Water Heating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>103.2 [PR2]</td>
<td>Plans, &amp; specifications contain enough detail for determining Energy Performance: Envelope, HVAC, Electrical, Service Water Heating</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Documents available for this study: Design Plans, “As Built” Plans, Specifications, Sequence of Operations (typically included in the Specifications documents)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Acceptance Documentation**

**Instructional Note:** The following is to be determined in a discussion with the building owner or facility manager. Please add comments.

<table>
<thead>
<tr>
<th>2009 IECC Section #</th>
<th>Plan Review</th>
<th>Y</th>
<th>N</th>
<th>N/A</th>
<th>Comments/Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>103.7 Mass Amendment</td>
<td>Did the building owner receive documentation that all HVAC, lighting control and power distribution systems were tested and that the designated building code official witnessed such tests?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>103.7 Mass Amendment</td>
<td>Did the building owner receive operations and maintenance manuals for the above systems?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Additional Comments/Assumptions Regarding Plans Review:** *Each section of the survey is followed by an additional comments opportunity – there will be a text box on the iPad for them.*
**Envelope**

**Instructional Note:** Utilize a combination of plans review and field inspection to determine installed conditions. For example, if the plans show a 5 ½” cavity wall with 2” of rigid foam, ½” sheetrock and a 1” façade; but the actual wall thickness totals less than 9”; the wall was not built to spec. When in doubt, add comments. Do not guess!

<table>
<thead>
<tr>
<th>2009 IECC Section #</th>
<th>Air Barrier</th>
<th>Detailed on Plans</th>
<th>Installed?</th>
<th>Comments/Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>502.4.3</td>
<td>Is there a continuous air barrier installed?</td>
<td>Y</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>502.4.9</td>
<td>Does the air barrier connect all of the following: Foundation; Walls; Windows; Roof; Envelope Penetrations?</td>
<td>Y</td>
<td>N</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2009 IECC Section #</th>
<th>Footing / Foundation Inspection</th>
<th>Verified Value</th>
<th>Installed?</th>
<th>Comments/Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>502.2.4 [FO1]²</td>
<td>Below-grade wall insulation R-value.</td>
<td>R- 5 - 30</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>Interior to foundation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exterior to foundation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>502.2.6 [FO3]²</td>
<td>Slab edge insulation R-value.</td>
<td>R- 5-30</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>502.2.6 [FO5]²</td>
<td>Slab edge insulation depth below grade</td>
<td>0-6 ft</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>303.2.1 [FO6]¹</td>
<td>Exterior insulation protected against physical and UV damage (trowel/spay-on or rigid covering)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

[²] Mass Amendment
[¹] 2009 IECC
<table>
<thead>
<tr>
<th>Section #</th>
<th>Wall &amp; Floor Systems</th>
<th>Verified Value</th>
<th>Comments/Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>503.2.7</td>
<td>Piping, ducts and plenum are insulated and sealed when installed in or under a slab.</td>
<td>R-1-11</td>
<td></td>
</tr>
<tr>
<td>502.6.2.1</td>
<td>For K-12 Schools, Daycare Centers and Residential Spaces; is there continuous insulation under the slab</td>
<td>R-5-30</td>
<td></td>
</tr>
<tr>
<td>502.3.2</td>
<td>Fenestration Labels Present?</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>502.4.1,</td>
<td>Doors - air leakage</td>
<td>0.2 – 1.2</td>
<td>Record temporary label information when present:</td>
</tr>
<tr>
<td>502.4.2</td>
<td></td>
<td>cfm/ ft²</td>
<td>Record ID numbers from glass and glazing spacer:</td>
</tr>
<tr>
<td>[FR2]³</td>
<td></td>
<td></td>
<td>Record window make and model # when available:</td>
</tr>
<tr>
<td></td>
<td>Windows - air leakage.</td>
<td>0.2 – 1.2</td>
<td></td>
</tr>
<tr>
<td>[FR3]³</td>
<td></td>
<td>cfm/ ft²</td>
<td>If none of the above are available, describe windows</td>
</tr>
<tr>
<td>502.3.2</td>
<td>Windows including fixed glazing</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>[FR9]¹</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 502.3.2 [FR10]¹

**Doors**

- **U factor**
  - 0.3–2.0

- **SHGC**
  - 0.1–0.6

- Record temporary label information when present:

- Record any ID numbers from unit:

- Record make and model # when available:

- If none of the above are available, describe doors:

### 502.4.7 [FR4]³

**Vestibule at main entrance?**

- Revolving Door?
- Self-Closing Door?

### 502.2.3 [IN8]¹

**Wall assembly 1**

- Above-grade wall insulation R-value.
  - If more than 1 wall assembly type, record area: 100 – 500,000 ft²

- **R-5-60**

- **Structure type**
  - Mass
  - Metal
  - Steel
  - Wood

### 502.2.3 [IN8]¹

**Wall assembly 2**

- Above-grade wall insulation R-value.
  - Record area: 100 – 500,000 ft²

- **R-5-60**

- **Structure type**
  - Mass
  - Metal
  - Steel
  - Wood

### 303.2 [IN7]¹

- If observable; is above-grade wall insulation properly installed?

- Voids
  - Compressed behind wires/pipes

- Other installation issues:
### Envelope Cont.

<table>
<thead>
<tr>
<th>2009 IECC Section #</th>
<th>Wall &amp; Floor Systems</th>
<th>Verified Value</th>
<th>Comments/Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wall Assembly Metal framing – continuous rigid insulation for thermal break</td>
<td>R- 5-30</td>
<td></td>
</tr>
<tr>
<td>502.2.5 [IN8]²</td>
<td>Floor assembly 1; R-value.</td>
<td>R- 5-60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• If more than 1 floor assembly type, record area: 100 – 500,000 ft²</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Structure type</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mass</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>502.2.5 [IN8]²</td>
<td>Floor assembly 2; R-value.</td>
<td>R- 5-60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Record area: 100 – 500,000 ft²</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Structure type</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mass</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>303.2 [IN9]²</td>
<td>Floor insulation properly installed?</td>
<td></td>
<td>Describe any installation issues:</td>
</tr>
<tr>
<td>303.1.1, 303.1.1.1 [IN10]²</td>
<td>If observable, is insulation labeled with R-value or is there an insulation certificate providing R-value and other relevant data.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Additional Comments/Assumptions:
<table>
<thead>
<tr>
<th>2009 IECC Section #</th>
<th>Roof Systems</th>
<th>Verified Value</th>
<th>Comments/Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Describe roof, including color</td>
<td>Flat</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pitched</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stone</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Membrane</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metal</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shingled</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Black/Dark White</td>
<td>□</td>
</tr>
</tbody>
</table>

502.4.1, 502.4.2 [FR1]<sup>3</sup>

- Are roof penetrations air/water sealed?  

502.2.1 [IN17]<sup>3</sup>

- Is there insulation installed on top of a suspended ceiling.  
If so, is that insulation intended for sound only?  

502.2.1 [FR5]<sup>3</sup>

- Roof 1  
Roof insulation R-value. (Do not include any insulation installed on top of a suspended ceiling.)  
- If more than 1 roof assembly, record area 100 – 500,000 ft²  
- R- 5-100 Above deck  
- Attic  

- Roof 2  
Roof insulation R-value. (Do not include any insulation installed on top of a suspended ceiling.)  
- Record area 100 – 500,000 ft²  
- R- 5-100 Above deck  
- Attic  

- If metal frame – is there continuous rigid insulation for thermal break  
- R Value 5-40  

502.3.2 [FR11]<sup>3</sup>

- Skylights  
- U factor  
- 0.3 – 1.5  
- SHGC  
- 0.1 – 0.6  

Additional Comments/Assumptions:
## Mechanical Systems

<table>
<thead>
<tr>
<th>2009 IECC Section #</th>
<th>Mechanical - HVAC</th>
<th>Verified Value</th>
<th>Comments/Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>503.2.3 [ME1]</td>
<td>1) HVAC equipment.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type:</td>
<td>Y N N/A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Small to Medium Unitary</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Packaged Terminal AC &amp; Heat Pumps</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Warm Air Furnace</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Boilers (Circle 1 Oil or Gas)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Condensing Units</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chillers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturer:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Model Number:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Capacity Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BTUH:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>kW: N Tons: N HP:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Efficiency:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) HVAC equipment.</td>
<td>Type:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Small to Medium Unitary</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Packaged Terminal AC &amp; Heat Pumps</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Warm Air Furnace</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Boilers (Circle 1 Oil or Gas)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Condensing Units</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chillers</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Manufacturer:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Model Number:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Capacity Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BTUH: 1,000 – 500,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>kW: 0.5 - 100 Tons: 0.5 - 100 HP: 1-100</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Efficiency: 50-98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>503.2.4.1 [F12]</td>
<td>Heating and cooling to each zone is controlled by an electronic thermostat with setback/ set forward control. (local stats or EMS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>503.2.4.1.1 [F15]</td>
<td>Heat pump controls prevent supplemental electric resistance heat from coming on when not needed. (Model #)</td>
<td></td>
<td>Make &amp; model # of system/controls</td>
</tr>
<tr>
<td>503.2.7 [ME8]</td>
<td>HVAC ducts and plenums insulated? R-1-10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>503.2.8 [ME9]</td>
<td>HVAC piping insulated? Wall thickness of insulation? 0.25 - 3 in.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>1st Column</td>
<td>2nd Column</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------------------------------------------------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>503.2.7.1</td>
<td>Are ducts and plenums sealed?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mastic</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tape</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>If sealed with tape:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Standard duct tape:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Listed/Labeled tape:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>503.3.1,</td>
<td>Air economizers installed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>503.4.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[ME10]²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zone controls can limit simultaneous heating and cooling and sequence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>heating and cooling to each zone.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>503.4.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[ME12]¹</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[ME17]¹</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Record any control system details available:
## Mechanical Systems Cont.

