DNV·GL

FINAL REPORT

Rhode Island Commercial Energy Code Compliance Study

National Grid

Date: October 25, 2016

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1 EXECUTIVE SUMMARY

This Executive Summary provides a high-level review of the results for the Rhode Island Commercial Energy Code Compliance Study (2016 study). 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 2016 study are to:

1. Update the overall state-wide compliance rate for Rhode Island commercial buildings provided in the Rhode Island Energy Code Compliance Baseline Study[1] (2012 study)
2. Provide feedback on patterns of compliance and non-compliance
3. Provide qualitative assessment of the effectiveness of Code Compliance Enhancement Initiative (CCEI)[2] and its influence on changes in compliance
4. Provide qualitative feedback on suggestions for improving the code compliance process[3]

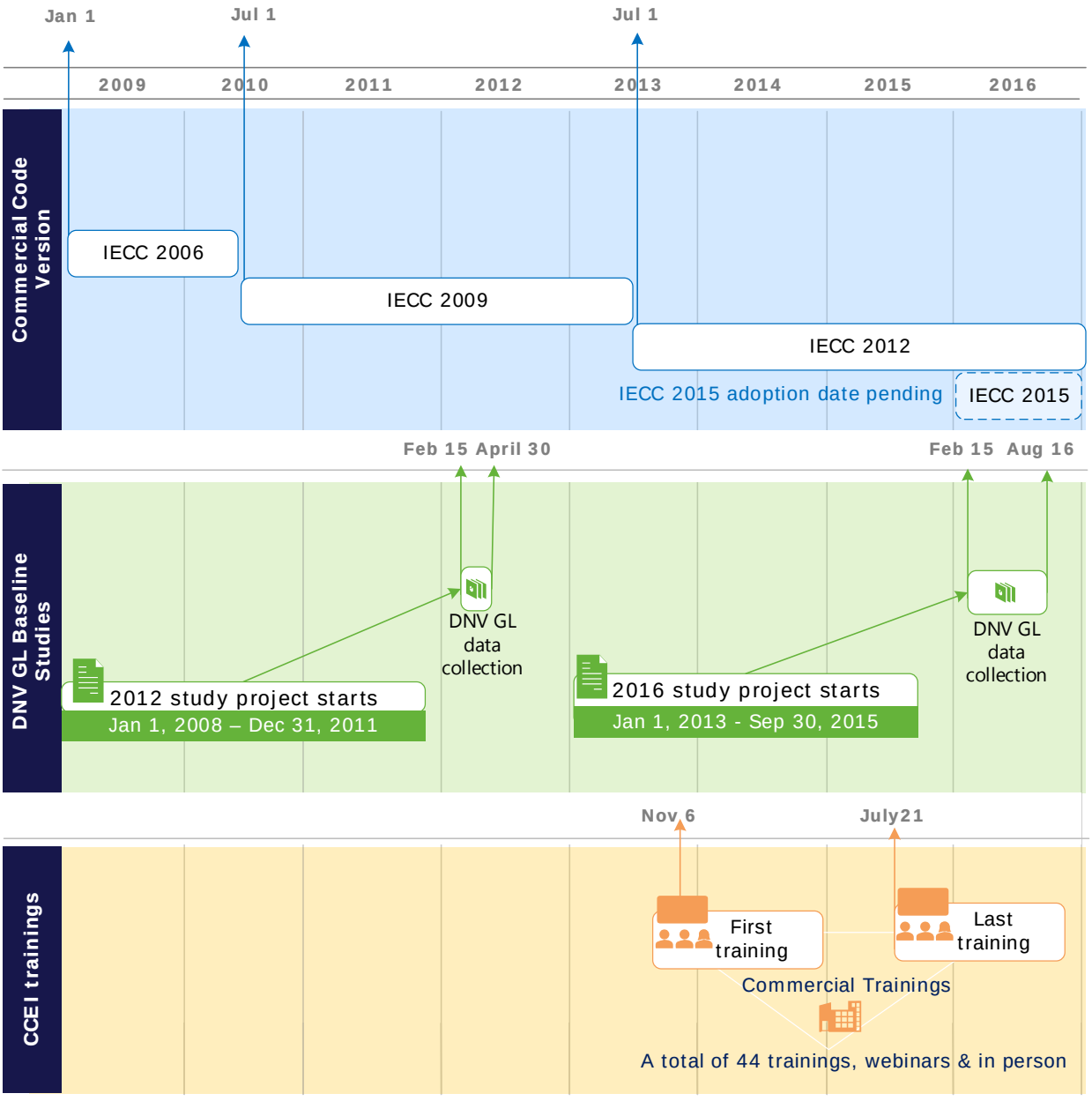
Figure 1 presents a timeline showing the 2012 and 2016 study data collection, the project starts of the sample buildings, and the trainings offered through the CCEI in the context of Rhode Island's adoption of the 2006, 2009, and 2012 commercial energy codes (IECC 2006, IECC 2009, and IECC 2012).

[1] DNV GL, ERS, and APPRISE. *Rhode Island Energy Code Compliance Baseline Study*. Prepared for National Grid, September 19, 2012.

[2] The Code Compliance Enhancement Initiative is also known as the Energy Code Technical Support Program.

[3] Additional secondary research objectives and tasks to address them are listed in the December 23, 2015 scope of work. If National Grid is interested in pursuing these objectives, the DNV GL team will prepare detailed scopes of work and budgets to address them.

Figure 1. Timeline of commercial code adoption, building project starts, and DNV GL studies



The DNV GL team[4] used data collection instruments, protocols and training materials, and analysis tools developed for the 2012 study as a starting point for the 2016 study. Updating existing tools enabled the team to develop meaningful comparisons across years and incorporate enhancements to the analysis methodology developed since 2012. Unlike the 2012 study, which required only minor modifications to the tools developed for the Massachusetts Code Compliance Baseline Study,[5] the 2016 study required several

[4] DNV GL, ERS and APPRISE

[5] *Code Compliance Baseline Study*. Prepared for Massachusetts Energy Efficiency Program Administrators. Prepared by DNV GL, ERS and APPRISE. August 24, 2012.

changes to the existing tools. These included changes from IECC 2009 to IECC 2012 and updates for RI amendments to the code. A high-level synopsis of the research approach is as follows:

Coordination with code compliance stakeholders – Our team coordinated with National Grid's Codes and Standards Program Manager and Evaluation Manager and the State of Rhode Island Office of the Building Commissioner about current and future initiatives to support and enforce code compliance in Rhode Island.

Marketing the research – In accordance with the U.S. Department of Energy's (DOE's) Building Energy Codes Program (BECP) recommendations, we branded the code compliance study so as to maximize the cooperation of building owners and the design and construction community.

Building code official and market actor interviews – The DNV GL team completed interviews with code officials and market actors to gain an understanding of these individuals' knowledge of commercial energy code, staffing and training practices, processes for determining energy code compliance, and barriers to enforcing energy codes in the State of Rhode Island.

Site data collection methodology – Our team developed several custom instruments and procedures to ensure thorough and accurate site data collection that is consistent with the baseline study, including a data collection tool and an analysis tool. We classroom-trained onsite staff to establish consistent data collection procedures and data accuracy. To conduct onsite data collection, staff visited buildings and used the data collection tool to gather data to assess code compliance.

Analysis and reporting – We estimated commercial code compliance rates for Rhode Island commercial buildings in accordance with the methodology developed by the DOE in conjunction with the Pacific Northwest National Laboratory (PNNL) (the DOE/PNNL method). We also estimated compliance rates using a new, enhanced method developed by our team to better represent energy savings opportunities from increased compliance (the DNV GL method). We also analyzed qualitative findings from interviews with building code officials and market actors. These interviews provided a solid foundation for understanding the market structure in regard to the existing energy code and related compliance and enforcement efforts. Furthermore, these interviews provided additional information to support (or refute) the findings of the site data collection.

1.2 Key findings and conclusions

Figure 2 shows overall statewide compliance rates of Rhode Island commercial buildings found through the 2012 and 2016 studies, using the DOE/PNNL method of calculating compliance.[6] Statistical differences at the 10% level of significance between estimates are illustrated in the chart via bars with dotted backgrounds. **Overall statewide compliance for commercial buildings increased from 78%[7] in 2012 baseline study to 86% in the 2016 study.** This difference is statistically significant at the 10% level of significance. Increases in compliance rates between 2012 and 2016 for buildings less than 25,000 square feet and

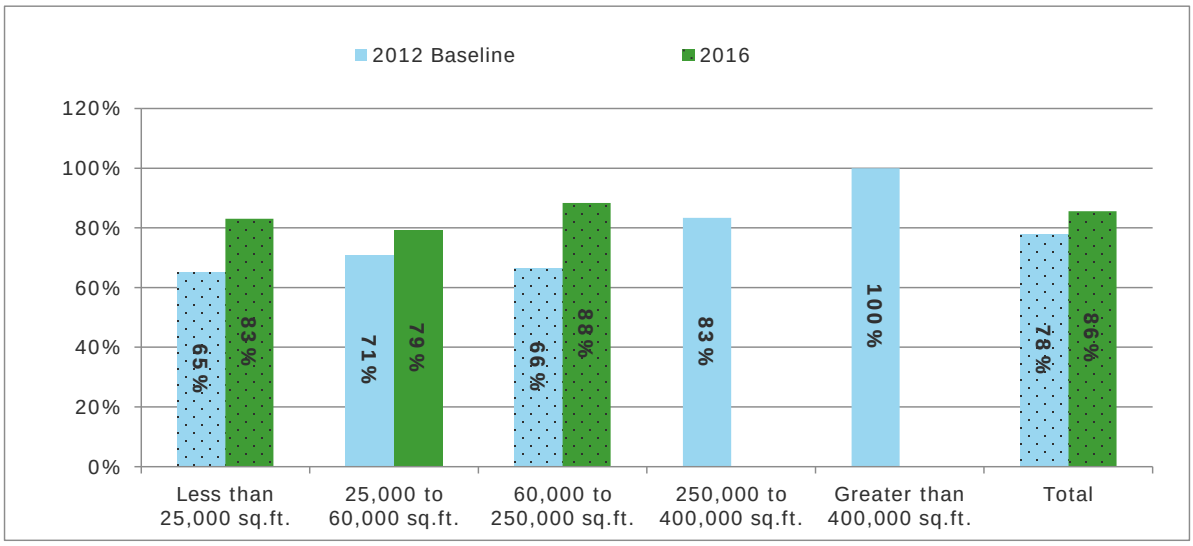
[6] The DNV GL team used the DOE/PNNL method to compare compliance rates in the 2012 and 2016 studies because the 2012 study used only this method, and did not collect the raw data necessary to recalculate compliance retroactively using the DNV GL team method described in 3.6. Thus, a meaningful "apples-to-apples" comparison between the 2012 and 2016 studies requires the use of the DOE/PNNL method.

[7] The overall statewide compliance for commercial buildings reported in the 2012 baseline study was 76% using the DOE/PNNL calculation and sample weighting methods. The 2012 study also reported a statewide compliance rate of 70% without using the sample weighting methods. To facilitate statistical comparisons across years, the DNV GL team used the DOE/PNNL calculation and sample weighting methods for 2012 and 2016. Additionally, as part of the 2016 study, the 2012 study data were re-analyzed using similar sampling adjustments added to the 2016 study. These adjustments were made to adjust the sample frame based on information (e.g., eligibility for study and square footage) learned about the projects during recruitment and site visits.

buildings between 60,000 and 250,000 square feet were also statistically significant at the 10% level of significance.

There were no sampled buildings in the 2016 study that were greater than 250,000 square feet.

Figure 2. Overall energy code compliance rates, 2012 and 2016 studies (DOE/PNNL method)*



*Bars with dotted backgrounds indicate the compliance rates are statistically different from each other at the 10% level of significance.

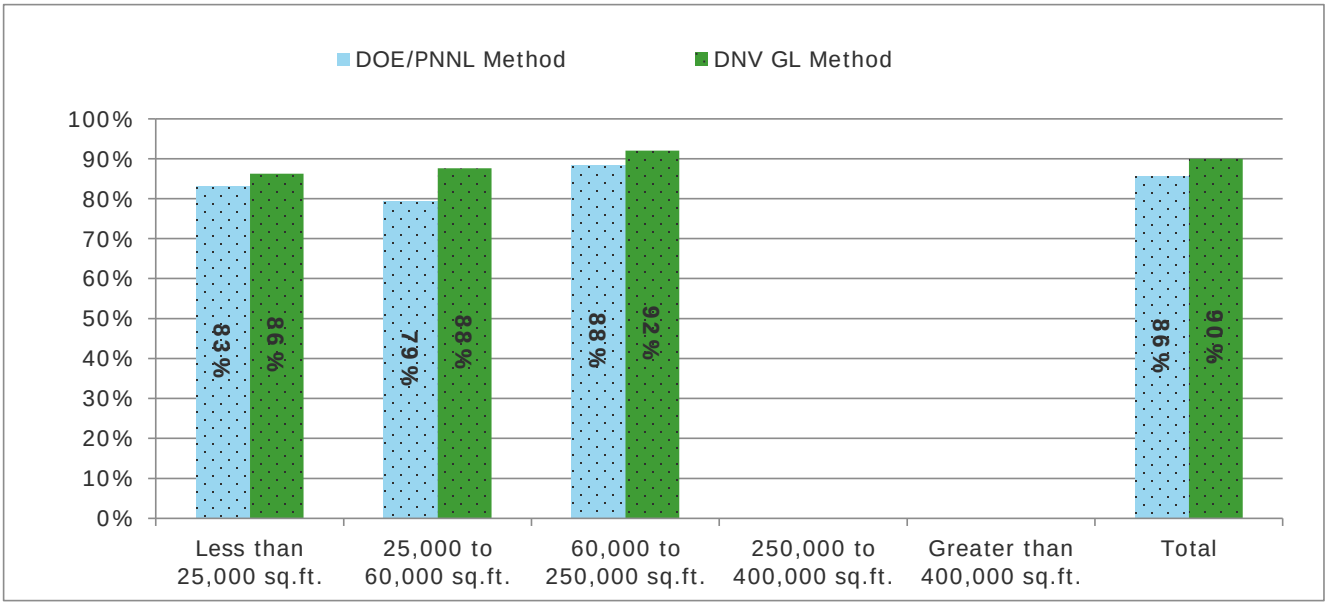
The 90% confidence interval for overall energy code compliance rates from the 2012 and 2016 studies are provided in Table 1. The overall 2016 energy code compliance rate is 86%, and the 90% confidence interval is ± 3 percentage points (i.e., 86% ± 3%). In other words, the point estimate of the compliance rate is 86%, and there is a 90% probability that the actual compliance rate lies between 82% and 89%.

Table 1. Overall energy code compliance rates, 2012 and 2016 studies (DOE/PNNL method)

	2012 study					2016 study				
			90% Confidence					90% Confidence Interval		
Strata	n	Compliance Rate	+/-	Lower Bound	Upper Bound	n	Compliance Rate	+/-	Lower Bound	Upper Bound
Less than 25,000 sq.ft.	15	65%	4.6%	60%	70%	15	83%	4.2%	79%	87%
25,000 to 60,000 sq.ft.	6	71%	3.1%	68%	74%	3	79%	14.5%	65%	94%
60,000 to 250,000 sq.ft.	10	66%	4.4%	62%	71%	3	88%	3.5%	85%	92%
250,000 to 400,000 sq.ft.	1	83%	<0.1%	83%	83%	-	NA	NA	NA	NA
Greater than 400,000 sq.ft.	1	100%	<0.1%	100%	100%	-	NA	NA	NA	NA
Total	**33**	**78%**	**1.6%**	**76%**	**79%**	**21**	**86%**	**3.4%**	**82%**	**89%**

Figure 3 provides a comparison of compliance rates found in the 2016 study using both the DOE/PNNL method and the DNV GL team method. In recognizing partial compliance as well as allowing for trade-offs within the building envelope, as permitted by IECC, the DNV GL team method overcomes significant limitations of the DOE/PNNL method to more accurately reflect the energy impact of observed building practices. Notably, the DNV GL team method finds compliance rates to be higher overall than the DOE/PNNL method, which suggests that the DOE/PNNL method may be overstating the savings opportunities created by compliance enhancement. The increased accuracy of the DNV GL team method makes it our recommended approach for estimating code compliance, in the 2016 study and going forward.

Figure 3. Overall energy code compliance rates, DOE/PNNL vs. DNV GL team methods*



*Bars with dotted backgrounds indicate the compliance rates are statistically different from each other at the 10% level of significance.

Based on the analysis of the 2016 study results, comparisons with the 2012 baseline study and findings from the interviews with code officials and markets actors, we offer the following conclusions.

1. Overall code compliance for new construction in Rhode Island is estimated at approximately 86% compliance using the DOE/PNNL method and 90% compliance using the DNV GL method. However, it is important to consider several factors.

- This result does not mean that these percentages of commercial buildings comply, as we found only one building fully in compliance.
- The overall number refers to the average provision compliance weighted by energy impacts as proposed by DOE/PNNL and modified for the DNV GL team method
- It is more accurate to say that on average, commercial buildings perform approximately 10%-15% worse than the code requires, and by extension, use 10%-15% more energy than fully compliant buildings.

2. Newer buildings built to the 2012 IECC have higher rates of code compliance than buildings built to the 2009 IECC.
3. Smaller buildings tend to have higher rates of envelope compliance, while larger buildings tend to have higher rates of lighting compliance.
4. In general, the compliance of newly constructed buildings is improving over time, even as the code gets more stringent.
5. Driven by the diversity of Rhode Island's villages, towns and cities, code officials continue to experience a wide range in the number of commercial permits issued each year.

6. Inadequate staffing resources continue to have an effect on code officials' ability to properly enforce the energy code.
7. Training is essential to code compliance and the CCEI is working. Although very few design team members attended the CCEI training, several felt that additional training was needed.
8. Opportunities still exist for increased training of code officials and design and construction professionals.
9. The majority of owners have energy efficiency goals for their buildings, but not a lot of interaction with code officials.
10. Owner satisfaction with building performance was high, and building performance met the expectations of a majority of owners interviewed.
11. Over half of the owners are familiar with National Grid's CCEI; design team members are also familiar with it, but have less training and technical support for it than for other programs.
12. Design team members interact more with local code officials than with building owners.
13. Design team members have experience working with the RI new construction energy efficiency incentive programs.

1.3 Recommendations

The DNV GL team offers the following recommendations for consideration.

1. Consider using the DNV GL team method instead of the DOE/PNNL method when estimating code compliance, to more effectively reflect energy savings opportunities from increased compliance.
2. Consider adjusting the baseline LPD assumptions to account for improved energy efficiencies of lighting measures.
3. Increase focus on the following area:

- day lighting controls
- commissioning of HVAC and lighting controls
- quality of insulation

4. Maintain current CCEI training efforts.
5. Expand CCEI training efforts to better reach design and construction professionals.
6. Expand CCEI training efforts to better serve code officials.
7. Market CCEI training to building owners around building performance.
8. Encourage code officials to speak with the owners specifically about energy code compliance.
9. Market the CCEI training and technical support to the design team members.
10. Provide more webinar/online and classroom training options.
11. Encourage design team members to discuss energy code compliance with building owners.
12. Set up stakeholder meetings for design team members and owners to voice their concerns.

2 INTRODUCTION

The DNV GL team conducted the Rhode Island Commercial Energy Code Compliance Study (2016 study) to update the energy code compliance findings provided in the Rhode Island Energy Code Compliance Baseline Study[8] (2012 study). DNV GL collaborated with ERS and APPRISE (DNV GL team) to design and complete the 2016 study.

This report provides the results for the 2016 study. In this section, we review the 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 this study are to:

1. Update the overall state-wide compliance rate for Rhode Island commercial buildings provided in the 2012 study
2. Provide feedback on patterns of compliance and non-compliance
3. Provide qualitative assessment of the effectiveness of Code Compliance Enhancement Initiative (CCEI)[9] and its influence on changes in compliance
4. Provide qualitative feedback on suggestions for improving the code compliance process[10]

2.2 Overview of approach

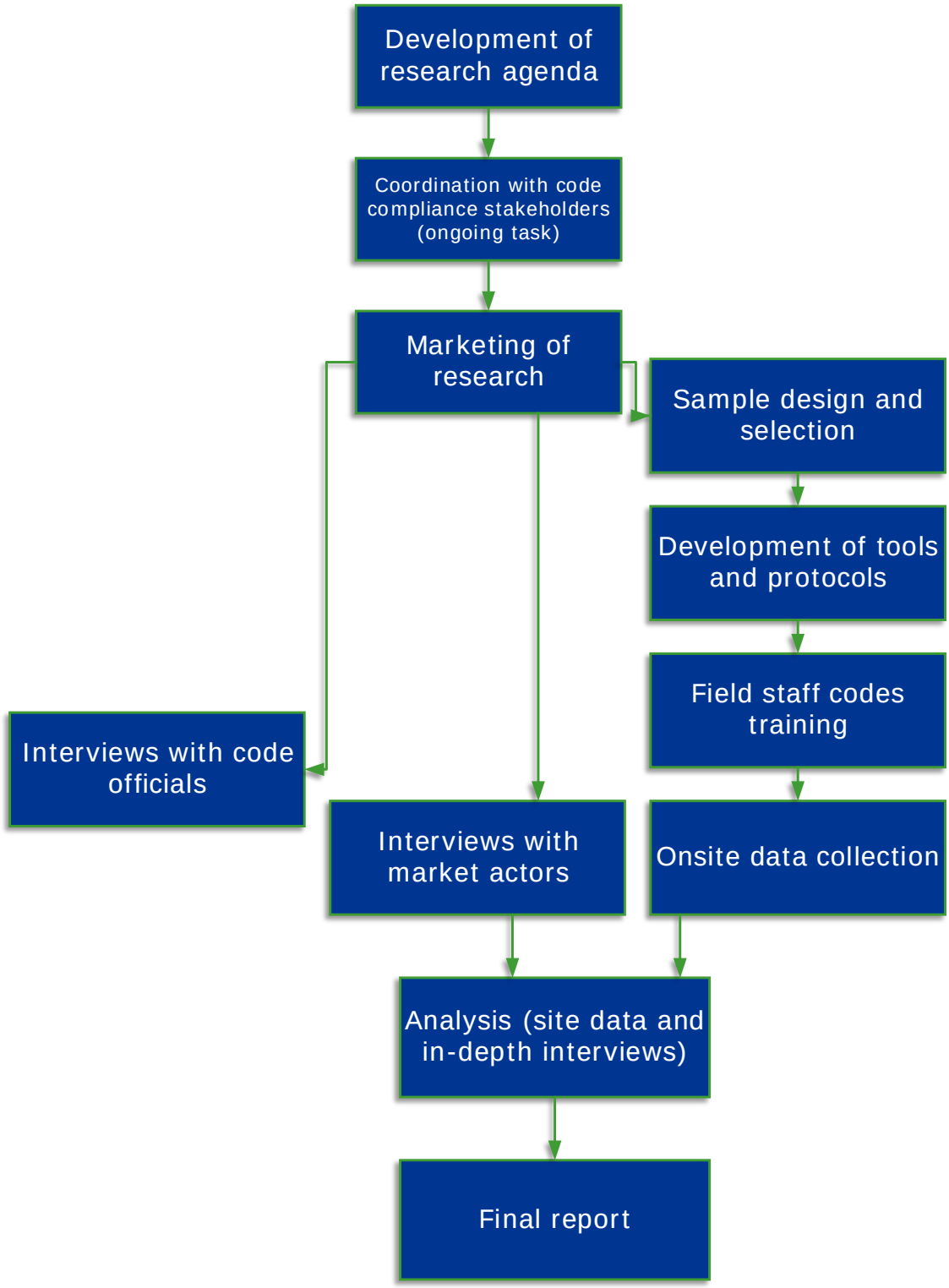
The DNV GL team developed the research approach in collaboration with the State of Rhode Island Office of the Building Commissioner and National Grid. Figure 4 outlines the research agenda for the 2016 study. Successful execution of this research required significant planning and stakeholder outreach efforts. A summary of this study's principal steps follows the diagram.

[8] DNV GL, ERS, and APPRISE. *Rhode Island Energy Code Compliance Baseline Study*. Prepared for National Grid, September 19, 2012.

[9] The Code Compliance Enhancement Initiative is also known as the Energy Code Technical Support Program.

[10] Additional secondary research objectives and tasks to address them are listed in the December 23, 2015 scope of work. If National Grid is interested in pursuing these objectives, the DNV GL team will prepare detailed scopes of work and budgets to address them.

Figure 4. Research agenda



Work plan and project management

The DNV GL team developed the draft scope of work based on our understanding of National Grid's research priorities, our experience with the 2012 study, and recent studies in other jurisdictions. We revised the draft scope of work following National Grid's review, subsequent discussions, and a December 21, 2015 conference call with the DNV GL team. Three firms (DNV GL, ERS, and APPRISE) worked together to complete this project. DNV GL served as the prime contractor and performed the sample design, data collection (site-level and in-depth interviews), and analysis. ERS served as the methodological lead and performed the updates to the site-level data collection and analysis tools prior to the incorporation of the data collected by DNV GL. APPRISE provided sampling support and development of population files.

Coordination with code compliance stakeholders

A key aim of the research was to provide National Grid's Codes and Standards Program Manager and Evaluation Manager and the State of Rhode Island Office of the Building Commissioner with information to assist with the delivery of current and future initiatives to support and enforce code compliance in Rhode Island. The National Grid Evaluation Manager was actively engaged in the coordination efforts to inform stakeholders of the DNV GL team's progress, and to solicit support and engagement in this important study. We also received ongoing support from the Building Code Commissioner via letter, emails, and phone calls to code officials seeking their engagement and support for this study.

Marketing the research

The U.S. Department of Energy's (DOE'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.). Getting cooperation from building owners and the design and construction community required careful planning and persistence. Instead of conveying the research as a code compliance study, the DNV GL team branded the study as an effort to learn about common construction practices. We also communicated the potential benefits of energy code-related energy efficiency programs to the target market, and alleviated any concerns the market actors had with participating in the research.

Building code official and market actor interviews

The DNV GL team attempted to conduct interviews with building officials from 30 of Rhode Island's 39 municipal jurisdictions from a list provided by the State of Rhode Island Office of the Building Commissioner. As of August 5, 2016, our team was able to complete interviews with building officials representing 23 of these jurisdictions. The building code official interviews focused on gaining an understanding of code officials' knowledge of commercial energy code, staffing and training practices, processes for determining energy code compliance, and barriers to enforcing energy codes in the State of Rhode Island.

Our team is also interviewing market actors associated with each of the projects receiving site visits, including owners, owners' project managers, and design team members. These interviews allow us to understand the code compliance process in the context of actual projects.

Sample design and selection

To facilitate comparisons with the 2012 study, the DNV GL team used the same sampling strategy (recommended by the DOE's BECP) for the 2016 study as was used for the 2012 study. The sample plan of

new construction buildings completed between 2013 and 2015[11] targeted 30 buildings and was stratified by building size (square footage).

Development of tools and protocols

The DNV GL team developed several custom instruments and procedures to ensure thorough and accurate site data collection that is consistent with the baseline study, including:

- A data collection tool developed by modifying data collection tools and approaches used in the 2012 study and 2015 Massachusetts compliance study, which used Filemaker Pro and Filemaker Go
- An analysis tool add-on to the data collection tool, which compared the data collected with the applicable code requirements to automate the assessment of code compliance

Field staff codes training

Classroom training of onsite staff was completed in January 2016, to establish consistent data collection procedures and data accuracy. The training included data collection procedures associated with the data collection tool. Staff involved in site data collection received in-field training that included hands-on collection and input of project data for building envelope, mechanical system and lighting system measures. The staff was also introduced to the 2009 and 2012 IECC codes.

Onsite data collection

To conduct onsite data collection, staff visited buildings and used the data collection tool 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 the data collection spreadsheets.

Analysis and reporting

The first step in the analysis was to perform a thorough review of the on-site data. Senior technical staff worked with the field team to address inconsistencies, anomalies, and omissions.

Utilizing the information collected during the site visits using the custom tool, the DNV GL team determined:

- Overall rates of compliance
- Compliance by category:
    - Envelope
    - HVAC
    - Lighting power density (LPD)
    - Lighting controls (separate compliance issue; varies greatly from LPD compliance)
- Compliance rate comparison for building built under each of the two codes (2009 & 2012)
- Comparison with results from the 2012 study
- Compliance rate utilizing IECC 2009 for all included buildings, as IECC 2012 was very new to RI during the targeted period. This better illustrated the progress being made in building practices.

[11] The sample plan developed per the December 23, 2015 scope of work anticipated using buildings completed in 2012 once the 2013 to 2015 sampled buildings were exhausted. The four year time period is consistent with the time period used for the baseline study to achieve the target of 30 buildings. During the implementation of the study, National Grid decided to not open the sample of 2012 buildings and focus on the buildings completed in 2013 to 2015.

- Individual measures with high or low compliance rates
- Opportunities for training, technical assistance and financial incentives

The DNV GL team also analyzed qualitative findings from interviews with building code officials and market actors. These interviews provided a solid foundation for understanding the market structure in regard to the existing energy code and related compliance and enforcement efforts. Furthermore, these interviews provided additional information to support (or refute) the findings of the site data collection.

2.3 Organization of report

The remainder of this report is organized as follows:

- **Methodology.** This section presents the DNV GL team's approach to the following:
  - Coordination with code compliance stakeholders
  - Marketing of research
  - Building code official and market actor interviews
  - Sample design
  - Site data collection
  - Estimating site-level compliance
  - Estimating overall energy code compliance
- **Code compliance results.** This section presents the results of the analysis of the code compliance rates for the 2016 study sites and comparisons to the 2012 study sites:
  1. Overall energy code compliance rates, estimated utilizing the DOE/PNNL tiered energy impact procedures developed in support of ARRA funded energy efficiency programs to facilitate comparisons with the 2012 study
  2. Additional comparisons across years and versions of the code
- **Building official and market actor interview findings.** This section presents the results of in-depth interviews conducted with Rhode Island building officials and market actors.
- **Conclusions and recommendations.** This section integrates the findings from the interviews and site visits. The DNV GL team provides recommendations for increasing levels of code compliance for consideration for the State of Rhode Island Office of the Building Commissioner and National Grid.
- **Appendices**

  A. Site data collection tool

  B. Letter of introduction from building commissioner's office

  C. Letter of introduction from National Grid

  D. In-depth interview survey instruments

3 METHODOLOGY

This section describes the process taken to complete the 2016 study; the methodologies used to gather data on new construction buildings; and the methods used to determine code compliance rates for commercial buildings in Rhode Island.

This section is organized as follows:

- **Coordination with code compliance stakeholders:** Description of the collaboration efforts between the DNV GL team, National Grid, the State of Rhode Island Office of the Building Commissioner, and other stakeholders
- **Marketing of research:** Discussion of marketing plan to promote study participation with building officials and building owners
- **Building code official and market actor interviews:** Overview of the interviews the DNV GL team conducted with Rhode Island building officials and market actors; this includes a description of the interviewees, data collection process, and survey instruments
- **Sample design:** Overview of the rationale used to create the sample design for conducting onsite visits
- **Site data collection:** Description of the site data collection approach and of the custom tool developed for code compliance analysis
- **Estimating site-level compliance:** Overview of the process used for estimating commercial code compliance rates using the DOE/PNNL and DNV GL methods

3.1 Coordination with code compliance stakeholders

Communication and coordination between the DNV GL team and National Grid was critical to the success of this project. The DNV GL team provided written status reports via email and reviewed these over the phone with the National Grid project manager. The National Grid project manager actively engaged the Building Code Commissioner to keep him apprised of the study's progress and to solicit his support for this effort.

3.2 Marketing of research

The BECP stresses the importance of marketing code compliance studies to stakeholders in order to obtain the necessary data from a representative sample of buildings. For this study, we used several approaches to inform building owners about the study and encourage their participation:

1. **Electronic announcement:** an email sent to all building officials informing them of the study activities
2. **Jurisdictional letter:** a written letter sent to building officials informing them of the study and encouraging participation
3. **Phone calls:** The DNV GL team called code officials seeking their support for the study and requesting assistance in encouraging building owners of sampled building in their jurisdictions to participate in the study.

Building upon experience from previous studies, the DNV GL team understood that proper branding of the study would be vital to its success. Instead of characterizing the research as a code compliance study, we branded it as an effort to learn about common construction practices in relation to the energy code. Our principal message was that the information collected through this study would be used to estimate a *statewide* energy code compliance rate for commercial buildings, identify opportunities for Rhode Island to

help reach its statewide goal of a 90% compliance rate with the energy code, and provide feedback on general patterns, rather than collect any jurisdiction-specific information. We also communicated potential benefits of energy code-related energy efficiency programs to the target market, and worked to alleviate any of the actors' concerns with this research.

We attribute our success in recruiting participants for the 2012 study to a combination of study marketing and the support of National Grid and the State Building Code Commissioner, John Leyden. In an attempt to recreate that success in the 2016 study, we initially drafted a letter of introduction to be sent on behalf of the Building Code Commissioner's office (APPENDIX B), explaining the study and encouraging participation. For the 2016 study we also drafted a letter of introduction on behalf of National Grid (APPENDIX C) in late February 2016. In April 2016 both letters were approved and sent to all building officials.

The DNV GL team reached out to 12 building officials to ask for their help in recruiting building owners in their jurisdictions to participate. We contacted these officials by phone and email, and provided them with an email containing a list of buildings, contact information, and the status of each sampled site in its respective jurisdiction. We copied the National Grid study manager and the Building Commissioner on the email to add credibility to our request for help. The DNV GL team performed another round of follow-up calls to code officials, and provided National Grid with a summary of this effort's outcomes.

3.3 Building code official and market actor interviews

This section discusses interviews the DNV GL team conducted with Rhode Island building code officials. A description of the building officials interviewed and a summary of the data collection process and survey instrument is provided.

The DNV GL team conducted 28 in-depth interviews (out of a population of 39) with building officials via telephone to gain an understanding of compliance practices for the current commercial building energy code in Rhode Island. The interviewers used their professional familiarity with energy code compliance in commercial building design and operation to gather important details and resolve inconsistencies in building officials' answers. These interviews were conducted by phone between July and September 2016 and averaged 50 minutes in length, with a range of 30 to 135 minutes.

The DNV GL team also interviewed 21 market actors associated with each of the projects receiving site visits. These markets actors fell into one of two groups: 1) owners and owners' project managers, or 2) design team members including architects, builders, engineers and other building design professionals. Nine interviews were completed in the first group, and 12 interviews were completed in the second. These interviews allowed us to review the code compliance process in the context of actual projects. Project participants were asked to describe in substantial detail their interactions with code officials and their understanding of how code provisions apply to the building. These interviews were conducted in August and September 2016.

Table 2 presents a summary of the key research topics covered in the building official, building owner/PM, and market actor interview guides. The interview guides contained questions that were asked of all three groups (on topics such as energy code training experience, energy code compliance practices, and interactions with CCEI training and technical support), as well as audience-specific questions (such as whether building owners are satisfied with building energy performance). 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 2. Building official, owner/PM, and market actor interview guide research topics[12]

	Building official	Owner/PM	Market actor
Identify roles and responsibilities	X	X	X
Energy code training	X	X	X
Energy code compliance practices	X	X	X
Awareness of energy efficiency programs		X	
Level of satisfaction with building and energy performance		X	
Maintenance procedures		X	
New construction program support			X
Effectiveness of CCEI	X	X	X
Overall suggestions	X	X	X

3.4 Sample design

The DOE's BECP recommends a minimum sample size of 30 for estimating Rhode Island's building code compliance rate for commercial new construction buildings within a tolerable margin of error, when using an average of 3 years of construction start data.[13] If the state wishes to have statistically reliable estimates of compliance rates for buildings with specific attributes, then a larger sample of buildings is necessary.

The BECP recommends that the state include commercial renovations in addition to new construction buildings in the code compliance study, but that the state report code compliance separately for new construction and renovations. Below, we discuss the sampling plan for the new construction buildings.

12 The Residential New Construction Baseline Study Team will analyze and present residential code compliance results from the building code official interviews.

13 BECP State Sample Generator uses construction starts data from 2008-2010 to generate the proposed sample size.

Table 3 shows the total non-residential new construction activity in 2012 through September 2015, reported by F.W. Dodge, in Rhode Island by building size group.[14] According to F.W. Dodge, 130 projects began construction during this period compared to 162 projects beginning during the 2012 study's timeframe (2008-July 2011). The building size groups, which are consistent with the BECP's recommended strata boundaries, are defined as follows:

- 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 and up to 400,000 ft^2
- XX-Large: Larger than 400,000 ft^2

Table 3. Non-residential new construction projects by year and size group, Rhode Island, 2012-September 2015

	Stratum				
Year	Small	Medium	Large	X-Large	Total
2012	27	7	8	0	42
2013	29	6	3	0	38
2014	22	4	4	0	30
2015 (through Sep 2015)	9	5	5	1	20
Total	87	22	20	1	130
Total (excluding 2012)	60	15	12	1	88

Source: F.W. Dodge

National Grid and the Building Code Commissioner preferred to limit the target population to buildings constructed (1) under IECC 2012 and (2) following the commencement of the CCEI. Due to the small number of buildings that have begun construction since the State of Rhode Island adopted IECC 2012[15] on July 1, 2013 (with the first CCEI training on November 6, 2013), the DNV GL team could not guarantee a sample of buildings meeting these two criteria. In an attempt to meet these criteria while still yielding an adequate number of completes in each stratum, we implemented the following sampling strategy. We combined the most recent 3 years (2013 through September 2015) of commercial new construction activity in Rhode Island, and design a stratified, simple random sample by the same type of process used in the 2012 study. As anticipated in the sample design, before achieving our target population of 30 buildings, we exhausted the population of 88 buildings started during the most recent 3 years and needed to sample the 42 buildings started in 2012. However, rather than open the 2012 buildings sample, National Grid decided to continue focusing on buildings completed in 2013 or later; accordingly, the DNV GL team continued to focus on the 2013-2015 buildings. DNV GL, National Grid, and the Building Code Commissioner worked together employing extensive and exhaustive techniques to continue to recruit buildings built in the most recent three years (2013 through September 2015). Together we were able to convert several additional sites that had previously refused to participate in the study.

Table 4 provides a comparison of the 2012 and 2016 sample frame, sample projects, and square footage for the projects the DNV GL team deemed eligible. DNV GL determined eligible projects based on the

[14] The sample frame for the 2012 study included new construction projects started between 2008 and 2011.

[15] The DNV GL team also recognizes that buildings started after July 1, 2013 may have been grandfathered into IECC 2009.

recruitment interviews and the field data collection performed in 2012 and 2016. Two primary corrections were made to the Dodge classifications: (1) We removed buildings from the frame that did not qualify for the study (e.g., project not completed, project not new construction, project not commercial); and (2) We reclassified projects into the appropriate size stratum based on recorded square footage. These adjustments were used to develop the sampling weights for 2016 and the re-weighting of the 2012 data using the same procedures to facilitate the most direct comparisons between years. This produced minor changes in the 2012 estimates compared to the 2012 estimates provided in the baseline study report.

Table 4. Comparison of sample frame and eligible projects, 2012 and 2016

Stratum	Frame Projects		Sample Projects		Frame		Eligible Projects		Eligible Sample		Eligible Sample	
	2012	2016	2012	2016	2012	2016	2012	2016	2012	2016	2012	2016
Less than 25,000 sq.ft.	102	59	11	14	1,025	462	88	58	15	15	963	444
25,000 to 60,000 sq.ft.	26	16	11	6	1,016	663	25	10	6	3	906	365
60,000 to 250,000 sq.ft.	25	12	7	1	2,890	1,344	19	11	10	3	2,623	1,260
250,000 to 400,000 sq.ft.	6	1	3	0	1,942	260	5	0	1	0	1,942	0
Greater than 400,000 sq.ft.	2	0	1	0	1,716	0	2	0	1	0	1,662	0
Total	**161**	**88**	**33**	**21**	**8,590**	**2,729**	**139**	**79**	**33**	**21**	**8,096**	**2,069**

Table 5 provides the distribution of sample projects by building type and size stratum.