<table>
<thead>
<tr>
<th>2009 IECC Section #</th>
<th>Mechanical - HVAC</th>
<th>Verified Value</th>
<th>Comments/Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>503.2.9.1 [ME41iecc]³</td>
<td>Air outlets and zone terminal devices have means for air balancing.</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>503.2.9.2 [ME42iecc]³</td>
<td>Do HVAC hydronic heating and cooling coils have means to balance flow?</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>503.2.9.2</td>
<td>Do HVAC hydronic heating and cooling coils incorporate pressure test connections?</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>503.2.10.1</td>
<td>If an HVAC system has a combined fan horsepower &gt;5; do the plans/specs include a calculation for maximum allowable horsepower per CFM (see IECC section 503.2.10.1)</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>503.2.11 [ME34]³</td>
<td>Efficiency level of Service water heating equipment</td>
<td>N/A</td>
<td>50-98%</td>
</tr>
<tr>
<td>504.5 [PL1]²</td>
<td>Insulation for piping for recirculating and non-recirculating service hot-water systems insulated.</td>
<td>Y</td>
<td>Rigid Foam, Flexible Foam, Fiberglass</td>
</tr>
</tbody>
</table>

### Additional Comments/Assumptions:
### Complex HVAC Systems

| 503.2.5.1 | Is demand control ventilation installed | Y | N | N/A | Comments/Assumptions: If installed, Describe the area it serves: |
| 503.4.2 | VAV fan motors ≥10 hp controlled VFD or Vane Axial Fan | VSD Vane axial fan |
| 503.4.3.3 | Two-position automatic valve interlocked to shut off water flow when hydronic heat pump with pumping system >10 hp is off. |
| 503.4.4 | Heat rejection Fan systems with motors ≥7.5 hp controlled by VFD. |
| 503.2.6 | Energy recovery (ERV or HRV) on systems ≥ 5,000 cfm and 70% outside supply air. |
| 503.4.6 | Condenser heat recovery system for preheating of service hot water in 24/7 facilities with loads >6 MMBtu (Hospital, etc.) |

Additional Comments/Assumptions:
### Lighting/Electrical

<table>
<thead>
<tr>
<th>Section #</th>
<th>Lighting Controls</th>
<th>Y</th>
<th>N</th>
<th>N/A</th>
<th>Comments/Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>505.2.2.2</td>
<td>Buildings &gt;5,000 ft². Automatic lighting control to shut off all non-emergency building lighting after hours (timer or occupancy)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>505.2.1</td>
<td>Each enclosed space includes at least a manual light switch</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>505.2.2.1</td>
<td>Bi-Level switching in offices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>505.2.3</td>
<td>Verify separate lighting control devices for specific uses installed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>505.4</td>
<td>LED or self-illuminating exit signs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>505.2.4</td>
<td>Automatic lighting controls for exterior lighting installed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>505.6.1</td>
<td>Exterior lighting over 100 W is fluorescent, HID or LED</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Additional Comments/Assumptions:

- [EL1]²: Buildings >5,000 ft². Automatic lighting control to shut off all non-emergency building lighting after hours (timer or occupancy).
- [EL2]²: Each enclosed space includes at least a manual light switch.
- [EL10iecc]¹: Bi-Level switching in offices.
- [EL4]¹: Verify separate lighting control devices for specific uses installed.
- [EL4]¹: Occupancy/Vacancy Sensors
- [EL4]¹: Timers
- [EL4]¹: Daylight dimming
- [EL6]¹: LED or self-illuminating exit signs
- [EL3]²: Automatic lighting controls for exterior lighting installed.
- [EL3]²: Photocell
- [EL3]²: Astronomical timer
- [EL7]¹: Exterior lighting over 100 W is fluorescent, HID or LED.
## Lighting Cont.

<table>
<thead>
<tr>
<th>2009 IECC Section #</th>
<th>Lighting Power Density Allowance</th>
<th>Comments/Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Collect LPD data for the entire building or 2 representative spaces</td>
<td>Describe Fixtures</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Space Type</th>
<th>Values As above</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>10 – 1,000</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>10 – 1000</td>
<td></td>
</tr>
<tr>
<td>Fixture:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2L4'T8</td>
<td>30-90 Watts</td>
<td></td>
</tr>
<tr>
<td>3L4'T8</td>
<td>30-120 Watts</td>
<td></td>
</tr>
<tr>
<td>4L4'T8</td>
<td>30-120 Watts</td>
<td></td>
</tr>
<tr>
<td>2 U T8</td>
<td>30-90 Watts</td>
<td></td>
</tr>
<tr>
<td>8' T8</td>
<td>60-200 Watts</td>
<td></td>
</tr>
<tr>
<td>CFL</td>
<td>5-200 Watts</td>
<td></td>
</tr>
<tr>
<td>Inc.</td>
<td>60-300 Socket rated Watts</td>
<td></td>
</tr>
<tr>
<td>HIF</td>
<td>100-400 Watts</td>
<td></td>
</tr>
<tr>
<td>HID</td>
<td>30-1,500 Watts</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1-1,000 Watts</td>
<td></td>
</tr>
</tbody>
</table>

### Area 2

<table>
<thead>
<tr>
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Additional Comments/Assumptions:
**Other**

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<th>2009 IECC Section #</th>
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<td>502.4.6 [F1]¹</td>
<td>Weather seals installed on all loading dock cargo doors</td>
<td>Y</td>
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<tr>
<td>504.7.1 [F13]˚C</td>
<td>Pool heaters are equipped with on/off switch and no continuous burning pilot light.</td>
<td>Y</td>
<td></td>
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<tr>
<td>504.7.3 [F14]˚C</td>
<td>Pool covers are provided for heated pools and pools heated to &gt;90˚F have a cover ≥R-12.</td>
<td>Y</td>
<td></td>
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<tr>
<td>504.7.2 [F15]˚C</td>
<td>Time switches are installed on all pool heaters and pumps.</td>
<td>N/A</td>
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</table>

Additional Comments/Assumptions:
B. Jurisdictional Letter

<<Company Name>>
<<Contact>>
<<Street, Suite>>
<<City, State Zip>>
<<Date>>

Dear [name of building official],

Buildings account for roughly 40 percent of the nation’s energy consumption, and enhancing their efficiency will lead to a stronger economy, greater energy security, and a cleaner environment. With this goal in mind, the Massachusetts Electric and Gas Utilities and Cape Light Compact (Energy Efficiency Program Administrators), and the State of Massachusetts’s Board of Building Regulations and Standards (through the Department of Public Safety) are asking local jurisdictions to participate in a statewide study to assess baseline construction practices in relation to building energy codes. This letter is meant to familiarize you with the study and to solicit your support for this important activity.

The study is part of a major effort to support and improve vital efficiency measures that will help address energy and environmental challenges here in Massachusetts. The objectives of the study are to understand current design and construction practices, the energy code enforcement process, and the future energy savings potential from recently, and newly, constructed buildings. To achieve this goal, the study team will hold a series of discussions with building officials and the design and construction community as well as conduct on-site observations at randomly selected buildings. It is our intention to better understand the real-world challenges of implementing the energy code and determining code compliance. Further, learning about real-world challenges can lead to improvements in the codes, increased educational and support activities, and support for code enforcement efforts.

The study will begin in November 2011 and continue for six months. In total, we plan to visit a randomly generated sample of approximately 75 commercial building projects constructed in the last 3 years. The Massachusetts Utilities and Cape Light Compact have hired the Massachusetts-based firms, KEMA Inc. and ERS, Inc., to conduct the study. They will be referring to the U.S. Department of Energy’s Building Energy Codes Program (BECP) survey protocol for guidance on this type of study. BECP protocols are available at www.energycodes.gov/arra/compliance_evaluation.htm.
What to Expect:

Building Departments Level of Work: There will be minimal disruption to building departments’ staff. For background on building energy code practices, department staff may be asked to participate in a standardized 30 minute phone interview.

If a commercial building in your jurisdiction is selected for a site visit, field research staff from KEMA or ERS will contact you to set up a date and time to visit you at the building department to conduct the 30 minute survey interview in person. At that time, the field researcher will also ask you about 1 or 2 specific commercial projects in your jurisdiction. The project(s) will have been selected at random, and questions will relate to energy code activities for the specific commercial project.

During the Building Department Visit. On the day of the visit, the field researcher will perform the following tasks:

- Conduct a short, standardized interview on your plan review, inspection and permitting processes
- Answer questions you may have about the energy code baseline study
- Review with you the data collection methods for the commercial projects
- Seek to collect energy-related information on the specific project(s) from plans, specifications, or related project documentation that may be available

In the Field. When visiting commercial projects in your jurisdiction, the field researcher will collect information on the building’s energy-relevant features. He or she will also look to get copies of any available as-built drawings and design plans from the building owners or design teams. When possible, building inspectors are encouraged to join the field researcher on site.

Information gathered during the site visits from individual buildings and jurisdictions will not be made public and the identity of Building Departments and individuals and buildings interviewed will not be disclosed.

Thank you very much for your consideration. On behalf of the Massachusetts Utilities and Cape Light Compact, we look forward to collaborating in the pursuit of energy savings. If you have any questions or concerns, please don’t hesitate to contact me or Jim Leahy of KEMA.