Table 5. Comparison of frame and sample by building type and size, 2012 and 2016[16]

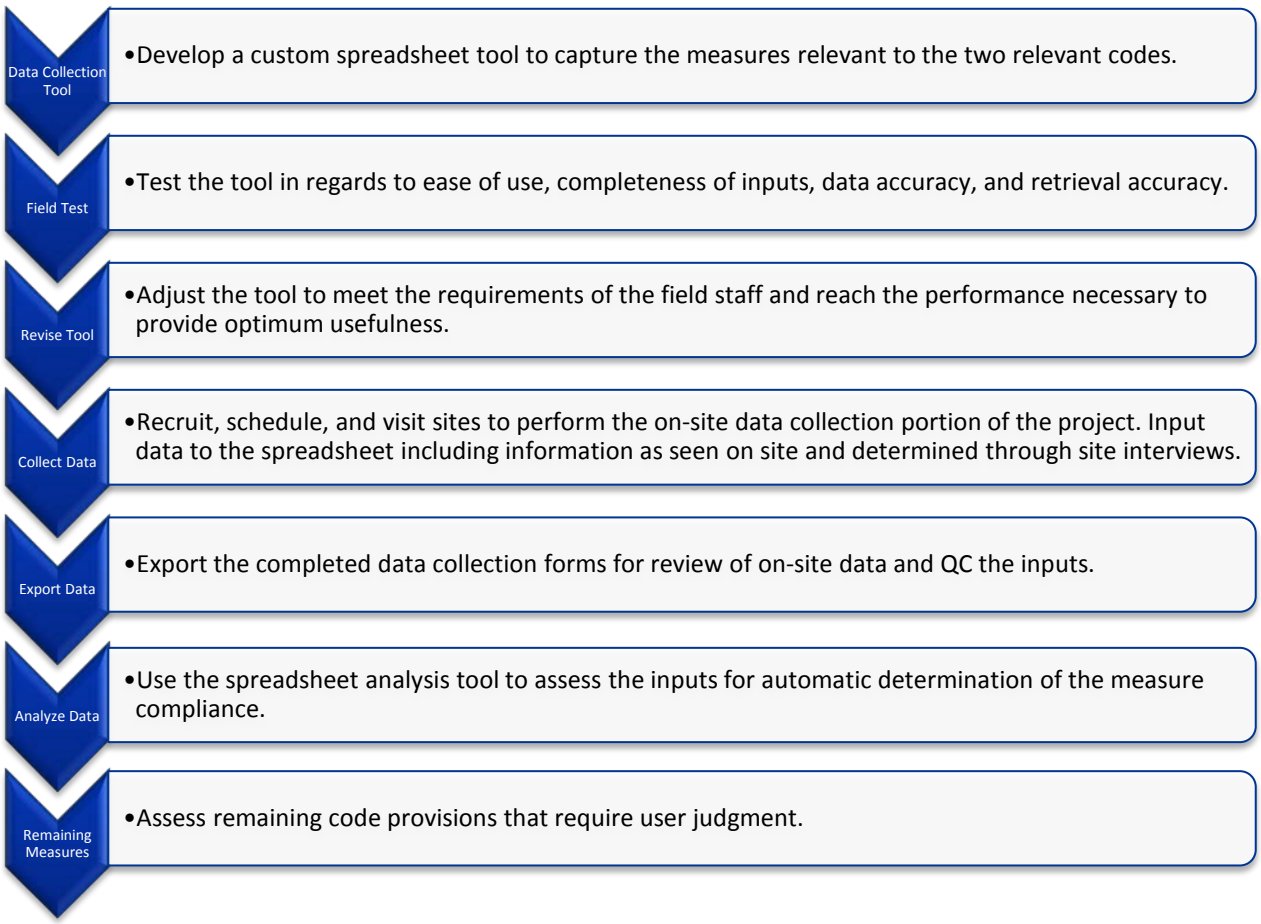
Stratum frame projects	Less than 25,000 sq.ft.		25,000 to 60,000 sq.ft.		60,000 to 250,000 sq.ft.		250,000 to 400,000 sq.ft.		Greater than 400,000 sq.ft.	
Building Type	**2012**	**2016**	**2012**	**2016**	**2012**	**2016**	**2012**	**2016**	**2012**	**2016**
Amusement, Social and Recreational Bldgs	0	1	1	1	1	0	1	0	0	0
Apartments	0	0	2	1	0	0	0	0	0	0
Dormitories	0	0	0	0	1	0	0	0	0	0
Government Service Buildings	1	1	0	0	0	0	0	0	0	0
Hospitals and Other Health Treatment	0	0	1	0	0	0	0	0	0	0
Hotels and Motels	1	0	1	1	0	0	0	0	0	0
Manufacturing Plants, Warehouses, Labs	0	0	0	0	1	0	0	0	0	0
Miscellaneous Nonresidential Buildings	3	1	0	0	0	0	0	0	0	0
Office and Bank Buildings	1	2	4	0	1	0	0	0	0	0
Parking Garages and Automotive Services	0	1	0	0	0	0	0	0	1	0
Religious Buildings	0	0	1	0	0	0	0	0	0	0
Schools, Libraries, and Labs (nonmfg)	0	3	3	2	3	1	2	0	0	0
Stores and Restaurants	5	4	0	1	0	0	1	0	0	0
Warehouses (excl. manufacturer owned)	0	1	1	0	1	0	0	0	0	0
Total	**11**	**14**	**11**	**6**	**7**	**1**	**3**	**0**	**1**	**0**

3.5 Site data collection

This section presents the methodology implemented to collect data regarding specific project sites in Rhode Island. It also describes the custom tool developed for code compliance analysis. Figure 5 illustrates the process employed to collect and verify the site data.

[16] APPENDIX E provides an expanded version of this table with the distribution of the frame projects by building type.

Figure 5. 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 DNV GL team developed custom data collection and analysis tools for this study. These tools were modifications of data collection tools and approaches used in both the 2012 study and the more recent 2015 Massachusetts compliance study. The study period for the 2016 study spans two versions of the energy code, IECC 2009 and IECC 2012. While existing tools covered IECC 2009, they needed to be modified to capture new and revised provisions in IECC 2012, as well as state-specific amendments for Rhode Island.

The intent of the data collection tool developed for this study was to maintain consistency with the 2012 study's methodology while incorporating the flexibility to assess both IECC 2009 and IECC 2012 based on the applicable code version for each site, as well as RI-specific code amendments. The data collection tool was designed not to assess code compliance in the field, but to collect "as-built" data for subsequent assessment using the analysis tool.

3.5.2 Training and quality control

The DNV GL team conducted several activities to ensure that field engineers were equipped with the necessary skills to collect data and perform quality control reviews. A full-day training session for field

engineers was conducted to review the energy code requirements and the functionality of the data collection tool. This training also included a field exercise to assess compliance using the tool in an existing building. Following training, the tool development team provided ad-hoc assistance to the field engineers and reviewers as the initial sites were completed. The tool development team provided guidance on how to assess code features and unique situations encountered onsite.

3.5.3 Site data collection procedures

The on-site data collection task consisted of visiting each of the identified survey sites and using the data collection tool to collect the data to assess code compliance. Field personnel were not required to ascertain compliance in the field. Their responsibility was to observe and record how the components had been installed. Specific tasks associated with this effort include:

- **Site scheduling** – In order to assure proper coordination, each DNV GL team member scheduled his or her own site visits. Team members worked from their assigned projects from the sample to record initial information regarding the status of the project (i.e., fully complete, under construction, design stage, etc.). Upon identification of viable sites, the site visits were scheduled.
- **Obtaining project documentation** – At the time of initial site scheduling, team members 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. This typically included project owners, design team members, and facility managers. They also scheduled a facility tour with adequate time to perform project assessment and data collection.
- **On-site interviews** – Although flexibility was maintained in order to accommodate project participants, each site visit began with discussion with a building representative onsite in order to gather as much project data as possible. These interviews assist in:
    - Obtaining key features of the project related to energy efficiency
    - 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 onsite in conjunction with the site survey, or were reviewed independently of the site work. Depending on the detail in the available documents, team members gathered and then verified the following project information 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. The DNV GL team was not given access to design documents for all sampled buildings. For these sites, as much data as possible were collected through physical inspection. In all cases, the 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 7 days of completing the site survey.

3.6 Estimating site-level compliance

3.6.1 Analysis tool

The DNV GL team developed an analysis tool to automate the assessment of code compliance. This analysis tool compared the data collected with the applicable code requirements, to determine whether or not each site was compliant with applicable codes. The analysis tool incorporated the Compliance assessment methodology described in the following section.

3.6.2 Compliance assessment methodology

The 2016 study assessed compliance with IECC 2009 and IECC 2012, based on a review of observable prescriptive energy code requirements for each study site that were captured on the data collection tool. While both IECC 2009 and IECC 2012 offer prescriptive and performance compliance options, the 2016 study took a prescriptive approach to assessing compliance for the following reasons:

- **The majority of design teams choose the prescriptive path for compliance**. The performance path requires two complete energy performance models: one for the building as designed, and one for a similar building that meets all of the prescriptive requirements. The primary reasons for buildings pursuing the performance path are either that the designed building has more than 30% glazing (40% IECC 2009)—which is generally only triggered for large high-rise developments with primary curtain wall envelope assemblies—or that the project is pursuing LEED® or another high-performance building program.

- **Buildings that elect to comply with the performance path must still meet many of the code requirements (termed "mandatory" in the code language) on a prescriptive basis**. This includes the air leakage requirements for the building envelope, most mechanical system requirements, and all service-water heating and electrical power and lighting system requirements.
- **It is difficult for code officials and compliance studies to assess compliance using the performance-based approach**. Often, officials and compliance evaluators have no access to documentation of the modeling procedures and assumptions used to comply with this approach. When the documentation is available, the procedure for verifying the model results is onerous, and beyond the budget capabilities of either code enforcement offices or compliance studies. Future proposed versions of the energy code include provisions requiring post-construction building performance monitoring to verify that the actual performance is consistent with the model results. Post-construction monitoring could make future assessment of performance methodologies more easily achievable.

The final compliance score for each site was assessed based on the observed code provisions, which were weighted by their relative energy impact. The compliance scores are based on the applicable energy code at the local (town or city) level. For the 2016 study, compliance was evaluated using two different methodologies: one developed by the DOE in conjunction with the Pacific Northwest National Laboratory (PNNL) (the DOE/PNNL method), and an enhanced method developed by the DNV GL team to more accurately capture the energy impact of observed building practices (the DNV GL team method). These methodologies are explained below.

3.6.2.1 Department of Energy/Pacific Northwest National Laboratory method

The DOE/PNNL method was originally developed as a tool to assess state compliance rates and develop plans to reach 90% compliance with IECC 2009; this goal was established in the American Recovery and Reinvestment Act (ARRA). The DOE/PNNL method weights each provision of the energy code according to the relative energy impact of its compliance or noncompliance. Each provision is assigned to one of three tiers: tier 1 provisions have the lowest impact; tier 2 has twice the impact of tier 1; and tier 3 has three times the energy impact of tier 1. This method is similar to that used during the 2012 study, and can provide a reasonable basis for comparing the compliance rates between the two studies.

The DOE/PNNL method, however, has limitations. The IECC and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 both allow for compliance trade-offs within the building envelope category. The DOE/PNNL method evaluates each individual provision as either "compliant" or "not compliant," generating a result inconsistent with code protocols. Also, the DOE/PNNL method does not consider the energy impacts for partial compliance of a provision. For example, if the above-grade wall insulation requirements were met by 75% of the above-grade walls at a building, this site would be evaluated as "not compliant" for this provision under the DOE/PNNL method, since 25% of the walls did not meet the code. The DOE/PNNL method has no way of taking this level of partial compliance into account when evaluating energy impacts, which is a significant drawback.

Modifications to Department of Energy/Pacific Northwest National Laboratory method

The DNV GL team identified a number of instances where the DOE/PNNL method does not accurately assess the impacts of energy code provisions. Many of these changes were identified and modified in the 2012 study as well. Adjusted weighting was applied for the following provisions:

- **Documentation and labeling**. Many code provisions under the DOE/PNNL method award compliance points for providing documentation such as fenestration performance certification labels, insulation R-value labels, etc. While these are important components to demonstrating compliance, the DNV GL team method assesses the actual performance of these features rather than just awarding points for the labels themselves. Where labels were absent, our field engineers used construction documents, product specification sheets, discussions with on-site contractors, and industry standard references such as the R-value per inch of insulation to determine the actual performance of the installed features.
- **Internal consistency**. In each broad energy code category (envelope, mechanical, and lighting), we evaluated code measures against each other to ensure that their relative weighting reflected the local climate conditions and impacts on building energy use. These modifications allowed for a more granular assessment of the actual impact of the energy code provisions.
- **Windows versus skylights**. Windows and skylights are assigned the same weight in the DOE/PNNL method; however, buildings that use both windows and skylights generally have much larger square footage of vertical fenestration (windows) than horizontal (skylights). Thus, the relative weight of windows should be higher than that of skylights.
- **Solar heat gain coefficient**. The DOE/PNNL method scores the impact of solar heat gain coefficient (SHGC) as greater than the impact of fenestration air leakage. In Rhode Island's climate zone, the impact of SHGC is lower than the impact of fenestration air leakage, and the relative weights should reflect this.
- **Bi-level switching versus automatic controls**. The DOE/PNNL method assigns a higher weight to bi-level switching than the ability to turn lights fully off manually or automatically. The relative impacts are likely the opposite, and so we have reversed the weights.
- **Interior versus exterior lighting**. Similar to windows and skylights, the DNV GL team determined that interior lighting should be weighted more than exterior lighting, as it is generally a larger contributor to the overall energy use. We have re-assessed interior lighting as tier 3, and exterior lighting as tier 2.

3.6.2.2 DNV GL team method

The DNV GL team method incorporates all of the modifications to the DOE/PNNL method, while also gaining the functionality to award partial compliance with energy code measures, and to assess trade-offs within the building envelope that are allowed by IECC. Using the DNV GL method results in compliance scores that better represent the actual energy impact of the building practices observed; we thus recommend it as the preferred approach for estimating code compliance.

Partial compliance

To assess partial compliance, the energy code provisions were divided into the following two categories:

- **Yes/no questions**. Many code provisions are assessed as either compliant or noncompliant under the DOE/PNNL method. The DNV GL team modified these questions to allow partial compliance values of 1/3 (recording a value of "somewhat" on the data collection form) or 2/3 (a value of "mostly" on the data collection form).
- **Performance and efficiency requirements**. Where specific efficiency or performance levels were required by code, the DNV GL team calculated the ratio of actual performance to the code level and used this ratio to weight the score. This was commonly used for mechanical equipment efficiencies and lighting power density (LPD). Any values that exceeded the energy code were given full credit for compliance but were not awarded more compliance points for exceeding the code.

Trade-offs within the building envelope

The IECC 2009 and 2012 codes allow trade-offs within the building envelope, yet a manual checklist-type of prescriptive compliance assessment evaluates each code provision and cannot easily incorporate interactive effects and trade-offs. In order to assess these trade-offs, the building envelope components observed by the field engineers were converted to u-factor equivalent and weighted by square footage, resulting in data points for the code allowed weighted u-factor for each code version, as well as an installed weighted u-factor. We compared these numbers to assess compliance across the relevant envelope provisions; we applied this score to all the envelope features subject to the u-factor analysis for which we collected data. For all of the compliance analyses completed in the 2016 study, the maximum allowable compliance was 100%. Trade-offs are not allowed between the code categories (e.g., envelope and lighting); awarding compliance scores greater than 100% would suggest that a building envelope modeled to perform better than code could offset other areas that may be worse than code. This is not allowed in the prescriptive path to energy code compliance.

During the course of conducting plan reviews and site visits for the RI Code Study, there were cases in which data was missing from the plans and unavailable to field staff during the site visits. The most common example of this is fenestration performance data for windows and doors. Often, the plans provided some characteristics of the glazing performance (e.g., low-e, insulated glass, etc.) but did not provide specific performance characteristics such as the u-factor and SHGC. Where possible, using product specifications and conversations with on-site staff, the project team made efforts to gather descriptive information about the equipment and used that information for trade-off assessments in the analysis tool. A list of building features used in trade-off assessment includes:

- Above- and below-grade walls
- Slabs and floors, roofs
- Windows and doors

3.6.3 Data upload and analysis procedure

While the analysis tool we developed is highly automated, it allows for quality control at every step. The user interface allowed 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.” We utilized the following procedure:

- **Data upload**. Upon assurance that collected data is complete and accurate, we uploaded the individual facility data from the data collection tool to the analysis tool.
- **Data quality assurance review**. Following the data upload, 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**. Many code provisions are prescriptive across all commercial building types; others are prescriptive but segregated by building type and/or building size. For all of these prescriptive provisions, the analysis tool uploaded the data and recorded baseline information, and the building type/size when appropriate. It then automatically made a code compliance determination, verifying whether individual provisions are met. COMcheck and “Total Building Performance” methodologies allow for some tradeoffs within building envelope measures. The DOE/PNNL method 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, these were not offset by corresponding beyond-code envelope practices.

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 thus require user judgment. For these provisions, the data was uploaded to the analysis tool 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 (e.g., LPD, which is the main avenue of lighting compliance), a calculation was needed to determine compliance with a specific provision. In these cases, we proceeded according to the following steps:

  - The 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.
  - The site surveyor selected a minimum of two 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 into the data collection tool.
  - The lighting fixture technologies were selected from drop-down menus.
  - The fixture quantity was recorded in the tool.
  - The analysis tool assigned the appropriate fixture wattage from an extensive database of lamp/ballast combinations, and calculated the LPD.
  - Upon uploading data to the analysis 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 DNV GL 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, these inquiries ultimately showed 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 could be verified without damaging the structure.

The DNV GL reviewed and tested the analysis tool during the first few site analyses to ensure that it was operating as designed. For each site, we developed compliance scores using the DOE/PNNL and DNV GL

team methods described above. For each provision that we could observe either during review of construction documents or during the site visit(s), we assessed a compliance score. Note that the DNV GL team method both allowed for partial compliance and incorporated envelope trade-offs as described above. Provisions that were not observable received a score of "not verifiable" or "n/v." The individual provision compliance assessments were aggregated according to each provision's tier weight (by energy impact) as explained in Section 3.6.2.1 above. The total score received, divided by the total score possible based on the number of observed provisions weighted by tier, resulted in the site's overall compliance score. Note that the number of observable provisions varied across the 2016 study sites.

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 is 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 DNV GL team methodically identified construction practice, recorded design document information, and verified design intent through a rigorous onsite inspection process. Data that cannot be verified to a reasonable degree of certainty are 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; each site is evaluated for compliance based only on verified data. Most common non-verifiable parameters were windows' and doors' U-values and solar heat gain coefficients (SHGC), insulation quality of the slab and below-grade wall, air barrier installation quality, and air outlets and zone terminal devices meant for air balancing.

3.7 Estimating overall energy code compliance

To facilitate comparison with the 2012 baseline study, we calculated the 2016 study statewide estimate using the proportion (P) weights and compliance score calculation developed by PNNL. These are provided as Equation 1 and Equation 2.

Equation 1. Calculation of P by size stratum

$$P_{size\ stratum} = \frac{Total\ constructed\ building\ space\ for\ size\ stratum\ of\ building\ (ft^2)}{Total\ constructed\ building\ space\ for\ all\ commercial\ buildings\ (ft^2)}$$

Equation 2. Calculation of average state compliance score, weighted by building size

$$P_{small} \times \left(\frac{sum\ of\ building\ scores\ in\ small\ strata}{n_{small}}\right) + P_{medium} \times \left(\frac{sum\ of\ building\ scores\ in\ medium\ strata}{n_{medium}}\right) + P_{large} \times \left(\frac{sum\ of\ building\ scores\ in\ large\ strata}{n_{large}}\right) + P_{Xlarge} \times \left(\frac{sum\ of\ building\ scores\ in\ X-large\ strata}{n_{Xlarge}}\right) + P_{XXlarge} \times \left(\frac{sum\ of\ building\ scores\ in\ XX-large}{n_{XXlarge}}\right) = Average\ Compliance\ Score$$

where P_i = the small, medium, large, X-large, XX-large proportion weight
n_i = the number of samples evaluated within the respective size stratum

The DNV GL team re-ran the 2012 study results using the same weighting scheme used for the 2016 study in order to develop the measures of precision needed for the statistical differences tests.

The tables reporting compliance rates in the next section of the report include the following:

- Estimated compliance rates calculated with the above equations
- Indicators of statistical precision at 90 percent confidence (90 percent confidence interval),
    - Plus/minus (±) error (%) – the absolute difference between the estimated percentage and the upper or lower confidence bound. If the study were re-done with the same population, we are 90% confident that the resulting point estimate would lie within this amount of the compliance rate.
    - Upper bound – the compliance rate plus the plus/minus (±) error (%)
    - Lower bound – the compliance rate minus the plus/minus (±) error (%)
- Sample sizes – the number of unique projects in the sample

4 CODE COMPLIANCE RESULTS

In this section, we present 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 2012 study results were re-weighted and analyzed using the same procedures used for the 2016 study.[17] This facilitated the most meaningful comparisons across years and the development of measure of precision to assess statistical differences.

The compliance results presented include:

- Overall energy code compliance rates, estimated utilizing the DOE/PNNL tiered energy impact procedures developed in support of ARRA-funded energy efficiency programs to facilitate comparisons with the 2012 study
    - Comparison of 2016 study estimates to 2012 study estimates
    - Estimated compliance rate by DOE/PNNL method vs. DNV GL team method
    - Compliance rates by energy code category (envelope, HVAC, lighting power density and lighting controls)
- Additional comparisons across years and versions of the code
    - 2012 vs. 2016 assessed per IECC 2009 (DOE/PNNL method)
    - 2016 projects assessed per IECC 2009 vs. all 2016 projects assessed per IECC 2012
        - DOE/PNNL method
        - DNV GL team method
    - 2016 projects built under IECC 2009 vs. 2016 projects built under IECC 2012
        - DOE/PNNL method
        - DNV GL team method

4.1 Overall energy code compliance rates

The 2012 study evaluated buildings that were designed to conform with IECC 2006 and IECC 2009,[18] while the 2016 study evaluated buildings that were designed to conform to either IECC 2009 or IECC 2012.[19] The results in this section were determined based on the applicable version of the code each building was built under.

4.1.1 2012 baseline vs. 2016 study

Figure 6 shows overall statewide compliance rates of Rhode Island commercial buildings found through the 2012 and 2016 studies, using the DOE/PNNL method. We used the DOE/PNNL method to compare compliance rates in the 2012 and 2016 studies because the 2012 study used only this method, and did not collect the raw data necessary to recalculate compliance retroactively using the DNV GL team method. Thus, a meaningful "apples-to-apples" comparison between the 2012 and 2016 studies requires the use of the DOE/PNNL method. Statistical differences at the 10% level of significance between estimates are illustrated in the chart via bars with dotted backgrounds. **Overall statewide compliance for commercial buildings increased from 78%[20] in 2012 baseline study to 86% in the 2016 study.** This difference is

[17] A description of the re-weighting is provided in Section 3.4 Sample Design.

[18] Only 3 buildings in the 2012 baseline study were built to conform to IECC 2009.

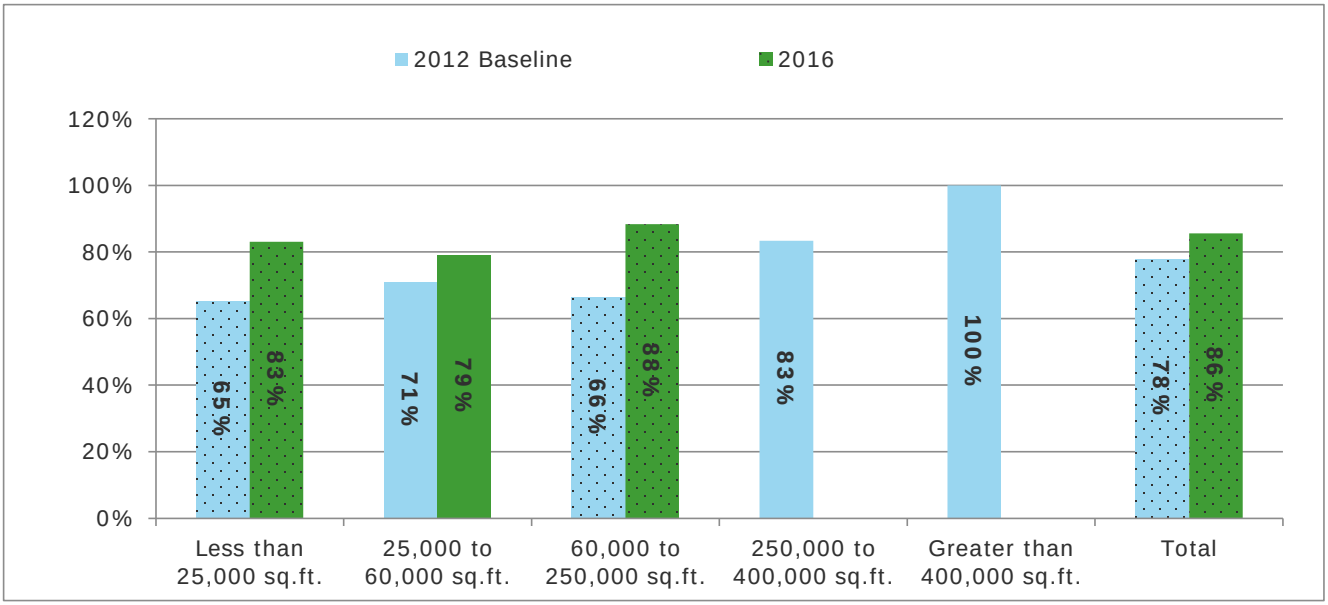
[19] Only 4 buildings in the 2016 study were built to conform to IECC 2012.

[20] The overall statewide compliance for commercial buildings reported in the 2012 baseline study was 76% using the DOE/PNNL calculation and sample weighting methods. The 2012 study also reported a statewide compliance rate of 70% without using the sample weighting methods. To

statistically significant at the 10% level of significance. Increases in compliance rates between 2012 and 2016 for buildings less than 25,000 square feet and buildings between 60,000 and 250,000 square feet were also statistically significant at the 10% level of significance.

There were no sampled buildings in the 2016 study that were greater than 250,000 square feet.

Figure 6. Overall energy code compliance rates, 2012 and 2016 studies (DOE/PNNL method)*



*Bars with dotted backgrounds indicate the compliance rates are statistically different from each other at the 10% level of significance.

The 90% confidence interval for overall energy code compliance rates from the 2012 and 2016 studies are provided in Table 6. The overall 2016 energy code compliance rate is 86%, and the 90% confidence interval is ± 3 percentage points (i.e., 86% ± 3%). In other words, the point estimate of the compliance rate is 86%, and there is a 90% probability that the actual compliance rate lies between 82% and 89%.

Table 6. Overall energy code compliance rates, 2012 and 2016 studies (DOE/PNNL method)

	2012 study					2016 study				
			90% Confidence					90% Confidence Interval		
Strata	n	Compliance Rate	+/-	Lower Bound	Upper Bound	n	Compliance Rate	+/-	Lower Bound	Upper Bound
Less than 25,000 sq.ft.	15	65%	4.6%	60%	70%	15	83%	4.2%	79%	87%
25,000 to 60,000 sq.ft.	6	71%	3.1%	68%	74%	3	79%	14.5%	65%	94%
60,000 to 250,000 sq.ft.	10	66%	4.4%	62%	71%	3	88%	3.5%	85%	92%
250,000 to 400,000 sq.ft.	1	83%	<0.1%	83%	83%	-	NA	NA	NA	NA
Greater than 400,000 sq.ft.	1	100%	<0.1%	100%	100%	-	NA	NA	NA	NA
Total	**33**	**78%**	**1.6%**	**76%**	**79%**	**21**	**86%**	**3.4%**	**82%**	**89%**

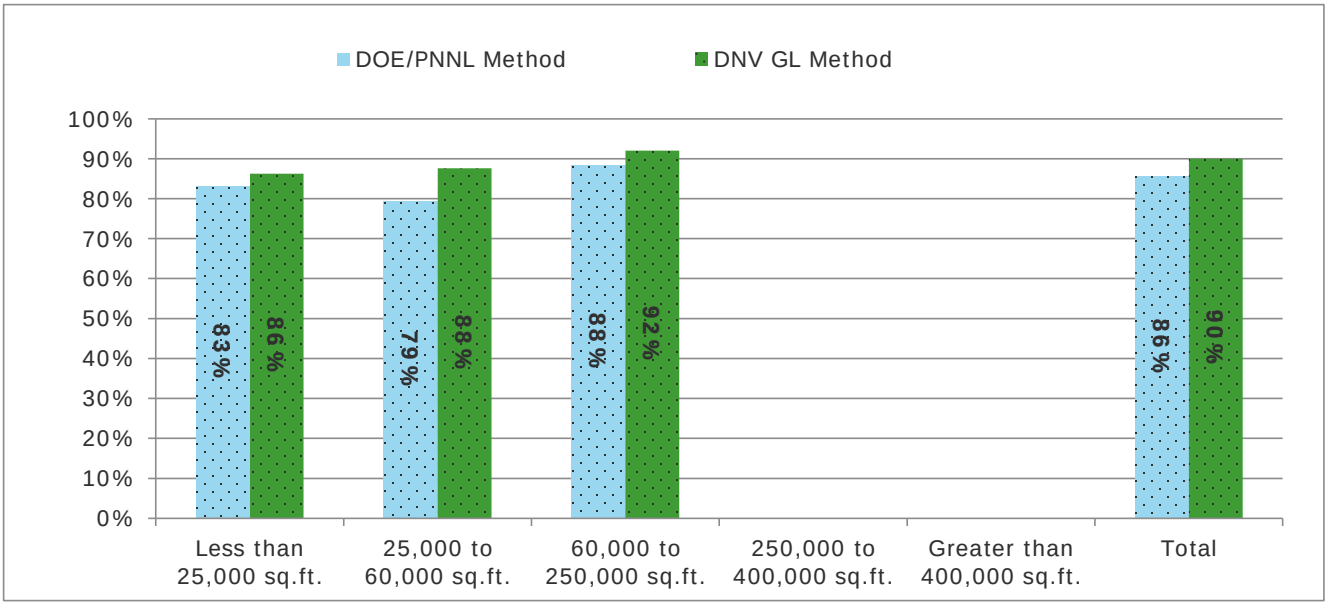
4.1.2 DOE/PNNL method vs. DNV GL team method

3.6 described the two different methods we used in the 2016 study to estimate site-level compliance: the **DOE/PNNL method** and the **DNV GL team method**. That section explained that in recognizing partial compliance as well as allowing for trade-offs within the building envelope, as permitted by IECC, the DNV GL

facilitate statistical comparisons across years DNV GL used the DOE/PNNL calculation and sample weighting methods for 2012 and 2016. Additionally, as part of the 2016 study, the 2012 study data were re-analyzed using similar sampling adjustments added to the 2016 study. These adjustments were made to adjust the sample frame based on information (e.g. eligibility for study and square footage) learned about the projects during recruitment and site visits.

team method overcomes significant limitations of the DOE/PNNL method to more accurately reflect the energy impact of observed building practices. The DNV GL method is thus our recommended approach for estimating code compliance. Figure 7 provides a comparison of code compliance rates for the 2016 study sites found using each of these methods. **Notably, using the DNV GL team method, statewide compliance increases from 86% (DOE/PNNL method) to 90%.** The differences for all size categories and the statewide total are significant at the 10% level of significance.

Figure 7. Overall energy code compliance rates, DOE/PNNL vs. DNV GL team methods*



*Bars with dotted backgrounds indicate the compliance rates are statistically different from each other at the 10% level of significance.

The 90% confidence interval for overall energy code compliance rates from the DOE/PNNL and DNV GL team methods are provided in Table 7.

Table 7. Overall energy code compliance rates, DOE/PNNL vs. DNV GL team methods

Strata	DOE/PNNL Method					DNV GL Method				
	n	Compliance Rate	90% Confidence +/-	Lower Bound	Upper Bound	n	Compliance Rate	90% Confidence Interval +/-	Lower Bound	Upper Bound
Less than 25,000 sq.ft.	15	83%	4.2%	79%	87%	15	86%	4.4%	82%	91%
25,000 to 60,000 sq.ft.	3	79%	14.5%	65%	94%	3	88%	11.3%	76%	99%
60,000 to 250,000 sq.ft.	3	88%	3.5%	85%	92%	3	92%	4.4%	88%	96%
250,000 to 400,000 sq.ft.	-	NA	NA	NA	NA	-	NA	NA	NA	NA
Greater than 400,000 sq.ft.	-	NA	NA	NA	NA	-	NA	NA	NA	NA
Total	**21**	**86%**	**3.4%**	**82%**	**89%**	**21**	**90%**	**3.5%**	**87%**	**93%**

4.1.3 Compliance rates 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 8 presents the estimated compliance by energy code category: building envelope, mechanical systems (HVAC), and lighting. Similar to Figure 6 above, the energy code category results were determined based on the applicable version of the code each building was built under and using the DOE/PNNL method to facilitate the comparison with the 2012 baseline

study. *Italics* are used in the table to indicate statistical differences across years at the 10% level of significance.

The 2012 study and 2016 study estimates for building envelope, mechanical systems (HVAC), and lighting are statistically different for buildings less than 25,000 square feet and buildings between 60,000 and 250,000 square feet. While the compliance rates increase markedly for each of the energy code categories, the greatest opportunities for increases in compliance rates continues to be envelope compliance with a 2016 study estimate of 83%.

Table 8. Compliance rate by energy code category, 2012 vs. 2016 (DOE/PNNL method)*

Compliance Category	Stratum										Total	
	Less than 25,000 sq.ft.		25,000 to 60,000 sq.ft.		60,000 to 250,000 sq.ft.		250,000 to 400,000 sq.ft.		Greater than 400,000 sq.ft.			
	2012	2016	2012	2016	2012	2016	2012	2016	2012	2016	2012	2016
Total Compliance	*65%*	*83%*	71%	79%	*66%*	*88%*	83%	NA	100%	NA	*78%*	*86%*
Envelope Compliance	*68%*	*88%*	65%	82%	*46%*	*82%*	71%	NA	0%	NA	*60%*	*83%*
HVAC Compliance	*62%*	*78%*	74%	89%	*75%*	*92%*	94%	NA	0%	NA	*79%*	*89%*
Lighting Compliance	*68%*	*80%*	73%	67%	*78%*	*96%*	100%	NA	100%	NA	*86%*	*87%*

*Italics indicate the compliance rates are statistically different from each other at the 10% level of significance.

Further, 100% of building officials interviewed stated that someone from their staff had attended some type of training on commercial energy code compliance and enforcement in the past two years. When asked about the primary impact(s) of that training, almost 70% mentioned an increase in awareness of the code. The next highest response, with about 20%, was “building envelope” compliance. While there is no causal link, this may explain why envelope compliance had one of the highest increases between 2012 and 2016 (see Table 7).

The compliance rate by energy code category breakouts identified several interesting finding by building size. For envelope compliance, the smaller buildings often scored higher than larger buildings due to insulation above the climate zone (primarily in ceilings and roofs). For example, multiple smaller buildings in the sample were constructed with sloped roofs that were designed and built with double layers of insulation and/or spray foam. The larger buildings tended to be built with flat roofs covered in a rubber membrane. The insulated board under the rubber membrane meets older versions of code, but not the newer versions used by the DOE/PNNL method.

Lighting compliance increased significantly for the small and large buildings. Trends in the lighting market and support from utility program efforts have dramatically shifted the market toward energy efficient technologies including the rapid adoption of LEDs. In most cases when a facility did not pass the DOE/PNNL method it was due to controls. The new codes have mandatory measures in some cases for daylight controls, outdoor isolated wiring, timers, bi-level fixtures, and other controls. These provisions were more often met by the larger buildings compared to small buildings.

HVAC compliance increased for all building sizes, but this was not surprising because the majority of the equipment installed onsite and specified in the drawings met or exceeded code requirements. 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.

4.2 Additional comparisons across years and versions of the code

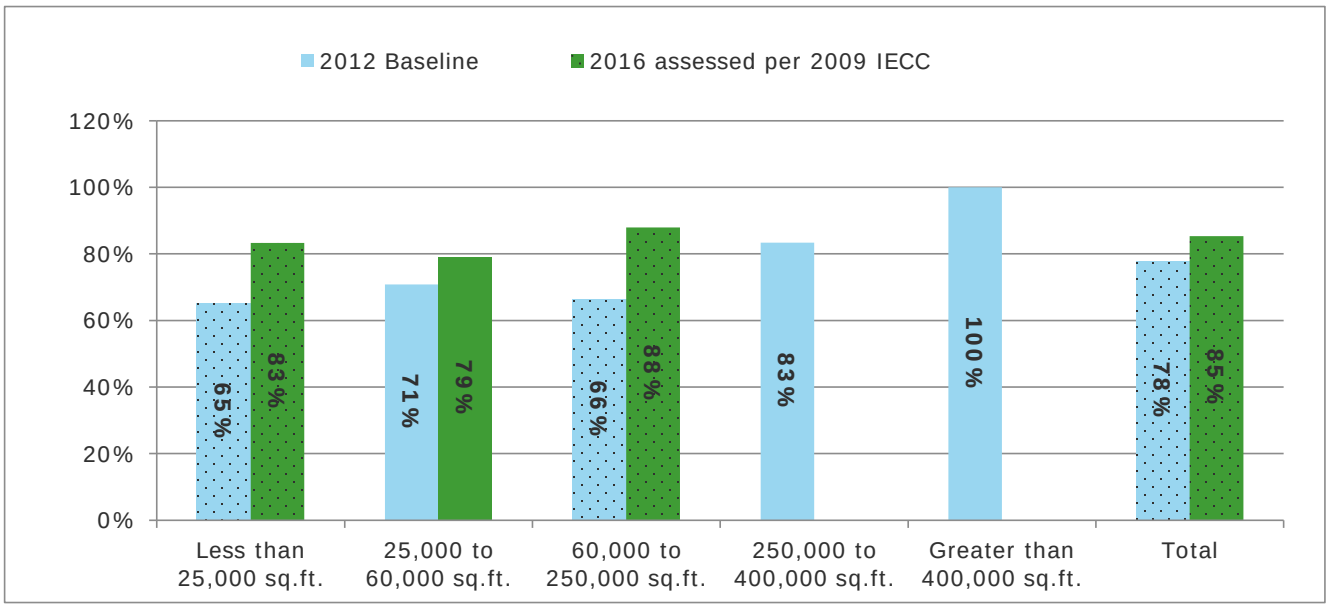
In this section we provide additional comparisons to further investigate the difference across years and versions of the code.

4.2.1 2012 vs. 2016 assessed per IECC 2009 (DOE/PNNL method)

To control for the influence of increases in code stringency from the 2012 baseline study to the 2016 study, we assessed the 2016 study site-level data according to IECC 2009, regardless of which code the building was built to conform to. It is important to note the 2012 baseline study included 30 buildings constructed under 2006 IECC and only 3 buildings constructed under 2009 IECC. The prior study did not perform site-level analyzes relative to multiple version of the code; therefore 2012 study sites assessed per 2009 IECC is not available for comparison with 2016 study sites assessed per 2009 IECC (the latter was new analysis added to the current study). Additionally, the sample of 2012 study buildings constructed to 2009 IECC is not sufficient for comparison with the 2016 study sites.

Figure 8 shows those results using the DOE/PNNL method compared to the 2012 baseline study. The results are similar to the overall results provided in Figure 6, indicating that changes in code from IECC 2009 to IECC 2012 had little impact on compliance rates, the small sample of buildings (only 4) built under IECC 2012 was too small to impact the statewide estimates, or the newest buildings tend to be built to higher energy efficiency standards (see Figure 11 and Figure 12 below).

Figure 8. Overall energy code compliance rates, 2012 vs. 2016 assessed per IECC 2009 (DOE/PNNL method)*



*Bars with dotted backgrounds indicate the compliance rates are statistically different from each other at the 10% level of significance.

The 90% confidence interval for overall energy code compliance rates from the 2012 vs. 2016 assessed per IECC 2009 (DOE/PNNL method) are provided in Table 9.

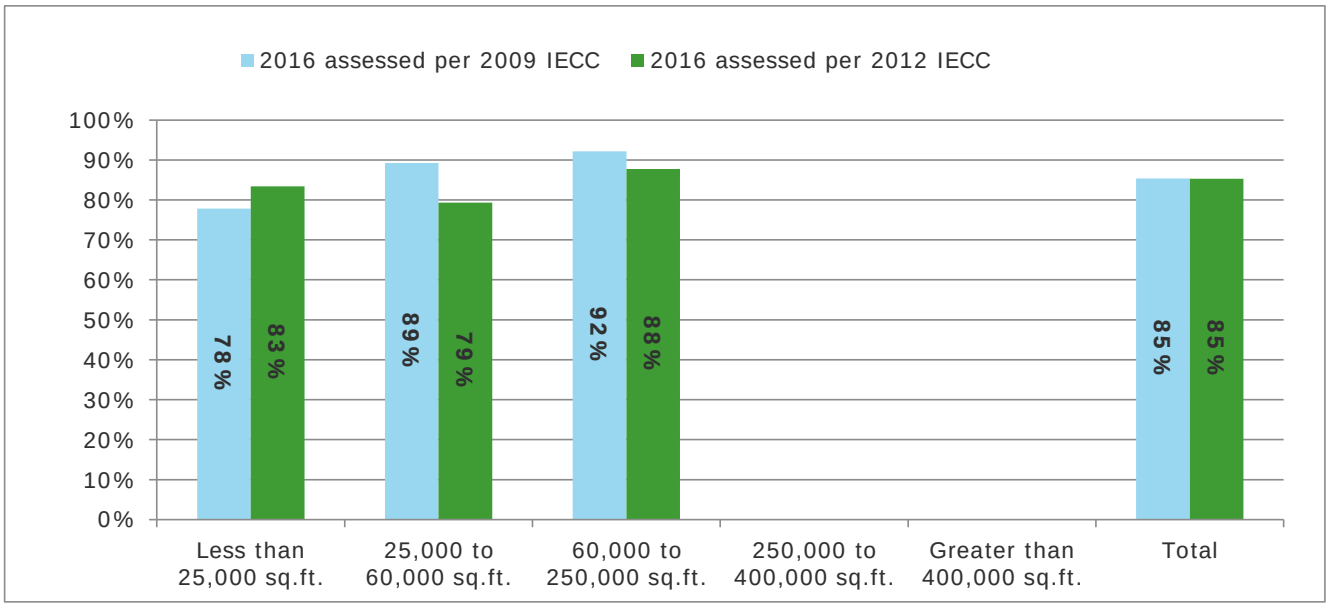
Table 9. Overall energy code compliance rates, 2012 vs. 2016 assessed per IECC 2009 (DOE/PNNL method)

Strata	2012 Baseline					2016 assessed per 2009 IECC				
	n	Compliance Rate	90% Confidence			n	Compliance Rate	90% Confidence Interval		
			+/-	Lower Bound	Upper Bound			+/-	Lower Bound	Upper Bound
Less than 25,000 sq.ft.	15	65%	4.6%	60%	70%	15	83%	4.4%	79%	88%
25,000 to 60,000 sq.ft.	6	71%	3.1%	68%	74%	3	79%	14.4%	65%	93%
60,000 to 250,000 sq.ft.	10	66%	4.4%	62%	71%	3	88%	3.3%	85%	91%
250,000 to 400,000 sq.ft.	1	83%	<0.1%	83%	83%	-	NA	NA	NA	NA
Greater than 400,000 sq.ft.	1	100%	<0.1%	100%	100%	-	NA	NA	NA	NA
Total	**33**	**78%**	**1.6%**	**76%**	**79%**	**21**	**85%**	**3.4%**	**82%**	**89%**

4.2.2 All 2016 projects assessed per 2009 IECC vs. all 2016 projects assessed per 2012 IECC

To further investigate the potential influence of increases in code stringency from IECC 2009 to IECC 2012, we assessed the 2016 study site-level data according to IECC 2009, regardless of which code the building was built to conform to. We also assessed the same 2016 site-level data according to IECC 2012. Any statistical difference in this comparison would be attributed to changes in code. We provide the results of this analysis using the DOE/PNNL method and the DNV GL team method in Figure 9 and Figure 10, respectively. There are no statistical differences using the DOE/PNNL method, but we did find a small decrease (1 percentage point) for buildings between 25,000 and 60,000 square feet using the DNV GL team method.