With kind regards,

Wendy Todd
nationalgrid
Energy Efficiency Evaluation
40 Sylvan Road – E1.550
Walsham, MA 02451
781-907-2232
Wendy.Todd@us.ngrid.com

Jim Leahy, PE, LEED A.P., BD+C
KEMA Inc
67 S. Bedford Street, Suite 201E
Burlington, MA 01803
781-418-3727
Jim.Lehay@kema.com
C. Marketing of Research Presentation

Massachusetts Code Compliance Baseline Study

Presented to: Massachusetts Building Commissioners and Inspectors Association

December 1, 2011
Overview of Presentation

- Introduction
- Study Objectives
- Research Plan
- Study Results
- What to Expect
- Study Benefits
- Contact Information
Introduction

- Project Sponsors: The Massachusetts Electric and Gas Utilities’ Energy Efficiency Program Administrators (the Program Administrators)

- Study Team – KEMA, ERS, Apprise
- In collaboration with: the Massachusetts Board of Building Regulations and Standards (BBRS)
Study Objectives

- Inform the Commonwealth of Massachusetts and the Massachusetts Energy Efficiency Program Administrators of current building design and practices
- Assess the potential for energy savings from a codes and standards program

Buildings account for roughly 40 percent of the nation’s energy consumption and enhancing their efficiency will lead to a stronger economy, greater energy security, and a cleaner environment.
Research Plan
Study Results

- Information collected from the site visits and in-depth interviews will be used to determine:
  - Estimate Statewide rate of compliance
  - Individual measures with high or low compliance rates
  - Geographic differences
  - Opportunities for training, technical assistance and financial incentives
  - Future program design

Compliance data collected from individual buildings will not be made public.
What to Expect

- Minimum disruption to builders and the design community
- Two group interviews with members of the design community
- 30 minute interviews with members of the design and construction team of the sampled buildings.

Discussion topic to include:
- Strategies for meeting code
- Method for documenting compliance
- Plan review, inspection and permitting process
Study Benefits

- Inform policymakers and program designers of real-world challenges of implementing the energy code and determining compliance
- Express need for code related education or other support for designers, contractors, owners & managers
- Inform future code iterations and practices
- Inform design of PAs’ planned Codes and Standard Initiative
Contact Information

Wendy Todd*
nationalgrid
Energy Efficiency Evaluation
40 Sylvan Road – E1.550
Waltham, MA 02451
781-907-2232
Wendy.Todd@us.ngrid.com

Jim Leahy, PE, LEED A.P., BD+C
KEMA Inc
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Suite 201E
Burlington, MA 01803
781-418-5727
Jim.Leahy@kema.com

* on behalf of the Massachusetts PAs
D. Initial In-Depth Instrument: Program Implementation
Staff Interview Guide
MA LCIEC – PROJECT 11 CODE COMPLIANCE BASELINE STUDY

INITIAL IN-DEPTH INTERVIEW GUIDE FOR ENERGY EFFICIENCY PROGRAM IMPLEMENTATION STAFF

Contact Name: _____________________________________________________________

Company: ________________________________________________________________

Address: __________________________________________________________________

City, State, __________________________________________________________________

Telephone: __________________________________________________________________

E-Mail Address: __________________________________________________________________

Interview Date: __________  Interview Time: __________(Duration in Minutes)

[NOTES TO INTERVIEWER]

Discussions with experienced new construction implementation staff members will provide a solid foundation for understanding the market structure with regard to the existing commercial energy code. The objectives of the interviews are to collect information on the following:

- New construction and major renovation energy efficiency programs and offerings.
- Impacts of commercial building energy code on new construction and major renovation program offerings.
- Extent to which new construction program implementers address commercial building energy code as part of their job responsibilities.

LEAD-IN:

Hi, my name is ________ and I work for KEMA, an energy consulting firm. We have been hired by the Massachusetts electric and gas utilities’ Energy Efficiency Program Administrators to conduct research on energy code compliance in recent new commercial building construction.

I would like to talk with you about your experience with energy efficiency practices in new construction and commercial energy code compliance. This conversation will cover your role in new construction program administration, new construction program offerings, and your experience with the Massachusetts energy code changes and code compliance. The conversation will take approximately 30 minutes.
Roles and Responsibilities

I would like to start by asking you a few questions about your job.

RR1. What is your job title at <UTILITY>?

RR2. How many years of experience do you with energy efficiency program implementation?

RR3. What are your primary job responsibilities?

 RR3a. [If not indicated in primary job responsibilities in RR3] Which commercial and industrial new construction and major renovation programs do you work on? [Probe for specifics -- If custom approach, what types of projects? Examples of custom approaches include Comprehensive Design Approach, industrial applications, and custom energy conservation measures for commercial buildings]

 RR3b. [If not indicated in primary job responsibilities in RR3] What types of customers do you work with? Examples include market segments such as office, retail, chain and franchise, healthcare.

 RR3c. [If not indicated in primary job responsibilities in RR3] What market actors do you work with? Examples include architects, engineers, construction managers, developers.

RR4. Do you have the opportunity to review commercial and industrial building drawings and specifications for energy performance compared to the building energy code requirements?

 RR4a. [If RR4=Yes] What do you review?
New Construction Programs

In this section, I would like to learn more about your new construction program offerings.

NC1. What technical assistance does the PA provide for new construction and major renovation projects?

NC2. What are your PA's incentive offerings for new construction and major renovation projects?

NC3. Which incentives provide the greatest savings to new construction and major renovation projects?

NC4. Which building systems and/or controls offer the greatest energy savings to your customers?

[Don’t read; Check all that apply]

☐ Lighting
☐ Lighting Controls
☐ Efficient Boilers/Furnaces
☐ Efficient Unitary Air Conditioning Systems
☐ Efficient Chillers
☐ Building Management Systems
☐ Building Air Sealing
☐ Enhanced Envelope Measures (such as high R value windows, or high R value insulation)
☐ Other: (Please describe: ________________________________)

NC5. Are there program offerings that provide high potential savings, but are not often selected by customers?

NC5a. [If NC5= YES] Which ones? Why are they not selected?

NC6. Would you recommend any additional program offerings that are not currently available?

NC6a. [If NC6=Yes] What would you recommend? Why do you say that?
NC7. Please describe how new construction programs are revised when there are updates to the commercial building energy code.

[Probe: Look for how Program Administrators have to change program offerings in response to increased energy efficiency]

NC8. How have the recent rapid sequence of commercial energy code updates impacted your new construction and major renovation programs?

[Probe in terms of qualitative measures (e.g., property developer satisfaction) and quantitative measures (e.g., number of participants and savings).]

[Note to interviewer: In Massachusetts, energy code changed September 9, 2008 (7th edition), July 1, 2009 (7th edition with amendments), and July 1, 2010 (8th edition).]

**Energy Code**

In this section, I would like to ask you questions about the Massachusetts commercial building energy code.

EC1. On a scale of 1 to 10, where 1 is “not familiar at all” and 10 is “extremely familiar,” how familiar are you with the following Massachusetts commercial building energy codes?

- EC1a. 7th edition enacted September 9, 2008
- EC1b. 7th edition with amendments, enacted July 1, 2009
- EC1c. 8th edition enacted July 1, 2010
EC2. In your current position, is it important to be familiar with the Massachusetts building energy code?

EC2a. Why do you say that?

EC3. How do new construction program implementers learn about the commercial energy code?

EC4. How has the adoption of the Stretch Code by municipalities impacted your new construction program?

[Probe for changes in program offerings and program participation]

EC5. Have any projects that had to meet the Stretch code requirements applied to the new construction program?

EC5a. [If EC5=YES] If so, how many commercial projects?

EC6. Are there advantages of a standardized commercial code based on IECC versus Massachusetts-specific energy code language?

EC6a. [If EC6=Yes] What are they?

EC7. Are there disadvantages of a standardized commercial code based on IECC versus Massachusetts-specific energy code language?

EC7a. [If EC7 YES] What are they?
EC8. Please describe your experience with architects, engineers, and developers regarding their knowledge of the commercial building energy code.

**Energy Code Compliance**

In this final section, I want to find out more about your experiences with commercial energy code compliance.

ECC1. Do you interact with local building code officials who enforce the building code?

ECC1a. [If ECC1=Yes] Please explain the nature of your interactions with building code officials.

ECC2. Is there any relationship between energy code compliance and project square footage? In other words, are smaller projects (buildings <10,000 SF), more or less likely to comply with energy code than larger projects (buildings >10,000 SF)?

ECC3. Are there any particular building owner categories that are more or less likely to comply with energy code? [Examples: Owner-occupied, speculative development]

ECC4. Are there any differences in commercial energy code compliance between new construction projects and major renovations?

ECC4a. [If ECC4=Yes] What are the differences?

ECC5. Which commercial and industrial building sector types are more or less likely to comply with energy code? [Examples: offices, multi-family units, schools, warehouses, retail, healthcare, laboratories, athletic facilities]
ECC6. Which building systems are more or less likely to comply with the energy code? List as many as possible. [Examples: boilers, chillers, VFDs]

ECC7. Which building system controls are more or less likely to comply with the energy code? List as many as possible. [Examples: lighting controls, building management systems, onboard controls for air handlers]

ECC8. What percent of projects that applied to the program have not met energy code requirements?

ECC8a. [IF ECC8>0%] Did you ask the applicants to correct items not in compliance with the energy code?

ECC8b. [IF ECC8a=No] If the non-compliant items did not pertain to new construction program measures, could the applicant continue to participate? Please explain.

ECC9. What policies and actions could be implemented to improve code compliance for commercial and industrial buildings?

**Closing Comments**

CC1. Do you have any other input regarding energy code compliance in regard to new construction, major renovations and additions?

**Those are all the questions I wanted to ask. Thank you for your time and participation.**
E. Initial In-Depth Instrument: Building Code Officials Interview Guide
MA LCIEC – PROJECT 11 CODE COMPLIANCE BASELINE STUDY

INITIAL IN-DEPTH INTERVIEW GUIDE FOR BUILDING CODE OFFICIALS

Contact Name: ______________________________________________________

Jurisdiction: ______________________________________________________

Address: ______________________________________________________

City, State: ______________________________________________________

Telephone: ______________________________________________________

E-Mail Address: ____________________________________________________

Interview Date: __________ Interview Time: __________ (Duration in Minutes)

[NOTES TO INTERVIEWER]
Discussions with building code officials will provide a solid foundation for understanding the compliance practices in regard to the existing building energy code. The objectives of the interviews are to collect the following information:

- Code officials’ knowledge of commercial building energy and Stretch codes.
- Commercial energy code compliance staffing practices.
- Process for determining commercial energy code compliance.
- Barriers for enforcing commercial energy code compliance.