Figure 9. Overall energy code compliance rates, 2016 projects assessed per IECC 2009 vs. 2016 projects assessed per 2012 IECC (DOE/PNNL method)*



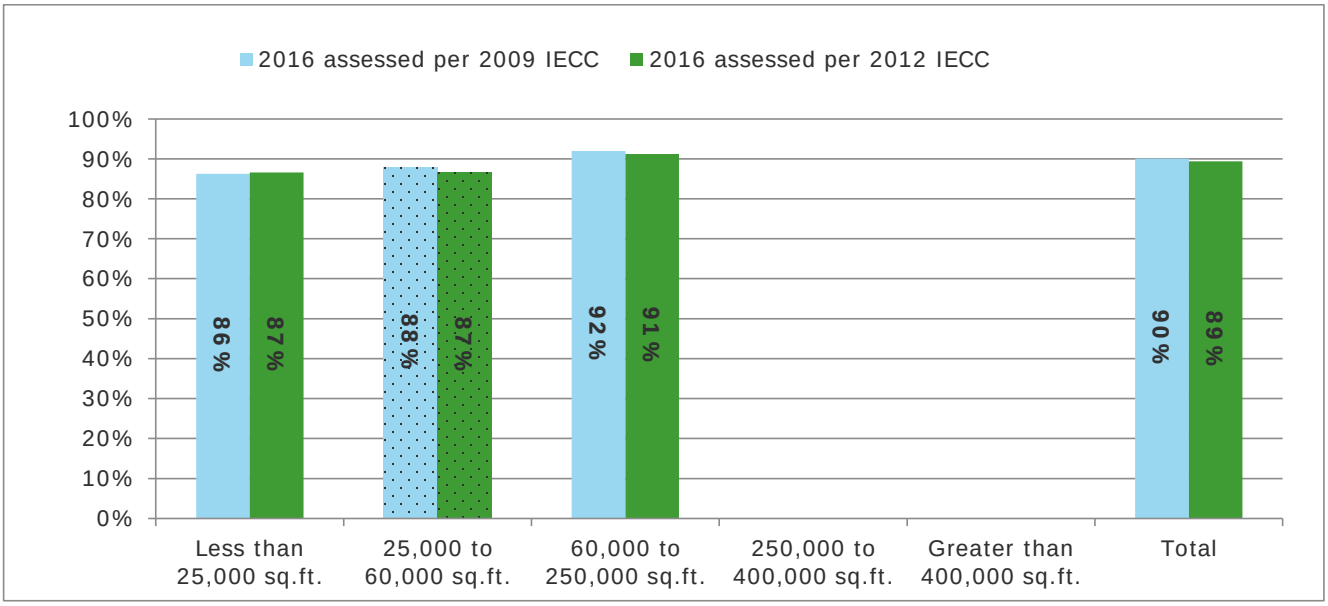
*Bars with dotted backgrounds indicate the compliance rates are statistically different from each other at the 10% level of significance.

The 90% confidence interval for overall energy code compliance rates from the 2016 projects assessed per IECC 2009 vs. 2016 projects assessed per 2012 IECC (DOE/PNNL method) are provided in Table 10.

Table 10. Overall energy code compliance rates, 2016 projects assessed per IECC 2009 vs. 2016 projects assessed per 2012 IECC (DOE/PNNL method)

Strata	2016 assessed per 2009 IECC					2016 assessed per 2012 IECC				
	n	Compliance Rate	90% Confidence			n	Compliance Rate	90% Confidence Interval		
			+/-	Lower Bound	Upper Bound			+/-	Lower Bound	Upper Bound
Less than 25,000 sq.ft.	15	78%	4.4%	73%	82%	15	83%	4.0%	79%	87%
25,000 to 60,000 sq.ft.	3	89%	14.4%	75%	104%	3	79%	14.8%	65%	94%
60,000 to 250,000 sq.ft.	3	92%	3.3%	89%	95%	3	88%	4.2%	84%	92%
250,000 to 400,000 sq.ft.	-	NA	NA	NA	NA	-	NA	NA	NA	NA
Greater than 400,000 sq.ft.	-	NA	NA	NA	NA	-	NA	NA	NA	NA
Total	**21**	**85%**	**3.4%**	**82%**	**89%**	**21**	**85%**	**3.8%**	**82%**	**89%**

Figure 10. Overall energy code compliance rates, 2016 projects assessed per IECC 2009 vs. 2016 projects assessed per 2012 IECC (DNV GL team method)*



*Bars with dotted backgrounds indicate the compliance rates are statistically different from each other at the 10% level of significance.

The 90% confidence interval for overall energy code compliance rates from the 2016 projects assessed per IECC 2009 vs. 2016 projects assessed per 2012 IECC (DNV GL team method) are provided in Table 11.

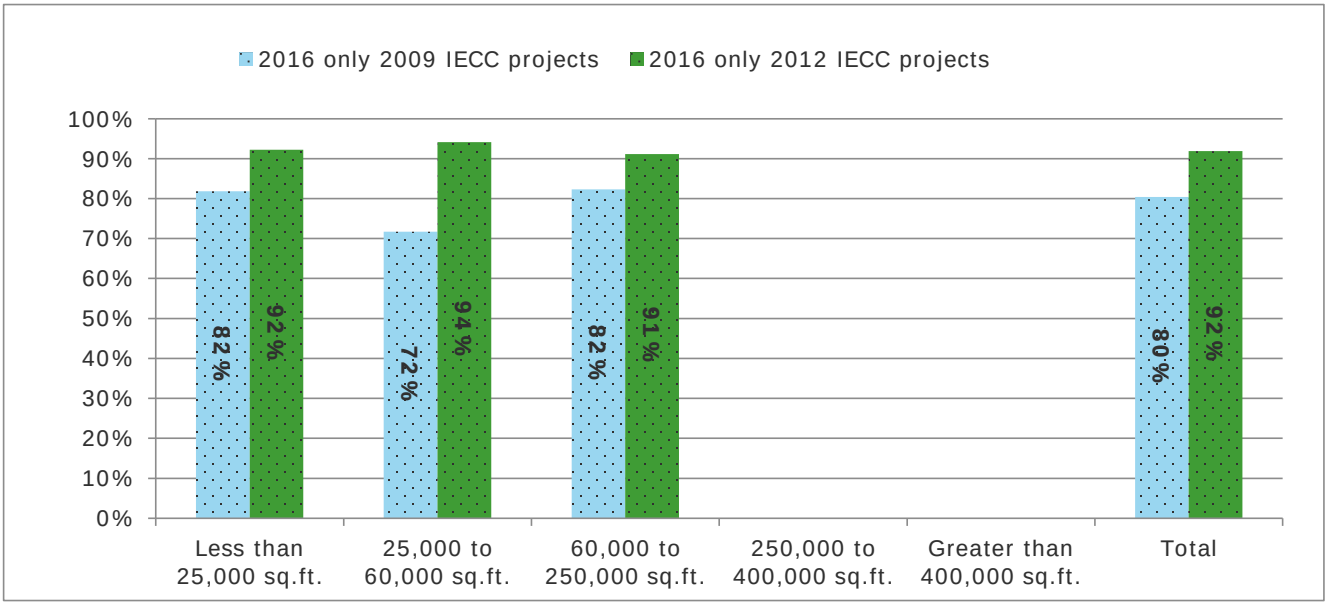
Table 11. Overall energy code compliance rates, 2016 projects assessed per IECC 2009 vs. 2016 projects assessed per 2012 IECC (DNV GL team method)

Strata	2016 assessed per 2009 IECC					2016 assessed per 2012 IECC				
	n	Compliance Rate	90% Confidence			n	Compliance Rate	90% Confidence Interval		
			+/-	Lower Bound	Upper Bound			+/-	Lower Bound	Upper Bound
Less than 25,000 sq.ft.	15	86%	4.4%	82%	91%	15	87%	4.2%	82%	91%
25,000 to 60,000 sq.ft.	3	88%	11.5%	76%	99%	3	87%	12.6%	74%	99%
60,000 to 250,000 sq.ft.	3	92%	4.3%	88%	96%	3	91%	5.6%	86%	97%
250,000 to 400,000 sq.ft.	-	NA	NA	NA	NA	-	NA	NA	NA	NA
Greater than 400,000 sq.ft.	-	NA	NA	NA	NA	-	NA	NA	NA	NA
Total	**21**	**90%**	**3.5%**	**87%**	**93%**	**21**	**89%**	**4.2%**	**85%**	**94%**

4.2.3 2016 projects built under 2009 IECC vs. 2016 projects built under 2012 IECC

We also investigated whether there were differences in compliance rates based on which code the buildings were built to conform to. **There are significant differences (10% level of significance) in code compliance rates for buildings built under IECC 2009 verses IECC 2012.** This finding applies to all building sizes and the total statewide compliance rate using both the DOE/PNNL method and the DNV GL team method. **The statewide compliance rate for buildings built to IECC 2009 was 81% compared to 92% for IECC 2012 buildings (DOE/PNNL method, Figure 11). Using the DNV GL team method, the statewide compliance rate for buildings built to IECC 2012 was 96% (Figure 12).** This indicates that the newer buildings were built to a higher energy efficiency standard, achieving higher rates of compliance despite being assessed against a more stringent version of the code.

Figure 11. Overall energy code compliance rates, 2016 projects built under IECC 2009 vs. 2016 projects built under 2012 IECC (DOE/PNNL method)*



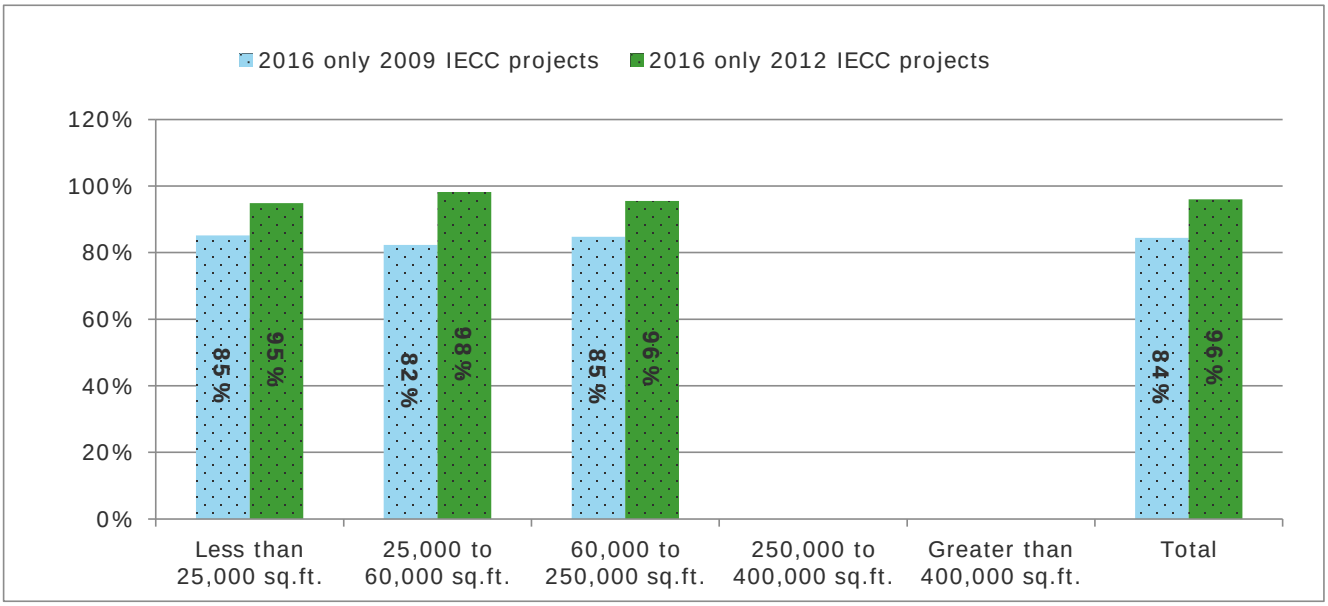
*Bars with dotted backgrounds indicate the compliance rates are statistically different from each other at the 10% level of significance.

The 90% confidence interval for overall energy code compliance rates from the 2016 projects built under IECC 2009 vs. 2016 projects built under 2012 IECC (DOE/PNNL method) are provided in Table 12.

Table 12. Overall energy code compliance rates, 2016 projects built under IECC 2009 vs. 2016 projects built under 2012 IECC (DOE/PNNL method)

Strata	2016 only 2009 IECC projects					2016 only 2012 IECC projects				
	n	Compliance Rate	90% Confidence			n	Compliance Rate	90% Confidence Interval		
			+/-	Lower Bound	Upper Bound			+/-	Lower Bound	Upper Bound
Less than 25,000 sq.ft.	13	82%	4.5%	77%	86%	2	92%	4.3%	88%	97%
25,000 to 60,000 sq.ft.	2	72%	17.0%	55%	89%	1	94%	<0.1%	94%	94%
60,000 to 250,000 sq.ft.	2	82%	0.7%	82%	83%	1	91%	<0.1%	91%	91%
250,000 to 400,000 sq.ft.	-	NA	NA	NA	NA	-	NA	NA	NA	NA
Greater than 400,000 sq.ft.	-	NA	NA	NA	NA	-	NA	NA	NA	NA
Total	**17**	**80%**	**3.1%**	**77%**	**84%**	**4**	**92%**	**0.4%**	**91%**	**92%**

Figure 12. Overall energy code compliance rates, 2016 projects built under IECC 2009 vs. 2016 projects built under 2012 IECC (DNV GL team method)*



*Bars with dotted backgrounds indicate the compliance rates are statistically difference from each other at the 10% level of significance.

The 90% confidence interval for overall energy code compliance rates from the 2016 projects built under IECC 2009 vs. 2016 projects built under 2012 IECC (DNV GL team method) are provided in Table 13.

Table 13. Overall energy code compliance rates, 2016 projects built under IECC 2009 vs. 2016 projects built under 2012 IECC (DNV GL team method)

Strata	2016 only 2009 IECC projects					2016 only 2012 IECC projects				
	n	Compliance Rate	90% Confidence +/-	90% Confidence Lower	90% Confidence Upper	n	Compliance Rate	90% Confidence Interval +/-	90% Confidence Interval Lower	90% Confidence Interval Upper
Less than 25,000 sq.ft.	13	85%	4.7%	80%	90%	2	95%	6.1%	89%	101%
25,000 to 60,000 sq.ft.	2	82%	14.0%	68%	96%	1	98%	<0.1%	98%	98%
60,000 to 250,000 sq.ft.	2	85%	2.8%	82%	88%	1	96%	<0.1%	96%	96%
250,000 to 400,000 sq.ft.	-	NA	NA	NA	NA	-	NA	NA	NA	NA
Greater than 400,000 sq.ft.	-	NA	NA	NA	NA	-	NA	NA	NA	NA
Total	**17**	**84%**	**3.1%**	**81%**	**88%**	**4**	**96%**	**0.6%**	**95%**	**97%**

To further investigate the higher levels of energy code compliance for the buildings built under the 2012 IECC compared to those built under 2009 IECC and those built under 2012 IECC we reviewed the interview findings for market actors associated with the four 2012 IECC projects. The DNV GL team completed interviews with at least one market actor associated with each building and two for the owners. Both design team and owners indicated a familiarity with National Grid's new construction and major renovations energy efficiency programs; however they indicated less familiarity with National Grid's CCEI.

Three of the four design team respondents have had direct experience with the new construction and major renovation efficiency programs. Specific engagements stated by the respondents include:

- "They did an analysis on the project, I think what happened, they reviewed we made a couple tweaks (foam roof insulation, glazing updates)."
- "We had numerous questions about specific compliance requirements – all were answered by National Grid program consultants."
- "Energy rebates and information"

Two of the four design team respondents indicated being somewhat or slightly familiar with National Grid's CCEI, while the remaining two state they were not at all familiar. Additionally, three of the four design team members were not aware that the initiative offered training or technical support.

Both owners were familiar with National Grid's new construction energy efficiency programs and had contact with the program and one owner expressed familiarity with the CCEI.

5 BUILDING OFFICIAL AND MARKET ACTOR INTERVIEW FINDINGS

This section provides the findings of the in-depth interviews conducted with Rhode Island building code officials and market actors. These interviews build on the success of the work conducted in 2012 by revisiting the interviews with code officials to update our understanding of compliance practices, while at the same time developing an understanding of the effectiveness of the CCEI and its influence on changes in compliance.

5.1 Building official interview findings

This section provides the findings of the in-depth interviews conducted with Rhode Island building code officials. These interviews build on the success of the work conducted in 2012 by revisiting the interviews with code officials to update our understanding of compliance practices, while at the same time developing an understanding of the effectiveness of the CCEI and its influence on changes in compliance. The information presented below includes the DNV GL team's findings based on 28 interviews with building officials conducted from July to September 2016. Further, this report includes the following analysis:

1. An exploration of any differences between the populations of existing code officials versus those who are new code officials since the 2012 Rhode Island study.
2. An exploration of differences between code officials based on the size of their jurisdictions. The jurisdictions represent a range of city and town population sizes, which the DNV GL team classified according to the following categories: Large (more than 40,000 residents); Medium (10,000–40,000 residents) and Small (less than 10,000 residents).

During the interview process, information was collected on the backgrounds and years of experience of the head building official and his or her inspectors. Table 14 presents a summary of the Rhode Island building code officials interviewed to date.

Based on our findings, building code officials interviewed have an average of 20 years of experience as a code official and 26 years of experience in the building trade. In addition, the average size of a jurisdiction's staff is 4 FTE.

Table 14. Summary of Rhode Island building code official interviews

Size of jurisdiction	Number of interviews		Years of experience		Average size of staff
	Census	Completed	Average	Range	
Large (>40,000 residents)	6	3	17	10-30	8
Medium (10,000 to 40,000 residents)	23	15	20	11-31	5
Small (<10,000 residents)	10	10	21	2-41	2
Total	**39**	**28**	**20**	**2-41**	**4**

The DNV GL team's interview findings provide background on the commercial new construction market in Rhode Island including information on code compliance practices, perspectives on designers and contractors who work on commercial construction, code training needs, and code enforcement challenges. The findings offer context for the energy code compliance ratings found in 4 of this report, and they give the DNV GL team an informed basis for its recommendations presented in 0. Building official interview responses are organized according to overarching themes, which include the following:

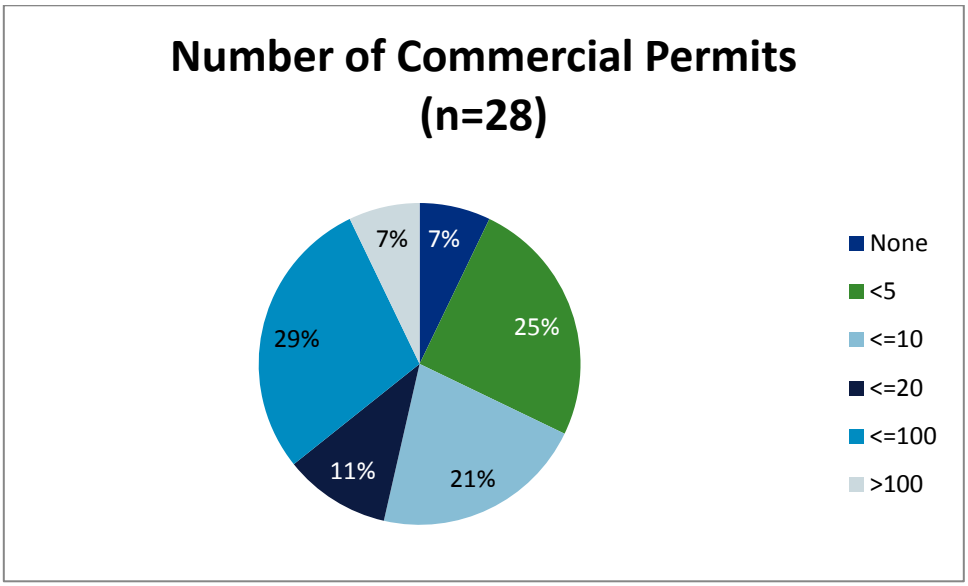
1. **Energy code general compliance practices –** This section summarizes the basic methods that building officials use to determine commercial code compliance, including documentation they require as well as the resources they use, and code officials' background and experience.
2. **Energy code enforcement barriers –** This section focuses on the practice of enforcing the energy code and the challenges building officials face. Officials report a variety of barriers, primarily contractors' knowledge and education and insufficient information submitted to verify code compliance.
3. **Energy code knowledge and training –** This section examines building officials' knowledge levels and current understanding of the commercial energy code, their assessment of market actors' knowledge and training as well as knowledge gaps and identified training needs. The rapid pace of change in regulations makes it difficult for builders to come up to speed on new codes, and as a result, building officials feel they must educate these builders. Additional training opportunities exist on the Green Buildings Act, as more than half the building officials request more training.
4. **Energy code technical challenges and opportunities –** This section summarizes the ongoing technical challenges that building officials face when trying to enforce energy code compliance as well as opportunities. Building officials suggestions on how to improve commercial energy code compliance cluster around three major categories: education, code revisions, staff assistance.
5. **Effectiveness of CCEI –** This section explores the effectiveness of the CCEI and code officials' opinions about the CCEI's effect on code compliance.