If respondents have questions about study, they can contact Wendy Todd of National Grid at wendy.todd@us.ngrid.com or 781-907-2232.
LEAD-IN:

Hi, my name is __________ and I work for KEMA, an energy consulting firm. We have been hired by the Massachusetts electric and gas utilities’ Energy Efficiency Program Administrators to conduct research on energy code compliance in new commercial building construction.

This study is part of a major effort to support and improve vital efficiency measures that will help address energy and environmental challenges in Massachusetts. The objectives of the study are to understand current design and construction practices, the energy code compliance process, and the future energy savings potential from recently constructed buildings. I would like to talk with you to find out more about your experience with the energy code.

The conversation should take approximately 30 minutes. Your responses are confidential and the report will not include the names or jurisdictions of the individuals we interview.

Roles and Responsibilities

I would like to start by asking you a few questions about your job.

RR1. What is your job title?

RR2. How long have you held this position?

RR3. What are your primary job responsibilities?

RR3a. [If not indicated in RR3] Do your job responsibilities involve residential, commercial and/or industrial buildings?

RR4. Have previous positions provided you experience with the energy code?
RR4a. [If RR4=Yes] Please describe this experience.
   [Probe: Name of position, Length of time in role, Description of role pertaining to the energy code]

RR5. During the previous year, how many commercial building permits were issued by your agency?

RR6. How is your department funded?
   [Read responses and check all that apply]
   - Permitting revenue
   - Jurisdictional budget
   - State funded
   - Other (Please describe: ________________________________________________)

Staff Energy Code Compliance Processes and Training

[If work with additional staff]
In this section, I would like to ask you some questions about your staff and their training.

[If do not work with additional staff]
In this section, I would like to ask you some questions about your training.

SECC1. [If work with additional staff] How many full time staff work in your office?

SECC2. [If work with additional staff] What is the average number of years of experience of your staff?
SECC3. Within the last two years, has anyone from your staff attended training on energy code compliance and enforcement offered by the State and its vendor, the Center for Ecological Technology?

☐ Yes  
☐ No

SECC3a. [IF SECC3 = YES] Have you changed your process of commercial energy code enforcement as a result of the training?

☐ Yes  
☐ No

SECC3b. [IF SECC3a=YES] How have your commercial energy code enforcement practices changed as a result of the training?

SECC3c. [If SECC3 =YES] Do you feel that this training has been sufficient?

☐ Yes  
☐ No

SECC3d. [If response to SECC3c indicated] Why do you say that?

SECC4. How would you prefer to receive training?
[Read responses and check all that apply]

☐ Webinar / Online  
☐ Classroom  
☐ In the field  
☐ Other (Please describe: __________________________________________________________)
Energy Code Compliance Practices

In this final section, I want to find out more about energy code practices for commercial buildings in your jurisdiction.

[Note to interviewer: interviewees may be responsible for both residential and commercial energy code compliance; however the focus of this interview is the commercial energy code.]

ECCP1. How do you typically go about assessing energy code compliance in commercial buildings?

ECCP2. Who conducts plan reviews for commercial energy code compliance?
[Read responses and check all that apply]

☐ Not done
☐ Interviewee (if single person code office)
☐ In-house staff
☐ 3rd party entities (Please describe: ____________________________)
☐ Other jurisdictions or government agencies (Please describe: ________________)
☐ Other (Please describe: ________________________________)

ECCP3. Who conducts field inspections for commercial energy code compliance?
[Read responses and check all that apply]

☐ Not done
☐ Interviewee (if single person code office)
☐ In-house staff
☐ 3rd party entities (Please describe: ____________________________)
☐ Other jurisdictions or government agencies (Please describe: ________________)
☐ Other (Please describe: ________________________________)

ECCP4. What documentation and/or calculations do you require from the applicant to demonstrate energy code compliance?
[Note to interviewer: If affidavit is mentioned in ECCP4, ask ECCP4a-c:]

ECCP4a. If you require affidavits to demonstrate energy code compliance, are the affidavits specific to the energy code or do they address all code provisions?

☐ Affidavits specific to the energy code
☐ Affidavits address all code provisions

ECCP4b. If an affidavit indicating code compliance is received, is that sufficient as energy code compliance documentation?

☐ Yes
☐ No

ECCP4c. [If ECCP4b=No] What else is required?

ECCP5. [If ECCP2 does not equal Not Done] Are energy plan reviews performed in conjunction with reviews for other code provisions?

☐ Yes
☐ No

ECCP6. [If ECCP2 does not equal Not Done] Please provide an estimate of the range of hours devoted to plan review for energy codes.

[Enter low and high ranges:] Low Range: _____ hours; High Range: _____ hours

ECCP6a. [If range in ECCP6>0 hours] What affects the number of hours devoted to plan review for energy codes?
[Probe: Building size, building type and complexity, staff, resources]

ECCP7. [If ECCP3 does not equal Not Done] Are field inspections conducted to confirm compliance with the commercial energy code?

☐ Yes
☐ No
ECCP8.  [If ECCP3 does not equal Not Done] Please provide an estimate of the range of hours devoted to field inspections for commercial energy codes? If energy field inspections are performed in conjunction with inspections for other code provisions, please estimate the time for the energy-related field inspections only.

[Enter low and high ranges:] Low Range: _____hours; High Range: _____hours

ECCP8a.  [If range in ECCP8>0 hours] For commercial projects, what affects the number of hours devoted to field inspections for energy codes? [Probe: Building size, building type and complexity, staff, resources]

ECCP9.  Do you engage the Master Code Officials to help answer questions on energy code issues?

☐ Yes  ☐ No

ECCP9a.  [If ECCP9=Yes] How so?

ECCP10.  Are there other sources of information or experts that you use to address energy code questions?

☐ Yes  ☐ No

ECCP10a.  [If ECCP10=Yes] What other sources do you use to address energy code questions?
ECCP11. Do you feel that the design and construction communities in your jurisdiction are familiar with the energy code – including recent updates dating back to the release of the 7th Edition of code?

☐ Yes
☐ No

ECCP11a. Why do you say that?

ECCP12. What format does your agency use to maintain permitting data?

[Read responses and check all that apply]

☐ Paper
☐ Electronic
☐ Other (Please describe: ________________________________________________)

ECCP13. How many years does your agency maintain permitting data?

[Prompt by reading if needed; Choose only one response]

☐ 1-2 years
☐ 3-5 years
☐ 6-7 years
☐ More than 7 years

ECCP14. Are there any limitations that impede your ability to enforce the commercial energy code?

☐ Yes
☐ No

ECCP14a. [If ECCP14=Yes] What limitations impede your ability to enforce the commercial energy code?

[Do not read list; Check all that apply]

☐ Lack of time
☐ Lack of staff
☐ Lack of money
☐ Lack of education or training
☐ Lack of data provided with the plans
☐ Lack of building access
☐ Lack of equipment
☐ Other (Please describe: ________________________________________________)

ECCP14b. [If response to ECCP14a indicated] What kind of assistance might help get around these impediments?
ECCP15. Are there other provisions of the code that generally take precedence over the energy code?

☐ Yes
☐ No

ECCP15a. [If ECCP15=Yes] What provisions take precedence over the energy code?

ECCP15b. [If ECCP15=Yes] How much time is spent reviewing other code provisions versus the energy code?

ECCP16. For commercial projects, are there items in the designs, materials, equipment, or procedures that you find are typically not energy code compliant during initial plan review?

☐ Yes
☐ No

ECCP16a. [If ECCP16=Yes] Which of the following plan review items do you generally find do not comply with the commercial energy code?

[Read responses and check all that apply]

☐ Envelope insulation levels
☐ Envelope insulation installation
☐ Envelope sealing around fenestration
☐ Envelope sealing at building joints and seams
☐ Fenestration
☐ Duct insulation
☐ Duct sealing
☐ Piping insulation
☐ Installed interior lighting power
☐ Installed exterior lighting power
☐ Lighting controls
☐ HVAC equipment
☐ HVAC system controls
☐ Other (Please describe: ___________________________________)
ECCP17. For commercial projects, are there items in the designs, materials, equipment, or procedures that you find are typically not energy code compliant during initial inspection?

☐ Yes
☐ No

ECCP17a. [If ECCP17=Yes] Which of the following inspection items do you generally find do not comply with the commercial energy code?

[Read responses and check all that apply]

☐ Envelope insulation levels
☐ Envelope insulation installation
☐ Envelope sealing around fenestration
☐ Envelope sealing at building joints and seams
☐ Fenestration
☐ Duct insulation
☐ Duct sealing
☐ Piping insulation
☐ Installed interior lighting power
☐ Installed exterior lighting power
☐ Lighting controls
☐ HVAC equipment
☐ HVAC system controls
☐ Other (Please describe: ________________________________)

ECCP18. Do you use energy code compliance software reports during the plan check process?

☐ Yes
☐ No

ECCP18a. [If ECCP18=Yes] How do you use energy code compliance software reports during the plan check process?

ECCP19. Has your jurisdiction adopted the Stretch code?
[Interviewer note: Look up jurisdiction’s status of Stretch code before interview]

☐ Yes
☐ No

ECCP19a.  [If ECCP19=Yes] When did or when will the Stretch code go into effect?

ECCP19b.  [If ECCP19=Yes] Has the energy code enforcement process been affected by adoption of the Stretch code?

☐ Yes
☐ No

ECCP19c.  [If ECCP19b=Yes] How so?

ECCP20.  During the design and construction of a building project in your jurisdiction, do you have any interactions with the gas or electric utilities serving the project?

☐ Yes
☐ No

ECCP20a.  [If ECCP20=Yes] Please describe these interactions.

[Probe: Why interact with utilities, how often interact with utilities, with whom interacting at utilities, when?]

ECCP21.  Energy efficiency programs offer incentives to building projects that exceed energy code thresholds. Do you think there is a role energy efficiency program administrators could perform to increase compliance with the commercial building energy code?

☐ Yes
☐ No

ECCP21a.  [If ECCP21=Yes] How could program administrators improve commercial compliance?
Closing Comments

CC1. Do you have any other input regarding energy code compliance in regard to new construction, major renovations and additions in commercial buildings?

Those are all the questions I wanted to ask. Thank you for your time and participation.
F. Initial In-Depth Instrument: Retailers, Wholesalers and Commercial Building Equipment Vendors Interview Guide
[NOTES TO INTERVIEWER]
Some energy code provisions are directly affected by the building supply markets as well as by the design community. For example, if local lumber yards and big box yards do not typically stock windows that are IECC 2009 or Stretch Code compliant, it is unlikely that smaller commercial buildings will be built with code compliant windows. The same holds true for HVAC equipment. Target market actors include wholesalers and retailers associated with lighting equipment and controls market, HVAC equipment and controls, and the broad range of building envelope products. The primary purpose of this interview is to gather information regarding market actors' knowledge of and supply strategies based on the building energy code. Key research topics include:

- Knowledge of Massachusetts commercial energy code
- Stocking practices
- Distribution of energy code information to customers
- Receipt of energy code related questions from customers
- Perspective of energy codes as an upsell opportunity
- Accessibility of and understandability of code information

If respondents have questions about study, they can contact Wendy Todd of National Grid at wendy.todd@us.ngrid.com or 781-907-2232.
LEAD-IN:

Hi, my name is __________ and I work for KEMA, an energy consulting firm. We have been hired by the Massachusetts electric and gas utilities and the Cape Light Compacts’ Energy Efficiency Program Administrators to conduct research on building supply markets and their potential impact on the energy efficiency of new commercial buildings and commercial renovations.

I would like to talk with you about your experience with the Massachusetts commercial building energy code, whether changes in the energy code impact your business, and whether customers seek advice from you about the energy code. The conversation will take approximately 30 minutes.

General Firm Information and Firmographics

I’d like to ask for some general information about your firm’s operations at this location.

F1. What is your job title?

F2. What are your primary job responsibilities?

F3. What is your company’s sales region?

F4. [IF a retail store] How many retail stores do you have in Massachusetts?

F5. How many employees work at your company in Massachusetts?

F6. Besides this location, from what other locations does your company operate in Massachusetts and outside the state?

F7. What products and services does your company offer related to commercial building projects?
F8. Does your company focus on certain commercial building types?

☐ Yes
☐ No

F8a. [IF F8 = Yes] What types of buildings?

[Probe if necessary; Check all that apply]
1. Office buildings
2. Healthcare
3. Primary/Secondary Education
4. Colleges/Universities
5. Multi-family residential/Senior living facilities
6. Retail
7. Hotel/Motel
8. Restaurants
9. Process Industrial
10. Assembly Industrial
11. Other (Specify: ______________________)
12. No specialization

Energy Code Awareness

EC1. How familiar are you with the recent updates to the Massachusetts Commercial Energy Code? [If necessary, In Massachusetts, energy code changed September 9, 2008 (7th edition), July 1, 2009 (7th edition with amendments), and July 1, 2010 (8th edition), and the Stretch Code was first adopted in July 2009).

[Read responses and only choose one]
1. Not familiar
2. A little familiar
3. Somewhat familiar
4. Very familiar

EC1a. [If EC1 = 2, 3, or 4] Does that knowledge include the Massachusetts amendments to the energy code?

☐ Yes
☐ No
EC2. Does your staff maintain a copy of the Massachusetts energy code?
   □ Yes
   □ No

EC3. Are you familiar with the Stretch Code?
   □ Yes
   □ No

EC3a. [IF EC3 = Yes] Have towns in your sales region adopted the Stretch Code?
   □ Yes
   □ No

EC3b. [IF EC3a = Yes] What towns in your sales region have adopted the Stretch Code?

EC4. [If EC1 = 2, 3, or 4] How do you usually learn about updates to the Massachusetts Commercial Energy Code?
   [Probe: trainings, meetings, written material; is the material understandable]

EC5. How familiar are your customers with the recent updates to the Massachusetts Commercial Energy Code? [Customers that participate in commercial new construction]
   [Read responses and only choose one]
   1. Not familiar
   2. A little familiar
   3. Somewhat familiar
   4. Very familiar

EC5a. In your opinion, which customers are most knowledgeable?
EC6. How often do your customers ask you to assure them that products supplied are code compliant?

[Read responses and only choose one]

☐ All the time
☐ Most of the time
☐ Some of the time
☐ Rarely
☐ Never

EC7. How often do your customers ask you to interpret the code?

[Read responses and only choose one]

☐ All the time
☐ Most of the time
☐ Some of the time
☐ Rarely
☐ Never

EC8. How often do your customers ask you to specify code compliant designs?

[Read responses and only choose one]

☐ All the time
☐ Most of the time
☐ Some of the time
☐ Rarely
☐ Never
EC9. Are you familiar with the efficiency programs offered by the Massachusetts energy efficiency program administrators? [If necessary, program administrators refer to the electric and gas utilities and Cape Light Compact]

☐ Yes  
☐ No

EC9a. [IF EC9 = Yes] Do you specify equipment to meet their program requirements?

☐ Yes  
☐ No

EC9b. [IF EC9 = Yes] Do you stock equipment that qualifies for program incentives?

☐ Yes  
☐ No

EC9c. [IF EC9 = Yes] Do you promote the programs?

☐ Yes  
☐ No

EC9d. [IF EC9c = Yes] How do you promote the programs?

EC10. [If F6 indicates business operates outside of Massachusetts] Do you think it is more difficult to meet energy code requirements in Massachusetts than in other states?

☐ Yes  
☐ No

EC10a. [If EC10=Yes] Why do you say that?

E11. What policies and/or actions could be implemented to increase energy code compliance for commercial projects in Massachusetts?
Lighting Vendors Only:

LV1. Does your staff produce lighting layouts for your customers?
☐ Yes
☐ No

LV1a. [IF LV1 = Yes] Are LPD’s (lighting power density) calculated?
☐ Yes
☐ No

LV1b. [IF EC1 = 2, 3, or 4 and LV1a = Yes] Can you obtain LPD’s lower than the code allowance?
☐ Yes
☐ No
[Record open ended responses]

LV2. Are you aware of new daylight control requirements?
☐ Yes
☐ No

LV2a. [IF LV2 = Yes] Do your customers understand the daylight zone concept?
☐ Yes
☐ No
Building Material Suppliers (Windows and Doors) Only:

B1. Are the new, stricter requirements for window performance understood by your:

   Staff  □ Yes □ No □ Somewhat
   Contractors  □ Yes □ No □ Somewhat
   Specifiers  □ Yes □ No □ Somewhat

B2. How often do customers request information about window and door energy performance characteristics? For example, inquiring about Energy Star rating?

B3. How often do your customers ask you to assure them that windows and doors for a project meet energy code requirements?

   [Read responses and only choose one]

   □ All the time
   □ Most of the time
   □ Some of the time
   □ Rarely
   □ Never

B3a. [IF EC3 = 1 and B2 not = Never] Do your customers ask you to assure them that windows and doors for a project meet the Stretch Code, when applicable?

   □ Yes
   □ No

B4. How do you communicate that custom windows are compliant with the energy code or Stretch Code?
HVAC Vendors Only:

H1. How often do your customers ask you to assure them that HVAC equipment for a project meets energy code requirements?

[Read responses and only choose one]

☐ All the time
☐ Most of the time
☐ Some of the time
☐ Rarely
☐ Never

H1a. [IF EC3 = 1 and H1 not = Never] For projects that have to meet the Stretch Code, are your customers more likely, less likely, or just as likely to seek assurance that HVAC equipment is compliant with the energy code requirements?

☐ More Likely
☐ Less Likely
☐ Just as Likely

H2. Do you help your customers size equipment for a project?

☐ Yes
☐ No

H2a. [IF H2 = Yes] Please explain how you help customers size equipment.

H3. In your opinion, do your customers understand the energy code provisions for HVAC control systems? [IF necessary, examples include demand control ventilation requirements, controls to prevent simultaneous heat/cooling, and economizer controls]

☐ Yes
☐ No

H3a. [IF H3 = No] Why do you say that?
Stocking Practices

S1. [If EC1 = 2, 3, or 4] Have the recent Massachusetts energy code changes affected the types of equipment and supplies that you stock? [In Massachusetts, energy code changed September 9, 2008 (7th edition), July 1, 2009 (7th edition with amendments), and July 1, 2010 (8th edition).], and the Stretch Code was first adopted in July 2009.]

☐ Yes
☐ No

S1a. [IF S1 = Yes] How have these changes affected your stocking practices?

S1b. [IF EC3=Yes and S1 = Yes] How has the Stretch Code affected your stocking practices?

S2. [If EC1 = 2, 3, or 4] Has the change that expands energy code requirements to nearly all renovation projects affected your stocking practices?

☐ Yes
☐ No

S2a. [IF S2 = Yes] How has this change affected your stocking practices?

S3. Does your company assist design teams by providing technical assistance or equipment to meet commercial energy code requirements?