5.1.1 Energy code general compliance practices

This section presents the DNV GL team's key findings related to commercial energy code compliance practices.

Rhode Island has experienced a low level of commercial activity and development in the past year. Of the jurisdictions interviewed, the range of commercial building permits issued within the last year is 0-400. Fifteen of the 28 jurisdictions issued fewer than 20 commercial permits over the last year. Figure 13 displays the number of commercial construction permits issued within one year of the study. The figure is meant to show the range in construction activity that we encountered in the study.

Figure 13. Commercial building permits* issued, prior year



* Number of permits issued indicates total for new construction, retrofits and renovations

Most often, code officials rely on professional certification as a means of documenting code compliance during plan review. The most frequently mentioned documentation required by building officials is professional certification. Some building officials also report leveraging the COMcheck documentation and Form 128 Certification. Some building officials require only one or the other, and some require both. Table 15 displays the breakdown of compliance documentation typically requested by the 28 building officials interviewed thus far.

Table 15. Compliance documentation requested by officials using approach

Compliance documentation typically requested for commercial new construction	Number of officials using approach (out of 28 building officials interviewed)
Professional certification	8
Professional certification & Form 128 Certification	10
Professional certification & COMcheck documentation	4
Professional certification, COMcheck, & Form 128	5
No standard approach*	1

*Some building officials do not have standard documentation approaches for new commercial construction because commercial projects are rare in their jurisdictions.

Building size, complexity and thoroughness of documentation are primary drivers of the time needed to review code compliance plans. Similarly, size, complexity and quality of construction are primary drivers of the time needed to review compliance in the field. Building officials report the time needed for plan review of commercial projects depends on three major factors: building size, building complexity, and the thoroughness of plans and specifications. Reportedly, code officials spend an average of 30 minutes to 3 hours on plan review per project. One respondent noted that the time needed depends on

"whether or not it is a new building…retrofits are the toughest; [the code official] has to figure out what is and is not feasible." Another official noted that it depends "on the completeness of the drawings, the detail of the specification, and the knowledge of the designer." He went on to note the need for more continuing education of professionals to ensure that the building is fully compliant with energy code.

To verify commercial energy code during field inspections, respondents reported devoting an average of 49 minutes (low range) to 5.1 hours (high range) to commercial projects. Similar to the plan review process, time allotted for field inspections for commercial energy code depends on the project size and/or complexity of systems. Other factors mentioned include the stage and quality of construction.

Code officials rely primarily on codebooks and the Building Commissioner's office to answer questions regarding the energy code. Building code officials use two primary resources to answer questions on energy code issues: the state building code and codebooks and contact with the Rhode Island Building Commissioner's office. Some officials use the Internet to research code issues, including websites such as www.energycode.gov and www.energy.gov, and others reach out to industry peers for information. Most officials use at least two or more sources.

Structural integrity and life safety often take precedence over energy code enforcement. Sixteen of 28 respondents report that there are provisions in the building code that take precedence over the energy code. The most frequently mentioned are structural integrity, life safety, and means of egress. This line of questioning was meant to gauge the perceived importance of the energy code compared to other code provisions. Five mentioned that they do not pick and choose, but enforce all codes equally.

During plan reviews for commercial buildings, the majority of building inspectors perform what one referred to as a "ministerial" review, giving a review to a range of systems/building measures. They largely rely on professional certification for review of code compliance, with a handful of jurisdictions noting a specific requirement for an engineer or design professional stamp.

Training of code officials is essential to comprehensively enforce building code. Among the 28 code officials answering, 21 referenced building official training or certification as one of the types of educational or professional backgrounds needed to comprehensively enforce the energy code. Fifteen mentioned experience in the trades, while only 6 mentioned education beyond high school.

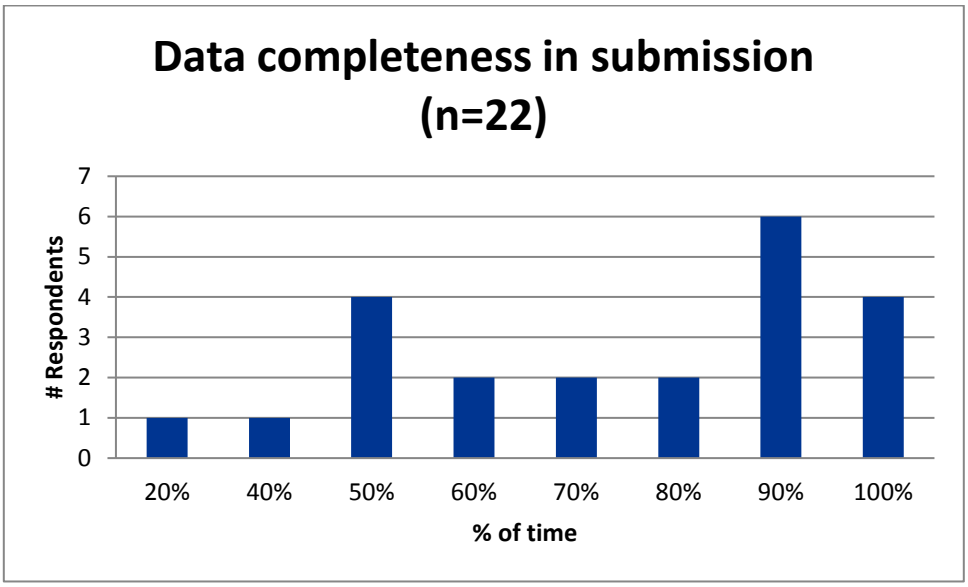
5.1.2 Energy code implementation barriers

This section presents key interview findings related to barriers to energy code implementation.

Limited time and/or staff is the single most common impediment to code enforcement. While 16 of 28 officials interviewed cited no limitations to their ability to enforce the energy code, 12 acknowledged impediments to code enforcement, with nearly all of these citing lack of time/available staff. One official who is new to commercial code enforcement claimed that training was a barrier, and cited a need for more training to better understand "what's being proposed and what's established."

Few building officials receive plans, specifications, and calculations in enough detail to verify commercial energy code compliance. The majority of respondents have to request further clarification and information from design teams or builders. Figure 14 presents the percentage of the time that the information submitted is adequate to determine energy code compliance.

Figure 14. Percentage of the time that information is adequate for code compliance determination



There is no "typical" missing energy compliance information, as this varies from project to project. In terms of compliance problems encountered during plan review, 11 out of 28 officials reported that they encountered non-compliance. The items cited for non-compliance primarily related to insulation (shell and components) and air sealing (shell and ducts).

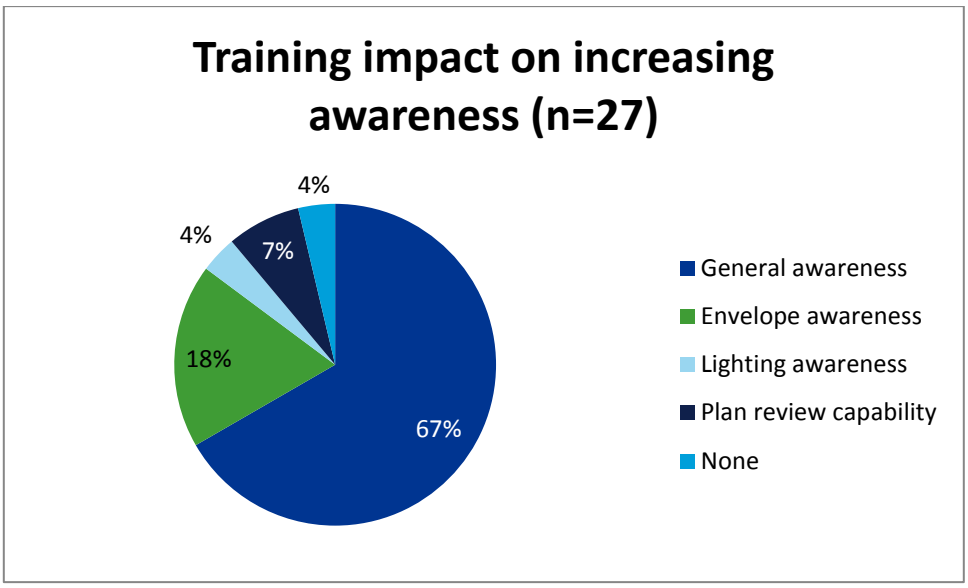
5.1.3 Commercial energy code knowledge and training

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

Building officials indicated that design professionals are much more familiar with commercial energy code than contractors are. All of the building officials felt that design professionals had some familiarity with commercial energy code. Six of the officials qualified their response by saying that professionals with lower-end projects and smaller firms are less familiar, but for the most part these professionals are aware. In relation to contractors, there was a much larger split of opinion between the building officials. Sixteen felt that contractors had some familiarity, but 7 stated that contractors are perplexed by what they need to do for code compliance, and that some do not want to even learn about it.

All building officials interviewed indicate that they and/or their staff members have attended trainings on Rhode Island's commercial energy code. Twenty-four of the 27 respondents said that the training was with National Grid as well as the Rhode Island Builders association. The trainings covered topics related to air sealing, insulation, mechanical, lighting, and general code. Figure 15 illustrates the areas of increased awareness from these trainings.

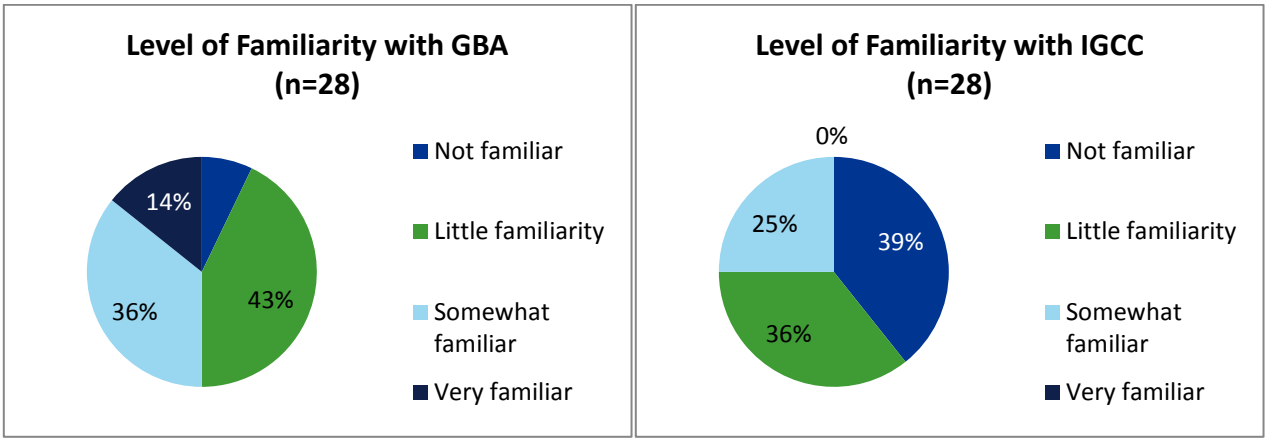
Figure 15. Areas of increased awareness from trainings



Over half the building officials interviewed felt that the training has been sufficient to understand and enforce all sections of the energy code. However, several officials stated that the size of the code and changing market makes this difficult. One official stated that there are so many codes that it is difficult to hit every single aspect. Another noted that there is not enough time in the day to fully understand it, and that it is difficult to find the time to go to the training.

23 out of 28 building officials reported that they have not had sufficient training to enforce the Green Buildings Act (GBA). Twenty-two building officials are "a little" or "somewhat" familiar with the GBA (12 and 10 respondents, respectively) but almost all said they need more training to enforce the GBA; in large part, this is due to a lack of projects requiring it. The level of familiarity with the International Green Construction Code (IGCC) is much lower. No officials stated they were "very familiar" with it, and only 25% (7 out of 28 respondents) mentioned that they were "somewhat familiar" with it. This could be due to the fact that only one respondent identified an IGCC project in his or her jurisdictions. These findings are shown in Figure 16.

Figure 16. Levels of familiarity with GBA and IGCC



When asked about their preferences for receiving training in the classroom, through demonstrations in the field, or via webinar/online training, the strongest preference is for classroom teaching. About 40% of respondents also prefer in-the-field demonstrations. Building officials are least open to an online webinar, with two respondents expressing interest in online training. One official described a benefit of classroom training as a force to be focused. Another official mentioned being prone to falling asleep during webinars.

If training on the 2015 IECC were available and offered, all respondents would attend this training. The most typical comment was that training is required. One respondent mentioned that going to these trainings reinforces what people know, while also making them encounter ideas they had not thought about before. They pick up more detail each time they attend.

5.1.4 Energy code technical challenges and opportunities

This section presents key findings related to energy code technical challenges and opportunities, including respondents' views on improving energy code.

When asked if there were particular provisions of the energy code for which compliance was difficult to determine, 10 of 28 said there were not, 7 referenced the challenge of HVAC calculations, and another 7 referenced specific systems including electrical, duct work, and building envelope. Table 16 shows paraphrased feedback from building officials regarding the provisions of the code that are difficult to assess.

Table 16. Energy code provisions that are difficult to assess

Building envelope
• It is confusing as to where to apply what part of the code
HVAC and lighting
• Duct: Duct insulation is difficult to assess, since it is not always properly labeled. • Electrical: This requires many calculations, and is very time consuming. • HVAC: It is difficult to calculate BTUs in boilers, sizing equipment. • HVAC: High-end mechanicals, geothermal and other high-tech are complex and require familiarity. We rely on mechanical engineers who are certified to assess these complex systems. • HVAC: There are not well-organized documents to follow. If officials are doing enough code enforcement they can figure it out, but specifications of systems are a problem.

Building officials' suggestions for improving commercial energy code compliance echo one main theme: additional training for contractors. Table 17 displays the summarized quotes gathered by the DNV GL team.

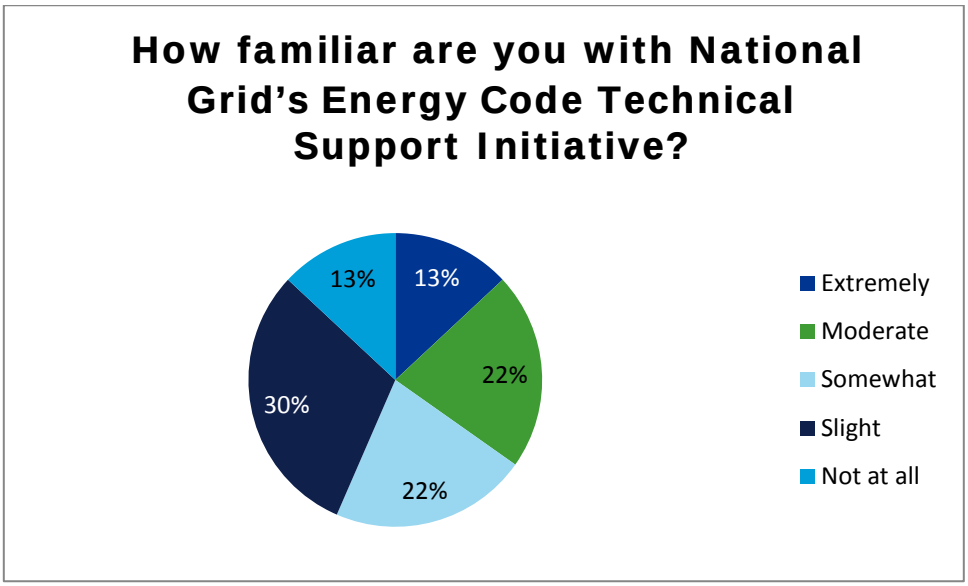
Table 17. Building officials' suggestions for improving energy code compliance

Education
• Several officials stated that contractors do not have enough knowledge to do the job right. There is a need to educate contractors. • One building official felt that there should be mandatory education for contractors, teaching them how to do it right. "80% of contractors don't know anything. Need to prove knowledge of codes. State doesn't send them addendums and amendments, no hotline for them. Target these contractors." • Education is the key, getting people to understand there is a reason for these codes. They provide more comfort and less operating expense. Once everyone (architects, engineer, contractors, officials) gets on board with that concept, then it is easier to enforce code. • There needs to be training for the contractors. Generally the building officials have to train them, and it is not always a friendly form of training because they have to be critical of the work the contractors have done. • There should be minimum educational or training requirements for the installers.
Staff assistance
• One code official mentioned the need for additional staff to help with enforcement.

5.1.5 Effectiveness of Code Compliance Enhancement Initiative

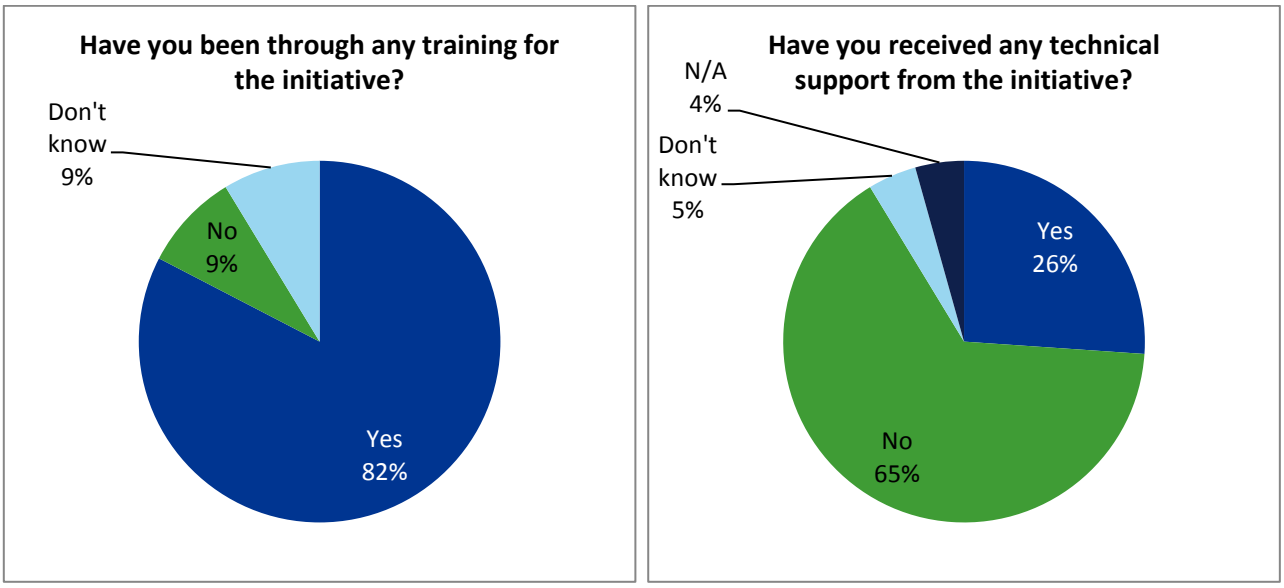
About 79% of the building officials interviewed said they were at least slightly familiar with National Grid's CCEI, with close to one third reporting they were either moderately or extremely familiar with the initiative. Conversely, 21% stated that they had no familiarity at all with the initiative. These findings are shown in Figure 17.