☐ Yes
☐ No

S3a. [IF S3 = Yes] What type of technical assistance do you provide?
Building Material Suppliers (Windows and Doors) Only:

W1. [If EC1 = 2, 3, or 4] Are you familiar with air barrier requirements for windows and doors?
   - □ Yes
   - □ No

   W1a. [If W1=Yes] Do you stock products that meet air barrier requirements?
       - □ Yes
       - □ No

   W1b. [If W1a = Yes] What products do you stock that meet the air barrier requirements?

W2. [If W1=Yes] Do your customers ask for advice on air barriers?
   - □ Yes
   - □ No

W3. [If EC1 = 2, 3, or 4] Do you stock a large variety of window performance levels, or only those meeting current energy code and Stretch code?
HVAC Vendors Only:

V1. [If EC1 = 2, 3, or 4] Is there any difference in the efficiency of products stocked to replace failed versus equipment that is ordered from new construction and major renovations? [Note to interviewer: seeking insight into differences between products stocked for retrofit versus new construction]
   ☐ Yes
   ☐ No

V1a. [IF V1 = No] Please explain why efficiency levels of stocked replacement equipment differ from that of new construction/major renovation.

V2. [If EC1 = 2, 3, or 4] Is there a long lead time for equipment that outperforms code, such as equipment that meets Stretch Code specifications?
   ☐ Yes
   ☐ No

V2a. [IF V2 = Yes] Does that affect final specification?
   ☐ Yes
   ☐ No

V3. Do you keep in stock all sizes of common equipment; such as RTUs and boilers? [If necessary, RTU stands for “packaged rooftop unit”]
   ☐ Yes
   ☐ No

V3a. How does equipment availability change a customer’s buying practices?

V3b. [IF V3 = No] If a proper size is not stocked, do customer oversize?
   ☐ Yes
   ☐ No
Closing Comments

CC1. Do you have any other input regarding energy code compliance in regard to new construction, major renovations and additions?

Those are all the questions I wanted to ask. Thank you for your time and participation.
G. Initial In-Depth Instrument: Design Community Members Interview Guide
MA LCIEC – PROJECT 11 CODE COMPLIANCE BASELINE STUDY

INITIAL IN-DEPTH FOCUS GROUP DISCUSSION GUIDE

DESIGN COMMUNITY MEMBERS

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<th>Focus Group Participant</th>
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Name of Discussion Leader: ________________________________

[NOTES TO DISCUSSION LEADER]

For this research effort, the Design Community is considered to include architects, engineers, construction managers, contractors and developers. We plan to conduct two focus group sessions one with architects and engineers, and one with construction managers and developers. This discussion guide addresses the Design Community’s experience complying with the Massachusetts commercial energy code, identifies barriers that impede code compliance and solicits suggestions to improve code compliance.
LEAD-IN:

Hi, my name is _________ and I work for KEMA, an energy consulting firm. We have been hired by the Massachusetts electric and gas utilities’ Energy Efficiency Program Administrators to establish an energy code compliance baseline for new commercial building construction.

This group discussion is part an effort to help understand your experience with the new energy code, compliance practices and on-the-ground code implementation.

All information gathered during this session will be confidential and will not be linked to any individual, firm or project.

I’d like to start off this session by asking…

1. **What is the typical process by which your firm documents compliance or participates in the commercial energy compliance practice?**

   [Ask following probes if time available]
   a. Who is primarily responsible for documenting compliance with the Massachusetts commercial energy code during the design of the building?
   b. What documentation is typically required by the building official(s) to demonstrate compliance with the energy code?

2. **In terms of energy code compliance, please describe your interactions with local code officials and their level of engagement on your projects.**

   [Ask following probes if time available]
   a. Do code officials seem knowledgeable about the commercial energy code?
   b. Have there been any difficulties in dealing with the code officials or in gaining approvals for energy code compliance?
   c. What difficulties did you encounter?
   d. During construction, how often do building officials conduct an inspection of the building?
   e. Has someone at your firm been present during the inspections?
   f. What are the main components that building officials focus on during inspections?
3. What challenges do you face in meeting the Massachusetts commercial building energy code?

[Ask following probes if time available]
  a. Are there any challenges your firm commonly encounters in meeting the energy code?
  b. Are there any challenges the construction teams commonly encounter in meeting the energy code?
  c. How did you overcome these challenges?
  d. Which area(s) of the energy code do you find most difficult to meet?
  e. Which area(s) of the energy code do you find are the easiest to meet?

4. How do team members familiarize themselves with new code requirements?

[Ask following probes if time available]
  a. Do you find it easy to track updates and amendments to the energy provisions of the code?
  b. What training or assistance would be useful in helping your firm document compliance with the energy code?
  c. How do you prefer to receive training?
  d. Has your firm initiated any commercial building projects since the 8th edition became available?
     i. Have you received any training specific to the 8th edition?

5. Which policies and/or procedures have you found work best for documenting compliance?

[Ask following probes if time available]
  a. What suggestions do you have on how energy code compliance rates could be improved?
  b. What types of policies or programs could be implemented to improve compliance for market sectors that are extremely sensitive to first-costs?

6. Has your firm been involved with any projects utilizing the Massachusetts Stretch Code?

[Ask following probes if time available]
  a. Are there issues you would like to note in relation to complying with the stretch code?
MA LCIEC – PROJECT 11 CODE COMPLIANCE BASELINE STUDY

PROJECT-SPECIFIC IN-DEPTH INTERVIEW GUIDE FOR BUILDING CODE OFFICIALS

Contact Name: ______________________________________________________

Jurisdiction: ______________________________________________________

Address: ______________________________________________________

City, State, Zip: ____________________________________________________

Telephone: ______________________________________________________

E-Mail Address: _____________________________________________________

Relevant Commercial Projects: _______________________________________

Interview Date: __________ Interview Time: __________ (Duration in Minutes)

[NOTES TO INTERVIEWER]

Discussions with building code officials will provide a solid foundation for understanding the energy code compliance practices in regard to specific commercial building projects identified by the LCIEC team. The objectives of the interviews are to collect the following information:

- Knowledge of commercial building energy and Stretch codes
- Energy code compliance practices for a specific commercial project
- Barriers to enforcing commercial building energy code
- Suggestions to improve commercial building energy code compliance

NMR has contacted a few building officials regarding residential code compliance. If building official representative indicates previously being contacted to discuss code compliance, let them know our study focuses on commercial and industrial buildings (not residential).

If respondents have questions about study, they can contact Wendy Todd of National Grid at wendy.todd@us.ngrid.com or 781-907-2232.
LEAD-IN:

Hi, my name is _________ and I work for <KEMA/ERS>, an energy consulting firm. We have been hired by the Massachusetts electric and gas utilities’ Energy Efficiency Program Administrators to study energy code compliance for randomly selected new commercial building projects.

We have been in touch with <BUILDING OWNER/MANAGER> of the <COMMERCIAL PROJECT> who has agreed to participate in this study. This interview is focused on the energy code compliance process for the <COMMERCIAL PROJECT> and your experience with the commercial energy code in Massachusetts.

The conversation will take approximately 20 minutes. Your responses are completely confidential and the report will not include the names of individuals we interview or their jurisdictions.

Roles and Responsibilities

I would like to start by asking you a few questions about your job.

RR1. May I ask, what is your job title?

RR2. How long have you held this position?

RR3. What are your primary job responsibilities?

RR3a. [If not indicated in RR3] Do your job responsibilities involve residential or commercial and industrial buildings?

RR4. Have previous positions provided you experience with the energy code?

RR4a. [If RR4=Yes] Please describe this experience.
[Probe: Name of position, Length of time in role, Description of role pertaining to the energy code]
Staff Energy Code Compliance Processes and Training

[If work with additional staff]
In this section, I would like to ask you some questions about your staff and their training.

[If do not work with additional staff]
In this section, I would like to ask you some questions about your training.

SECC1. [If work with additional staff] How many full time staff work in your office?

SECC2. [If work with additional staff] What is the average number of years of experience of your staff in terms of building code compliance?

SECC3. Within the last two years, have you or anyone from your staff attended training on energy code compliance and enforcement offered by the State and its vendor, the Center for Ecological Technology?

☐ Yes
☐ No

SECC3a. [IF SECC3 = YES] Have you changed your process of commercial energy code enforcement as a result of the training?

☐ Yes
☐ No

SECC3b. [IF SECC3a=YES] How have your commercial energy code enforcement practices changed as a result of the training?

SECC3c. [If SECC3 =YES] Do you feel that this training has been sufficient?

☐ Yes
☐ No

SECC3d. [If response to SECC3c indicated] Why do you say that?
SECC4. How would you prefer to receive training?
[Read responses and check all that apply]

☐ Webinar / Online
☐ Classroom
☐ In the field
☐ Other (Please describe: ________________________________)

Energy Code Compliance Practices

In this final section, I want to find out more about energy code practices for the <COMMERCIAL PROJECT> constructed in your jurisdiction.

ECCP1. How do you typically go about assessing energy code compliance?

ECCP2. Under which version of the building energy code was the commercial project submitted?
[Read responses; Check only one]

☐ 7th edition enacted October 6, 2008
☐ 7th edition with amendments, enacted July 1, 2009
☐ 8th edition enacted July 1, 2010
☐ Stretch Energy Code [Appendix 115AA in 8th edition]

ECCP3. For the <COMMERCIAL PROJECT>, what documentation do or would you require from the applicant to demonstrate energy code compliance?
[Don’t read: Possible answers include Prescriptive, Trade-off, Performance, Stamped affidavit]
ECCP4. Were energy plan reviews performed in conjunction with reviews for other code provisions for the <COMMERCIAL PROJECT>?

☐ Yes
☐ No
☐ Will perform plan review in future

ECCP4a. Please provide an estimate of the number of hours devoted to plan review for energy code compliance for the <COMMERCIAL PROJECT>.

ECCP4b. [If ECCP4a>0 hours] For commercial projects in general, what factors affect the number of hours devoted to plan review for energy codes?
[Probe: Building size, building type and complexity, staff, resources]

ECCP5. Were field inspections performed for energy code compliance for the <COMMERCIAL PROJECT>?

☐ Yes
☐ No
☐ Will perform field inspections in future

ECCP5a. [If ECCP5=Yes] Please provide an estimate of the number of hours devoted to field inspections for energy code compliance for the <COMMERCIAL PROJECT>.

ECCP5b. [If ECCP5a>0 hours] For the <COMMERCIAL PROJECT>, what affected the number of hours devoted to field inspections for energy codes?
[Probe: Building size, building type and complexity, staff, resources]

ECCP6. [If ECCP4=YES] What information was available to your staff during field inspections for the <COMMERCIAL PROJECT>?

[Read responses and check all that apply]

☐ Approved plans
☐ Energy code compliance checklist(s)
☐ Published energy codes and/or standards
☐ Other (Please describe: ____________________________ )
ECCP7. [If ECCP4 AND ECCP5=YES] Did the energy plan review and field inspections cover all aspects of the energy code for the <COMMERCIAL PROJECT>?

☐ Yes
☐ No

ECCP7a. [If ECCP7=No] What aspects were not covered?

ECCP8. [If ECCP4 OR ECCP5=YES] Were there plan review and/or field inspection items that did not comply with the commercial energy code for <COMMERCIAL PROJECT>?

☐ Yes
☐ No

ECCP8a. [If ECCP8=Yes] What plan review and/or inspection items did not comply with the commercial energy code for <COMMERCIAL PROJECT>?

[Read responses and check all that apply]

☐ Envelope insulation levels
☐ Envelope insulation installation
☐ Envelope sealing around fenestration
☐ Envelope sealing at building joints and seams
☐ Fenestration
☐ Duct insulation
☐ Duct sealing
☐ Piping insulation
☐ Installed interior lighting power
☐ Installed exterior lighting power
☐ Lighting controls
☐ HVAC equipment
☐ HVAC system controls
☐ Other (Please describe: _______________________________________

ECCP8b. [If ECCP8=Yes] Why did these items not comply with the commercial energy code for the <COMMERCIAL PROJECT>?
ECCP9. Were there any limitations that impeded your ability to enforce the commercial energy code for the <COMMERCIAL PROJECT>?

☐ Yes
☐ No

ECCP9a. [If ECCP9=Yes] What limitations impeded your ability to enforce the commercial energy code?

[Don’t read; Check all that apply]
☐ Lack of time
☐ Lack of staff
☐ Lack of money
☐ Lack of education or training
☐ Lack of data provided with the plans
☐ Lack of building access
☐ Lack of equipment
☐ Other (Please describe: ____________________________)

[Interviewer note: Look up jurisdiction’s status of Stretch code before interview]

ECCP10. [If Stretch code adopted] When did or when will the Stretch code go into effect?

ECCP11. [If Stretch code adopted] Has the energy code enforcement process been affected by adoption of the Stretch code?

☐ Yes
☐ No

ECCP11a. [If ECCP11=Yes] How so?

ECCP12. Do energy code compliance software reports satisfy compliance without conducting a full plan review?

☐ Yes
☐ No

ECCP12a. Why do you say that?
ECCP13. Approximately what percentage of the time, if any, is the full compliance documentation incomplete?

ECCP13a. [Ask if ECCP13 >0%] What information is typically missing from commercial project plans, specifications and/or actual construction that prevents you from determining energy code compliance?

ECCP14. During the design and construction of <COMMERCIAL PROJECT> in your jurisdiction, did you have any interactions with the gas or electric utilities serving the project?

☐ Yes
☐ No

ECCP14a. [If ECCP14=Yes] Please describe these interactions. [Probe: Why interact with utilities, how often interact with utilities, with whom interacting at utilities, when?]

ECCP15. Energy efficiency programs offer incentives to building projects that exceed energy code thresholds. Do you think there is a role energy efficiency program administrators could perform to increase compliance with the commercial building energy code?

☐ Yes
☐ No

ECCP15a. [If ECCP15=Yes] How could program administrators improve commercial compliance?

Closing Comments

CC1. Do you have any other input regarding energy code compliance in regard to new construction, major renovations and additions?

Those are all the questions I wanted to ask. Thank you for your time and participation.
I. Project-Specific Instrument: Building Owners and Property Managers Interview Guide
MA LCIEC – PROJECT 11 CODE COMPLIANCE BASELINE STUDY
PROJECT-SPECIFIC IN-DEPTH INTERVIEW GUIDE FOR BUILDING OWNERS AND PROPERTY MANAGERS

Contact Name: ____________________________________________________________

Job Description: □ Building Owner  □ Property Manager  □ Other (Please describe: ________________________________)

Name of Building: __________________________________________________________

Building Type: [Interviewer note: Record only one response - If facility used to conduct more than one type of business activity, indicate the primary activity.]
□ Retail  □ Office  □ School  □ Multi-family  □ Warehouse  □ Other (Please describe: ________________________________)

Address: ________________________________________________________________

City, State, Zip: __________________________________________________________

Telephone: ______________________________________________________________

E-Mail Address: __________________________________________________________

Interview Date: _________  Interview Time: _________(Duration in Minutes)

[NOTES TO INTERVIEWER]
Discussions with building owners and property managers will provide a solid foundation for understanding energy code compliance practices in regard to specific commercial building projects identified by the LCIEC team. The objectives of the interviews are to collect the following information:

- Level of satisfaction with overall building and energy performance
- Identify problem areas (e.g. areas of the building that are too hot/cold)
- Knowledge of energy code compliance
- Awareness of energy efficiency programs
- Interaction with code officials
- Receipt of operation and maintenance manuals
- Training needs
- Systems tests & balancing needs

If respondents have questions about study, they can contact Wendy Todd of National Grid at wendy.todd@us.ngrid.com or 781-907-2232.
LEAD-IN:

Hi, my name is ________ and I work for <KEMA or ERS>, an energy consulting firm. We have been hired by the Massachusetts electric and gas utilities’ Energy Efficiency Program Administrators to conduct research on energy code compliance for randomly selected, recently constructed commercial buildings.

This interview is part of a statewide effort to study common construction practices and the impacts of recent code changes. I would like to talk with you to find out more about the <COMMERCIAL PROJECT> you own/manage. Any information we collect on individual buildings will not be made public.

The conversation will take approximately 20 minutes. Your responses are completely confidential.

Roles and Responsibilities

I would like to start by asking you a few questions about the <COMMERCIAL PROJECT> project.

RR1. Were you involved in design and construction of the building?

RR2. How would you describe your role in the design and construction process?

Awareness of Energy Efficiency Programs

I have a few questions for you about energy efficiency and utility incentive programs.

EEP1. Are you familiar with the Massachusetts new construction energy efficiency programs? [Prompt: the “Utilities”, or Cape Light Compact?]

☐ Yes
☐ No
EEP2. During the design and construction of the <COMMERCIAL PROJECT>, did your organization, an owner’s representative, or members of the design team make contact with new construction energy efficiency incentive programs? [Prompt: the Utilities, or Cape Light Compact?]

☐ Yes
☐ No

EEP2a. [If EEP2=Yes] Please describe your experience with the new construction program?

EEP2b. [If EEP2=No] Why not? [Probe: Was project in a municipal power plant district? Not a priority? Too late in the design process? Incentives not worth the effort?]

Level of Satisfaction with Building and Energy Performance

The questions in this section address satisfaction with the performance of <COMMERCIAL PROJECT>.

SAT1. Did the project establish any goals for energy efficiency of the building or overall energy performance of the building?

☐ Yes
☐ No

SAT1a. [If SAT1a=Yes] What were the goals?

SAT1b. [If SAT1a=Yes] What motivated you to set goals?

SAT2. On a scale of 1 to 10, where 1 is “Not satisfied at all” and 10 is “Very Satisfied,” how satisfied are you with the overall performance of the building?

SAT2a. Why do you say that?
SAT3. Does the energy consumption of the building meet your expectations?

☐ Yes
☐ No

SAT3a. Why do you say that?

SAT4. Are there any aspects of <COMMERCIAL PROJECT> that do not perform as expected? Examples may include areas in the building that are too hot or too cold, non-functioning equipment, or faulty automatic controls.

☐ Yes
☐ No

SAT4a. [If SAT4=Yes] What are they?

SAT5. [If building is occupied] Have there been any significant changes in the functioning or occupancy of the building, such as major equipment replacement, changes in tenancy, or changes in building usage since the building opened?

☐ Yes
☐ No

SAT5a. [If SAT5=Yes] What changes have occurred?

Energy Code Compliance

In this section, I would like to ask you questions regarding your experience with energy code compliance for <COMMERCIAL PROJECT>.

ECC1. Who was primarily responsible for documenting compliance with the Massachusetts commercial energy code during the design of the building?
ECC2. During the design and construction of <COMMERCIAL PROJECT>, did you have any interactions with local code officials?

☐ Yes  ☐ No

ECC2a. [If ECC2=Yes] Please describe your interactions with the code officials. [Probe: Why did you interact with code officials, how often interact with code officials, when interact with code officials?]

ECC2b. [If ECC2=Yes] Did code officials discuss compliance with the commercial energy code?

☐ Yes  ☐ No

ECC2c. [If ECC2=Yes] Did code officials seem knowledgeable about the commercial energy code?

☐ Yes  ☐ No

ECC2d. [If ECC2c=Yes] Why do you say that?

ECC3. Were there any particular challenges that the design team had to overcome to meet energy code?

☐ Yes  ☐ No

ECC3a. [If ECC3=Yes] Please explain.
ECC4. Were there any particular challenges that the construction team had to overcome to meet energy code?

☐ Yes
☐ No

ECC4a. [If ECC4=Yes] Please explain.