Figure 17. Familiarity with National Grid's Code Compliance Enhancement Initiative



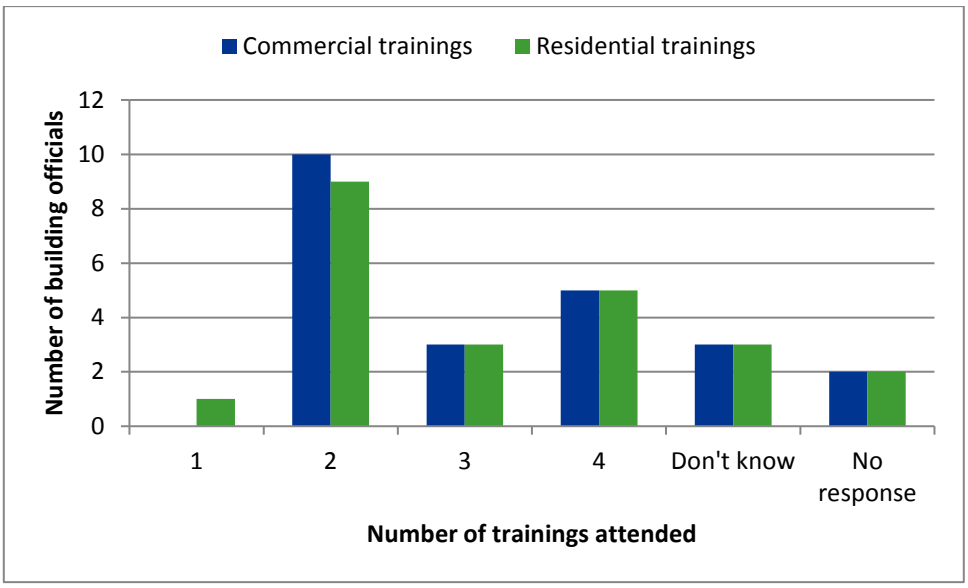
Since November 2013, the CCEI has offered 44 trainings on commercial energy code compliance: 37 in-person trainings and 7 webinars on specific code compliance topics including daylighting, and HVAC and building envelope. Over 85% of the building officials interviewed said that they had been through training for the initiative. The discrepancy between this number and the number of code officials reporting familiarity with the National Grid CCEI is likely driven by a name recognition issue. Some respondents may be aware of the training, but may not realize that it is run by National Grid, and may therefore have responded that they were not familiar with the training program despite having actually attended it. However, 61% of the building officials said they have not received any technical support from the initiative. These findings are shown in Figure 18.

Figure 18. Levels of training and support



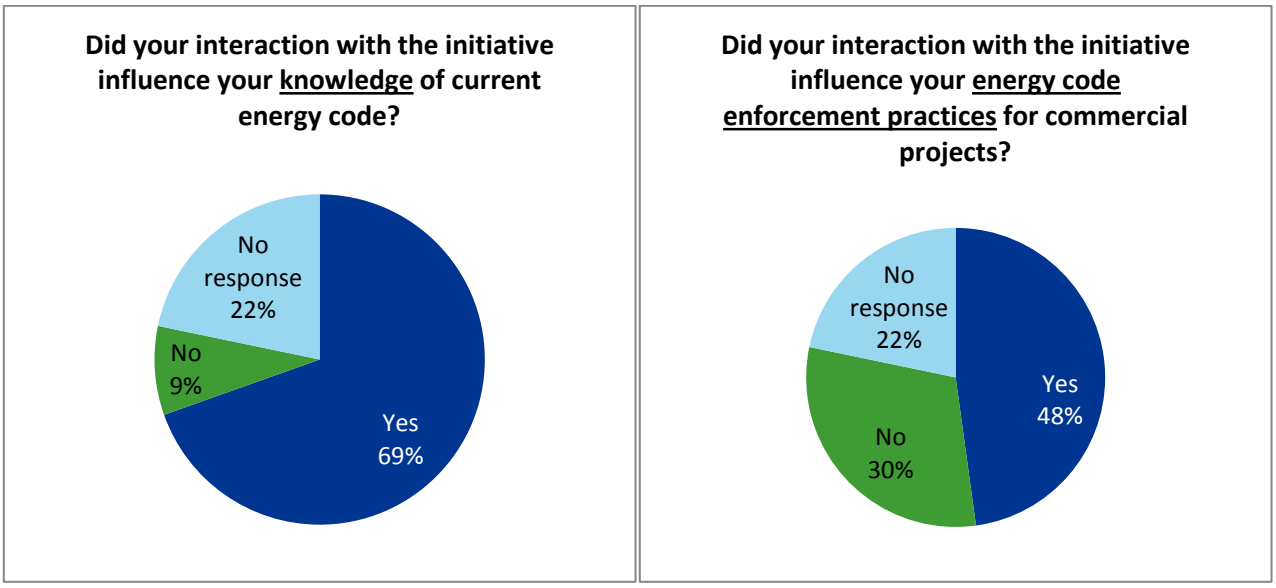
The majority of those interviewed had been to at least two commercial and residential trainings, as shown in Figure 19.

Figure 19. Number of trainings attended



Overall, nearly 70% of the building officials interviewed stated that the initiative influenced their knowledge of current energy code. At the same time, about 50% stated that the initiative influenced enforcement practices. These findings are shown in Figure 20.

Figure 20. Initiative influencing knowledge and practices



Code officials that were influenced by the initiative identified several areas where they had changed their enforcement practices. Several mentioned that they had become more diligent during the inspections, changing their inspection techniques to be more thorough. Others mentioned that the initiative gave them

pointers on where to look in certain buildings to check for compliance, and that the initiative helped them increase their knowledge of common mistakes when it came to enforcement practices.

The DNV GL team reviewed the CCEI training materials to better understand the specific topics covered, and found that the trainings emphasized the importance of complying with the energy code and provided practical tools and information that an inspector can use when assessing a building's compliance with code.

Table 18 summarizes comments from building officials about how to improve the CCEI.

Table 18. Building officials' suggestions for improving the CCEI

Code Compliance Enhancement Initiative
• The initiative has been fine, but the hope is that training will quickly show the building officials the changes, modifications, and new elements in the updated code. • There should be more residential training. The majority of towns are not doing much commercial, so there is a need and want for more residential training. • Continue the initiative so that as code changes, officials can stay on top of the updates for both review and inspection purposes. There was disconnection surrounding code changes over the last 10 years, and not a lot of training initially. National Grid initiatives have helped officials get up to speed. They do not want to fall behind and try to play catch-up again. • The general public needs to understand why the updated code is important, since they are the people who are paying for it at the end of the day.

5.1.6 Comparison to the 2012 study

The comparison to the 2012 study has two components:

1. A comparison between code officials who were active during the 2012 study timeframe and code officials who were active during the 2016 study timeframe
2. A comparison between the results of the code official interviews conducted during the 2012 study and the results of those conducted during the 2016 study

Of those code officials interviewed for the 2016 study, there was only one official who was not serving as an active code official or assistant in 2012, and this particular official has over 35 years of experience in the trades. Therefore, there is no useful comparison to be made between those who were working as code officials during the 2012 study period and those who became code officials after the launch of the National Grid CCEI.

What is potentially useful is a comparison between answers to questions that were asked on both the 2012 survey and the 2016 survey. In order to complete this analysis, the DNV GL team compared the 2012 responses to the 2016 responses on 25 questions asked during both survey efforts. While there are several instances where the responses differ, it should be noted that this comparison is qualitative in nature; no inference of significant differences should be made.

The bulk of responses did not change from 2012 to 2016; however, two items arise for the National Grid team to consider:

- **Reliance on professional certification appears to have increased.** Compared to 2012, all of the building officials who reported a standard approach for commercial projects require professional

certification—most frequently both stamped plans and Form 128. This underscores the need to ensure that both the design and construction community and the code enforcement community are aware of and knowledgeable about the prevailing energy code.

- **The average experience of code officials has increased.** In 2012, the code officials interviewed reported average experience of 9.4 years, while in 2016 the average experience was 11.5 years. While not unexpected, it does potentially indicate that there are few new code officials entering the profession. The requirements for building official certification are onerous and if there truly is a lack of new talent entering the profession, this could eventually lead to fewer code officials being available to enforce code requirements.

5.1.7 Differences based on jurisdiction size

This section presents the results of our analysis of any qualitative differences between respondents based on the size of their jurisdictions. The jurisdictions represent a range of city and town population sizes, which the DNV GL team classified in the following categories: large (more than 40,000 residents); medium (10,000–40,000 residents) and small (less than 10,000 residents). The analysis of this issue shows little to no difference in responses based on the size of the jurisdiction represented. However, as with the comparison to 2012, it should be noted that this comparison is qualitative in nature and no inference about significant differences should be made. The results of this analysis were all subject to the limitation of a very small sample size in the "large" category. Observed differences noted below between this category and the other two may in some cases be an artifact of the acquired sample.

Nonetheless, we discovered some differences that might be worth factoring into the design of future National Grid initiatives:

- There appears to be a reasonable and predictable correlation between the size of the jurisdiction and the number of commercial permits issued annually. There is also a correlation between these two factors and the amount of time and attention reported as given to energy issues in project review (see Figure 21**Error! Reference source not found.** below).
- A plausible explanation for this correlation is that the greater exposure to and experience with C&I projects leads to increased knowledge and less reliance on professional assertions of compliance. The higher level of staffing at larger jurisdictions may allow those staff to give more attention to specific projects.
- Increased attention on the part of jurisdiction staff may also lead to increased rate of finding items during plan review that are not compliant with energy code requirements (see Figure 22**Error! Reference source not found.**). This is consistent with the ministerial review approach described by many officials in the medium and small jurisdiction categories.

Figure 21. Correlation of size vs. time

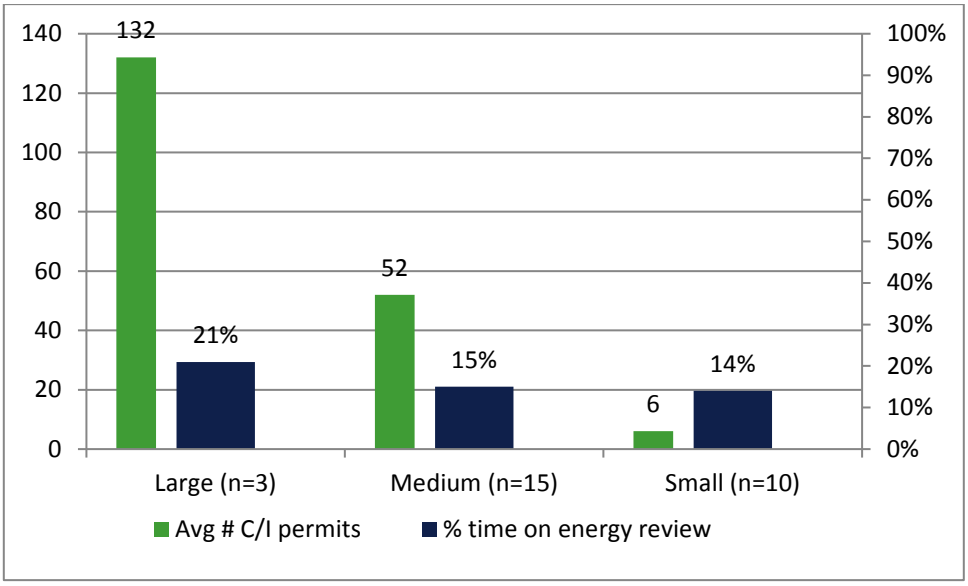
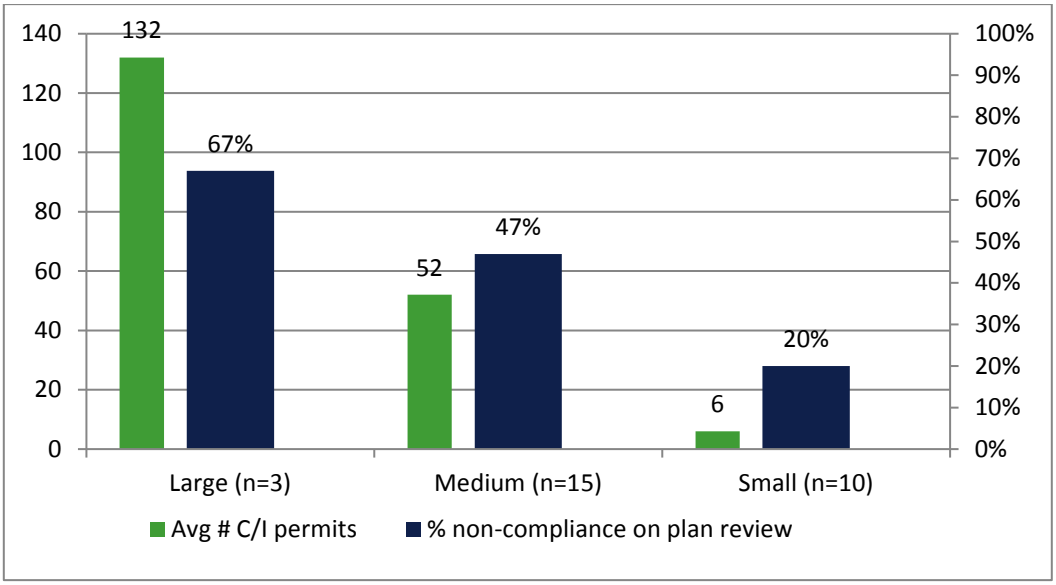


Figure 22: Correlation of size vs. non-compliance findings



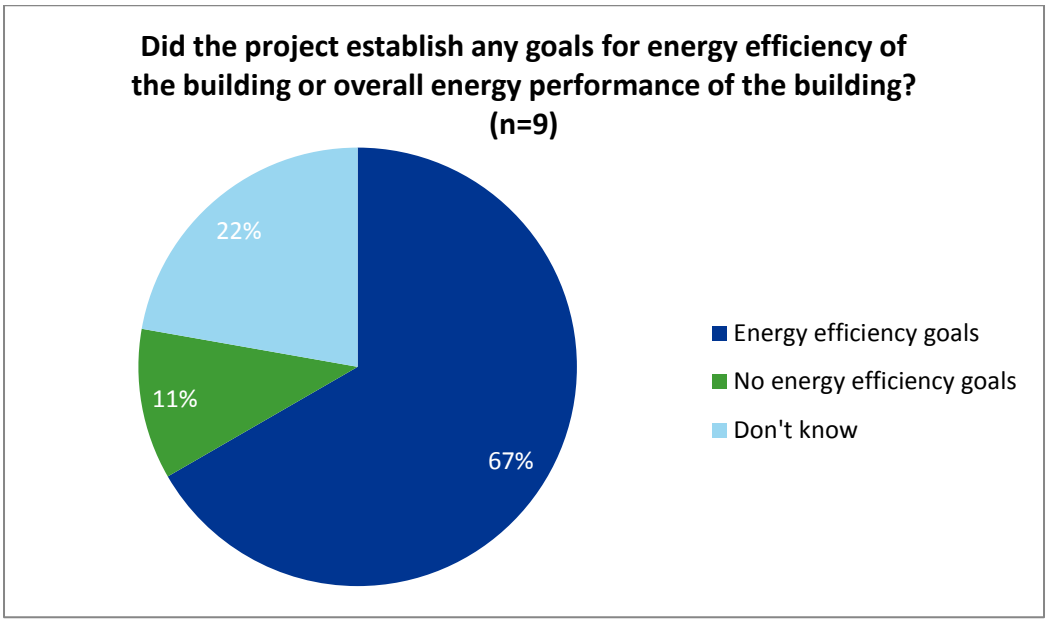
Taken together, these two findings support a targeted outreach effort on commercial and industrial energy code directed at the smaller jurisdictions, if reinforced by additional investigation. One such approach might include a pilot program incorporating onsite inspection support, a field training approach, for these jurisdictions.

5.2 Building owner interview findings

This section provides DNV GL's findings of the in-depth interviews conducted with Rhode Island building owners in this study's onsite sample. We used these interviews in our analysis to understand how building owners interact with code officials and the CCEI. Our findings are based on 9 interviews with building owners conducted from August to September 2016.

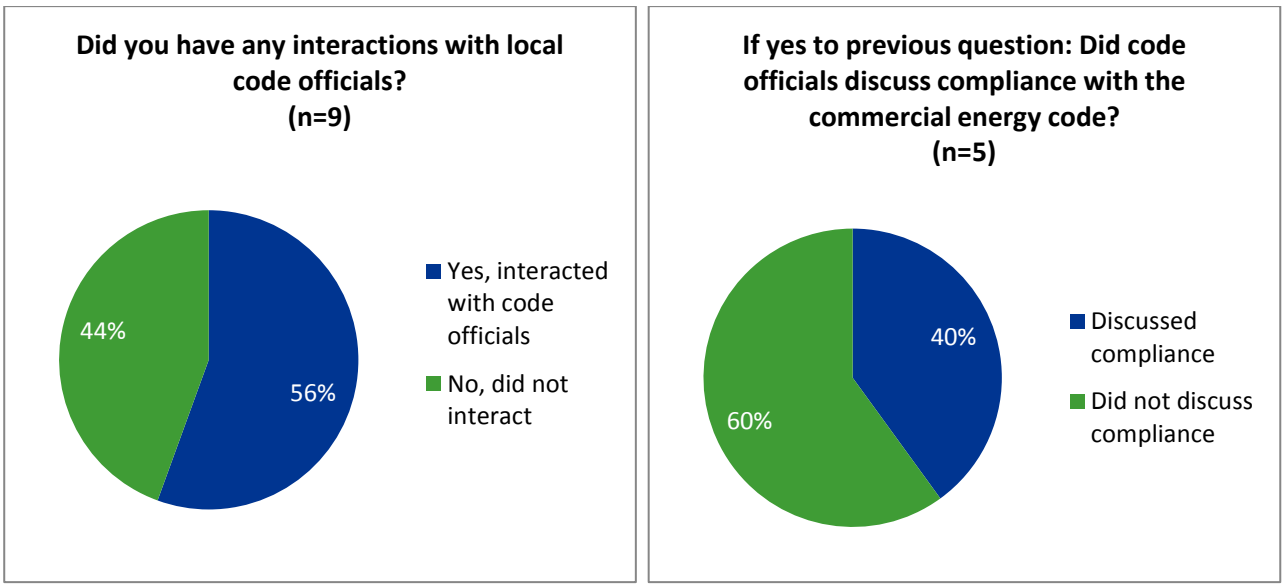
Six of the 9 building owners (67%) had building energy efficiency performance goals. Several of them set targets to be 30% or more efficient than code required. Figure 23 shows the breakout of the owners with energy efficiency goals.

Figure 23. Building performance goals



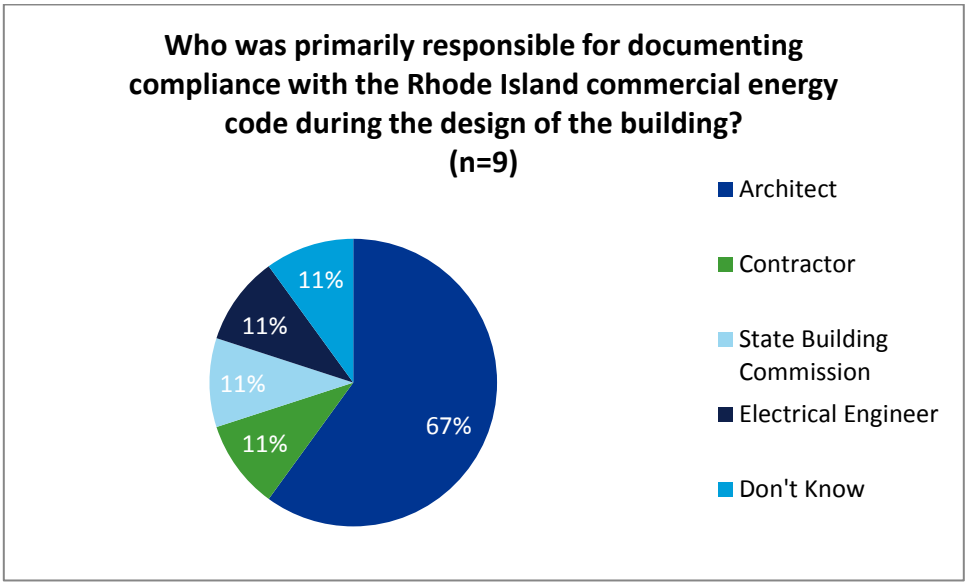
Five out of 9 owners (56%) had discussions with a code compliance official, and of those 5, only 2 (40%) recalled discussing compliance with the commercial energy code. Figure 24 illustrates this breakout.