Training Needs

In this section, I would like to ask you a few questions about training on building systems and controls at <COMMERCIAL PROJECT>.

TN1. Was training on building systems offered for <COMMERCIAL PROJECT>?

☐ Yes
☐ No

TN1a. [If TN1=Yes] Who offered the training?

TN1b. [If TN1=Yes] For which systems was training offered?

☐ Lighting controls
☐ Heating System (boilers or furnaces)
☐ Fans & Motors
☐ Pumps & Motors
☐ Cooling System (chiller, DX units, split systems, chilled beams)
☐ Variable Frequency Drives
☐ Air Handling Units
☐ Lighting controls
☐ Building Management System
☐ Other (Please describe: _______________________________________________)

TN1c. [If TN1=No] Is there a need for training on building systems at <COMMERCIAL PROJECT>?

☐ Yes
☐ No

TN1d. [If TN1c=Yes] Please indicate the types of building systems training needed.
**Maintenance Procedures**

In this final section, I have a few questions about maintenance procedures at <COMMERCIAL PROJECT>?

MP1. For the <COMMERCIAL PROJECT>, were testing and balancing services provided for air handling systems and hydronic systems?

[Prompt if needed: Hydronic systems include boilers and chillers]

☐ Yes
☐ No

MP2. Do you regularly perform testing and balancing procedures on the air and hydronic systems?

☐ Yes
☐ No

MP2a. [MP2=Yes] What are your reasons for regularly testing and balancing your air and hydronic systems?

MP3. Did the <COMMERCIAL PROJECT> go through a commissioning process?

☐ Yes
☐ No

MP3a. [If MP3=Yes] Why was commissioning completed?

MP3b. [If MP3=No] Why wasn’t commissioning completed?
MP4. According to recent editions of the Massachusetts building energy code, contractors are required to deliver operations and maintenance manuals to building owners. Did you or your organization receive a full set of Operations & Maintenance manuals?

☐ Yes
☐ No

Closing Comments

CC1. Do you have any other comments – suggestions, improvements, other observations to share with the Massachusetts electric and gas utilities’ Energy Efficiency Program Administrators?

Those are all the questions I wanted to ask. Thank you for your time and participation.
J. Project-Specific Instrument: Design Team Members
Interview Guide
MA LCIEC – PROJECT 11 CODE COMPLIANCE BASELINE STUDY

PROJECT-SPECIFIC IN-DEPTH INTERVIEW GUIDE FOR DESIGN TEAM MEMBERS

Contact Name: ______________________________________________________

Name of Firm: ______________________________________________________

Address: __________________________________________________________

City, State, Zip: _____________________________________________________

Telephone: _________________________________________________________

E-Mail Address: _____________________________________________________

Name of Commercial Project: _________________________________________

Interview Date: __________ Interview Time: __________(Duration in Minutes)

[NOTES TO INTERVIEWER]
Commercial building projects will be selected at random for the purposes of collecting energy code compliance data. In parallel with onsite data collection, the LCIEC team will contact members of project design teams to learn more about energy code compliance processes and practices. The interview will address general energy code compliance questions and questions specific to the particular commercial project as follows:

- Process for documenting energy code compliance
- Interactions with local code officials and level of engagement on the project
- Experience on project meeting the energy code
- How design team members familiarize themselves with new code
- Ideas for improving energy code compliance process

If respondents have questions about study, they can contact Wendy Todd of National Grid at wendy.todd@us.ngrid.com or 781-907-2232.
LEAD-IN:

Hi, my name is _________ and I work for <KEMA/ERS>, an energy consulting firm. We have been hired by the Massachusetts electric and gas utilities’ Energy Efficiency Program Administrators to conduct research on energy code compliance in new commercial building construction.

This interview is part of a statewide effort to study experience with the new energy code, compliance practices, and on-the-ground code implementation. The <COMMERCIAL PROJECT> was randomly selected and <BUILDING OWNER/PROPERTY MANAGER> has agreed to participate in this study. I would like to find out more about your involvement with <COMMERCIAL PROJECT> and how code compliance factored into this project. Any information we collect on individual buildings will not be made public.

The conversation will take approximately 20 minutes. Your responses are completely confidential.

[Note to Interviewer: If role in <COMMERCIAL PROJECT> is minor, ask for recommendation to speak with someone more closely involved with project.]

Roles and Responsibilities

I would like to start by asking you a few questions about your position and role on the <COMMERCIAL PROJECT>.

RR1. May I ask, what is your job title?

RR2. What are (or were) your primary job responsibilities in regard to the design and construction of <COMMERCIAL PROJECT>?

Energy Code Compliance for Commercial Project

Regarding the <COMMERCIAL PROJECT>, I would like to ask you a few questions about designing to the new energy code and interactions with local code officials.
ECC1. Under which version of the building energy code was the <COMMERCIAL PROJECT> submitted?  
[Read responses; Check only one]

☐ 7th edition enacted October 6, 2008  
☐ 7th edition with amendments, enacted July 1, 2009  
☐ 8th edition enacted July 1, 2010  
☐ Stretch Energy Code [Appendix 115AA in 8th edition]

ECC2. What is the typical process that your firm and related consultants use to document compliance with the Massachusetts commercial energy code during design?

ECC3. Do all members of your firm learn the energy code provisions equally well or are there some members who become in-house resources on energy code?

ECC4. What documentation was required by the building official to demonstrate compliance with the energy code?

ECC5. During the design and construction of <COMMERCIAL PROJECT>, did you or members of your firm have any interactions with local code officials?  

☐ Yes  
☐ No
ECC5a. [If ECC5=Yes] Please describe your interactions with the code officials.  
[Probe: Why did you interact with code officials; How often did you interact with code officials; When did you interact with code officials?]

ECC5b. [If ECC5=Yes] Did code officials discuss compliance with the commercial energy code? 
☐ Yes 
☐ No

ECC5c. [If ECC5=Yes] Did code officials seem knowledgeable about the commercial energy code? 
☐ Yes 
☐ No

ECC5d. [If ECC5c=Yes or No] Why do you say that?

ECC5e. [If ECC5=Yes] Were there any difficulties in dealing with the code officials or in gaining approvals for energy code compliance? 
☐ Yes 
☐ No

ECC5f. [If ECC5e=Yes] Please explain.

ECC5g. [If ECC5=Yes] During construction, how often did building officials conduct an inspection of the building?

ECC5h. [If ECC5=Yes] Were you present during the inspections? 
☐ Yes 
☐ No

ECC5i. [If ECC5h=Yes] Please describe the interaction you had with the building officials during the on-site inspections.
ECC5j. [If ECC5=Yes] What were the main components that the building officials focused on during the inspection?

ECC6. Were there any particular challenges that the design team had to overcome to meet energy code?

☐ Yes
☐ No

ECC6a. [If ECC6=Yes] Please explain.

ECC7. Were there any particular challenges that the construction team had to overcome to meet energy code?

☐ Yes
☐ No

ECC7a. [If ECC7=Yes] Please explain.

New Construction Program Support

For this section, I would like to discuss project goals and the involvement of the new construction energy efficiency programs.

NCPS1. Were energy efficiency goals established for the building during design?
NCPS1a. [If NCPS1=Yes] What were the goals?

NCPS1b. [If NCPS1=Yes] What motivated your firm to set goals?

NCPS1c. [If NCPS1=No] Why wasn’t energy efficiency a goal?

NCPS2. Have you or your firm ever worked with the Massachusetts new construction/major renovation efficiency programs? [Prompt: Did you have any interaction with the "Utilities", or Cape Light Compact?]

Yes
No

NCPS2a. [If NCPS2=Yes] Did you submit documentation to the program that could also be used to show code compliance?

[Prompt: Such as COMcheck, energy models]

Yes
No

NCPS2b. [If NCPS2a=Yes] What documentation did you use to show code compliance?

NCPS3. [If NCPS2=Yes] During the design and development of the <COMMERCIAL PROJECT>, did you or members of your firm contact staff of new construction energy efficiency incentive programs? [Prompt: the Utilities, or Cape Light Compact?]

Yes
No
NCPS3a. [If NCPS3=Yes] Did you receive any assistance that helped you comply with the energy code?

☐ Yes
☐ No

NCPS3b. [If NCPS3a=Yes] What assistance did you receive?

NCPS3c. [If NCPS3a=Yes] Did you receive the assistance from program staff or their technical assistance vendors?

[Read responses and check all that apply]

☐ Program staff
☐ Technical assistance vendors

NCPS3d. [If NCPS3=No] Why was the new construction energy efficiency incentive programs not contacted for this project?
[Note to interviewer: Was project in a municipal power plant district? Not a priority for owner? Too late in the design process? Incentives not worth the effort?]

CPS4. Is there training or other types of support that you could have used to help demonstrate compliance with the energy code?

☐ Yes
☐ No

NCPS4a. [If NCPS4=Yes] What other types of support could you have used to help demonstrate compliance with the energy code?

Improving Compliance Process

I would like to ask about your ideas on improving the commercial building energy code compliance process.

ICP1. Would you or members of your firm prefer to receive more training on the commercial energy code?
ICP1a.  [If ICP1=Yes] How would you prefer to receive training?

[Read responses and check all that apply]

☐ Webinar / Online
☐ Classroom
☐ In the field
☐ Other (Please describe: ______________________________________)

ICP1b.  [If ICP1=Yes] What additional topic areas would you like to receive training on regarding the commercial energy code?

ICP2.  Are there policies and/or actions that could have been implemented to improve code compliance process for this project?

☐ Yes
☐ No

ICP2a.  [If ICP2=Yes] Please explain.

Closing Comments

CC1.  Do you have any other input regarding energy code compliance in regard to new construction, major renovations and additions?

Those are all the questions I wanted to ask. Thank you for your time and participation.