Figure 24. Interaction and discussion with code officials



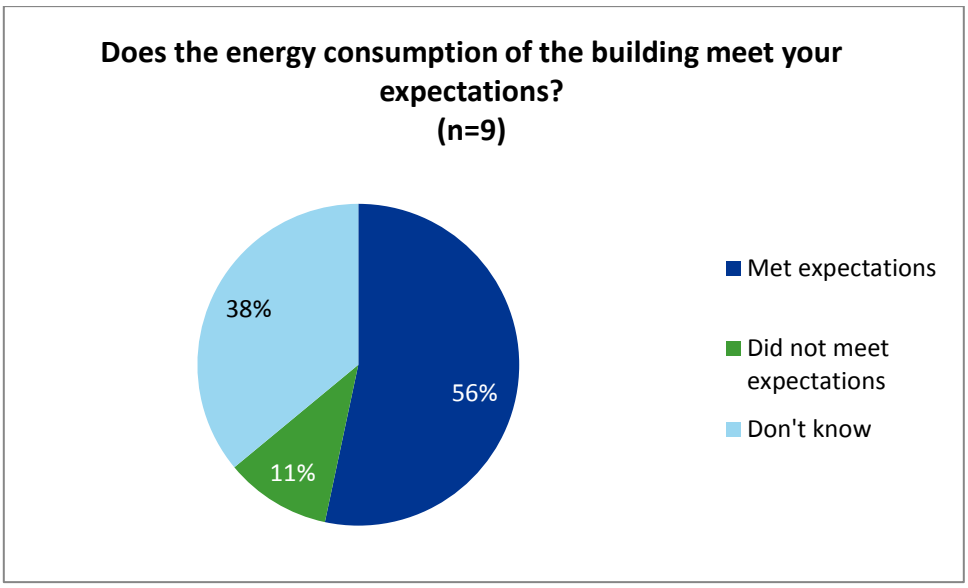
As Figure 25 shows, 6 of 9 owners (67%) indicated that architects are primarily responsible for documenting compliance with the Rhode Island commercial energy code during the design of the building.

Figure 25. Party responsible for code compliance



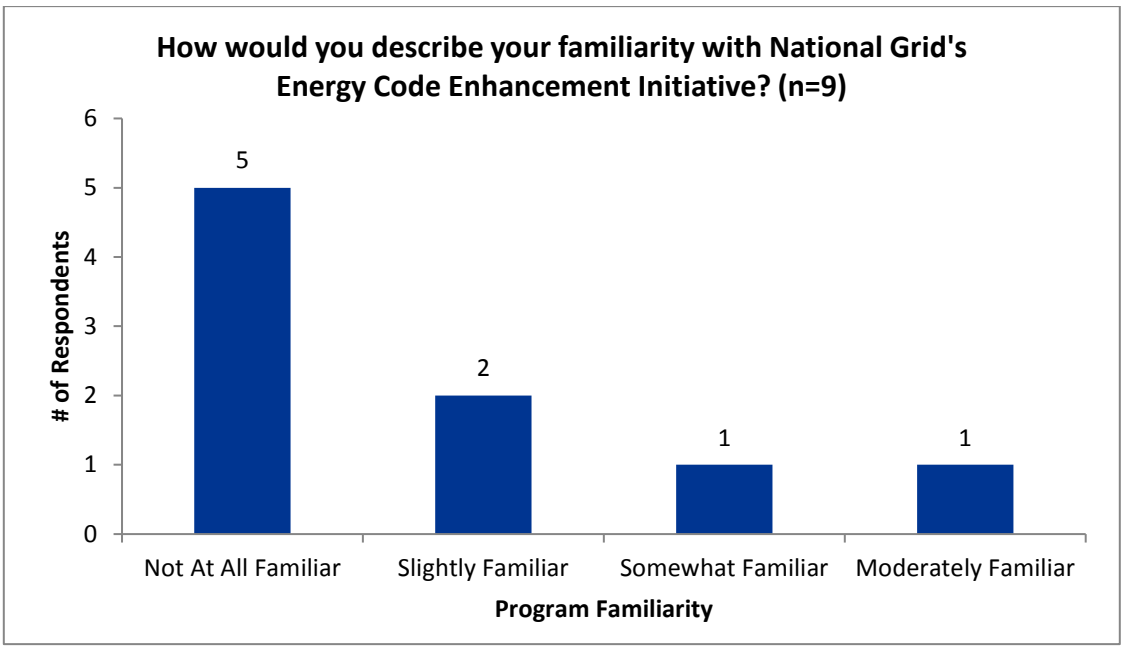
The building owners surveyed were satisfied with their building's performance. Seven of 9 owners responded for an average score of 8 out of 10 on a satisfaction scale. As Figure 26 shows, 5 of 9 (56%) owners stated that their building's energy consumption met their expectations.

Figure 26. Building energy consumption expectations



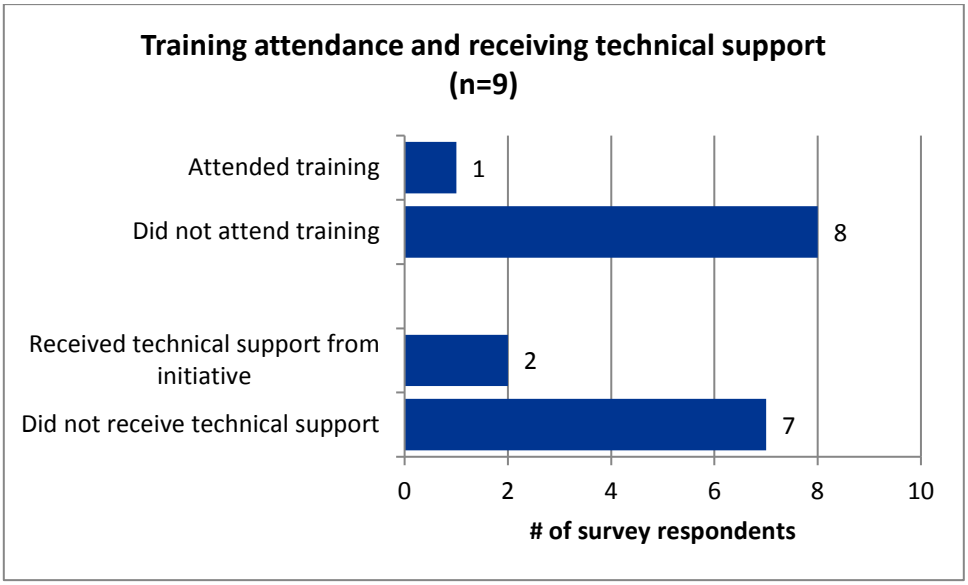
Four of 9 owners (44%) surveyed said they were in some way familiar with the National Grid CCEI. This was in contrast to 7 of 9 owners (78%) that indicated that they were familiar with the Rhode Island new construction energy efficiency programs, which is rebate-based. Figure 27 shows the breakout of owner familiarity with the CCEI.

Figure 27. Familiarity with National Grid's CCEI



As Table 19 shows, 8 of the 9 owners answered that they had not been through any CCEI training. Only 2 of 9 respondents indicated that they had received technical support through the initiative.

Table 19. Initiative training attendance and receiving technical support



Seven of the 8 owners did not attend the training because they were unaware that it was being offered. When we asked what would have attracted them to the training, respondents answered that they wanted to gain more knowledge about building operation efficiency, and learn more about HVAC system operations.

The owners who did not receive technical support responded that they were unaware of the technical support being offered.

5.3 Design team interview findings

In addition to building owners, we conducted in-depth interviews with Rhode Island design team (DT) members that were also part of DNV GL's onsite sample. We used these interviews in our analysis to understand how design team members interacted with code officials and the CCEI. Our findings are based on 12 interviews with DT members conducted from August to September 2016. The targets for DT member interviews are listed in Table 20, along with our completed interviews in each category.

Table 20. Design team target and completed survey sample

Design team category	Target completes	Completed interviews
Architect	5	9
Contractor	5	1
Engineer	5	2
Construction	5	0
Total	20	12

Six of 12 (50%) DT members interviewed submitted their project under the 2012 IECC, while 5 (42%) DT members said that the 2012 IECC was the code they followed. Figure 28 shows the breakout of the different building codes utilized.

Figure 28. Previous building code used

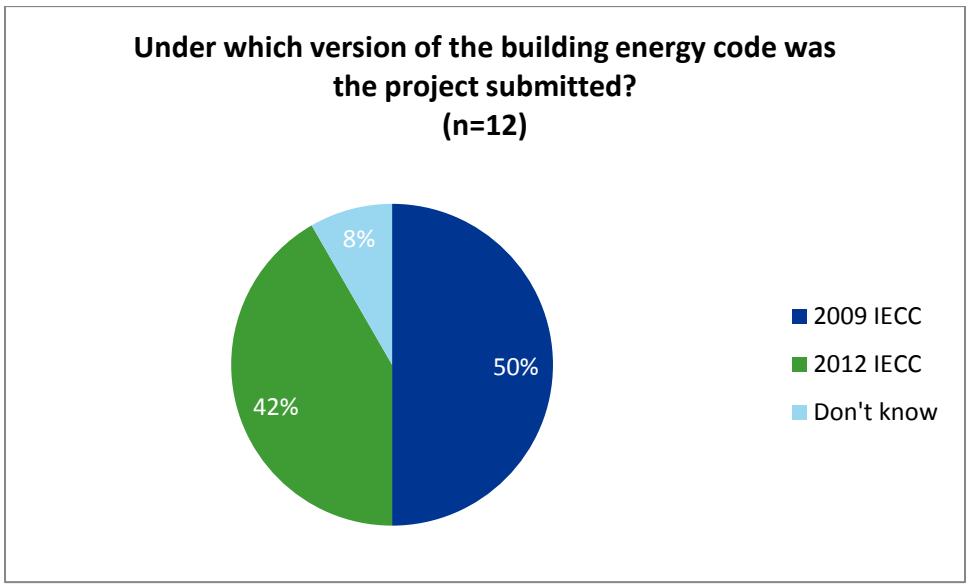
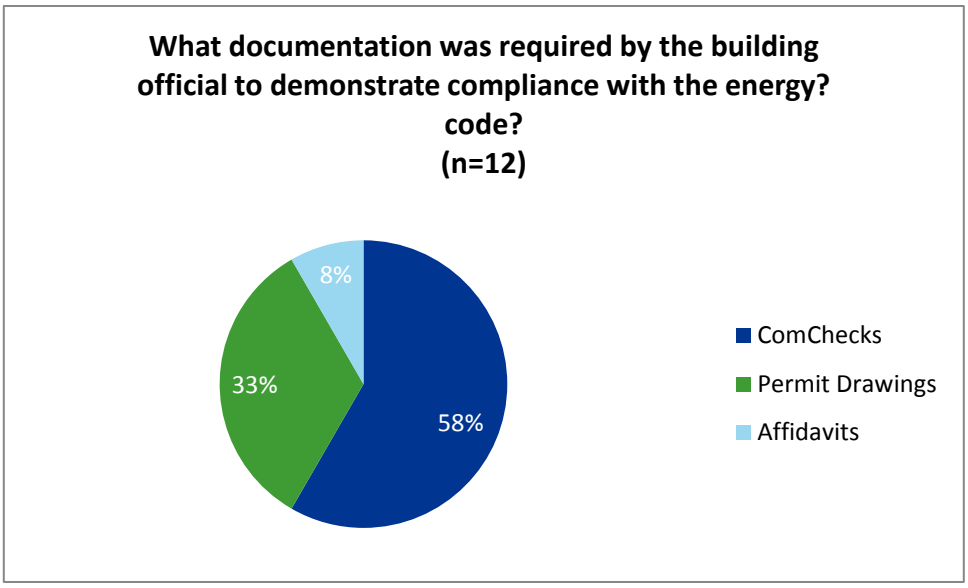


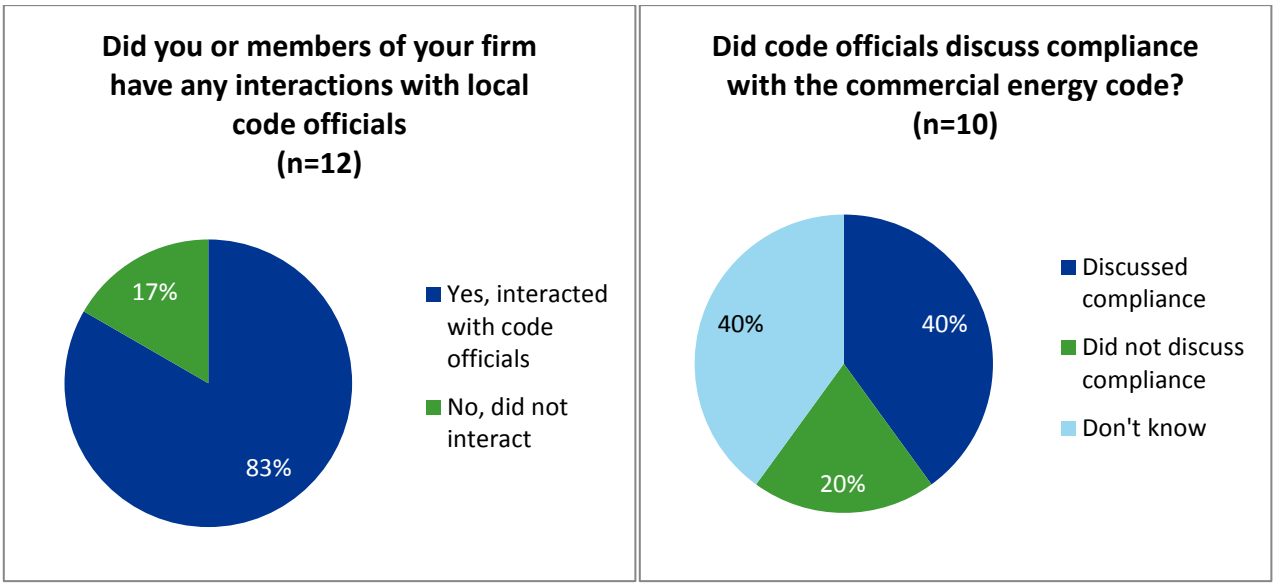
Figure 29 shows that 7 of 12 DT members interviewed mentioned ComCheck as the documentation required by the building official to demonstrate compliance with the energy code. The second most popular response was permit drawings.

Figure 29. Documentation for code compliance



83% (10 of 12) DT members interviewed said they had interactions with the local code official. However, as seen in Figure 30, of these 10 DT members, only 4 (40%) indicated that the code official discussed commercial energy code compliance with them. This is the same percentage as the owners who also had interaction with code officials.

Figure 30. Interaction and discussion with code officials



The interview results in Figure 31 indicate that 7 of 12 DT members interviewed (58%) had experience working with the RI new construction energy efficiency incentive programs. Six of those 7 contacted the staff of the program to receive technical assistance and program staff feedback.

Figure 31. Experience with new construction energy efficiency incentive programs

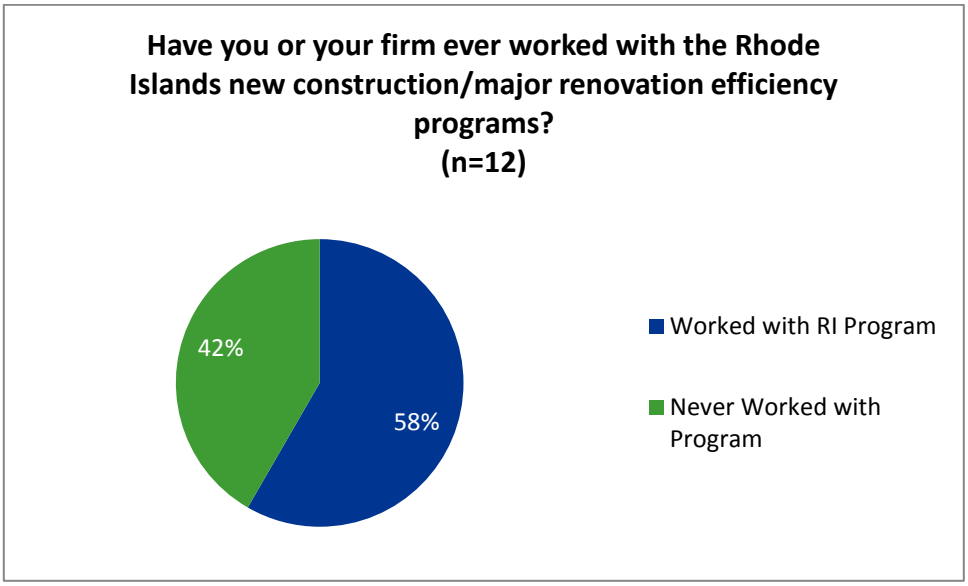


Figure 32 shows that 6 of 11 DT members interviewed (55%) indicated that more training is needed to help demonstrate compliance with the energy code. Some DT members suggested training on how the code is changing on a measure level, and comparing the previous code to changes in the new code. Others indicated that training on an energy code compliance checklist would be useful, as would an overall increase in the number of seminars offered.

Figure 32. Training to help compliance with energy code

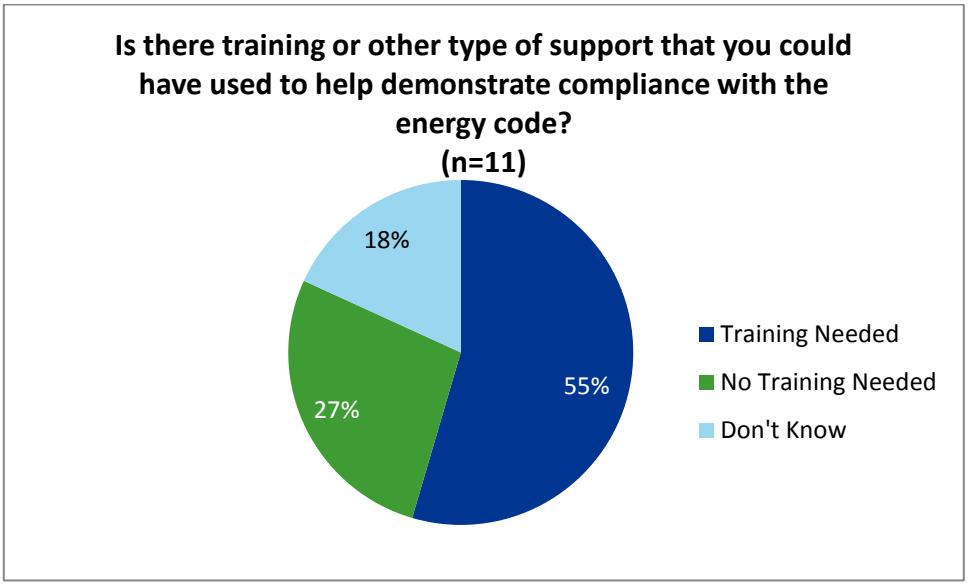


Figure 33 shows how DT members would prefer to receive additional training that was discussed in Figure 32. The most common answer was webinar/online, with classroom training coming as the second most favored choice.

Figure 33. Preferred method of trainings

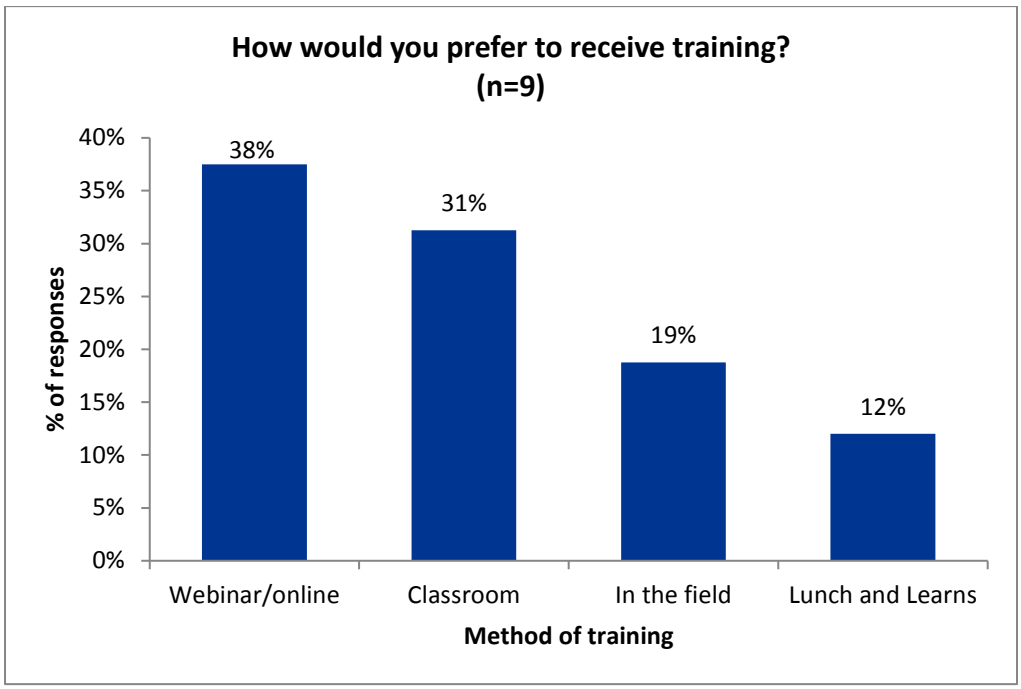


Figure 34 shows that 7 of 12 DT members (58%) indicated that they had some familiarity with National Grid's CCEI. This was similar to the 7 of 12 DT members (58%) that indicated that they were familiar with the new construction energy efficiency programs, which is rebate- based.

Figure 34. Design team familiarity with National Grid's CCEI

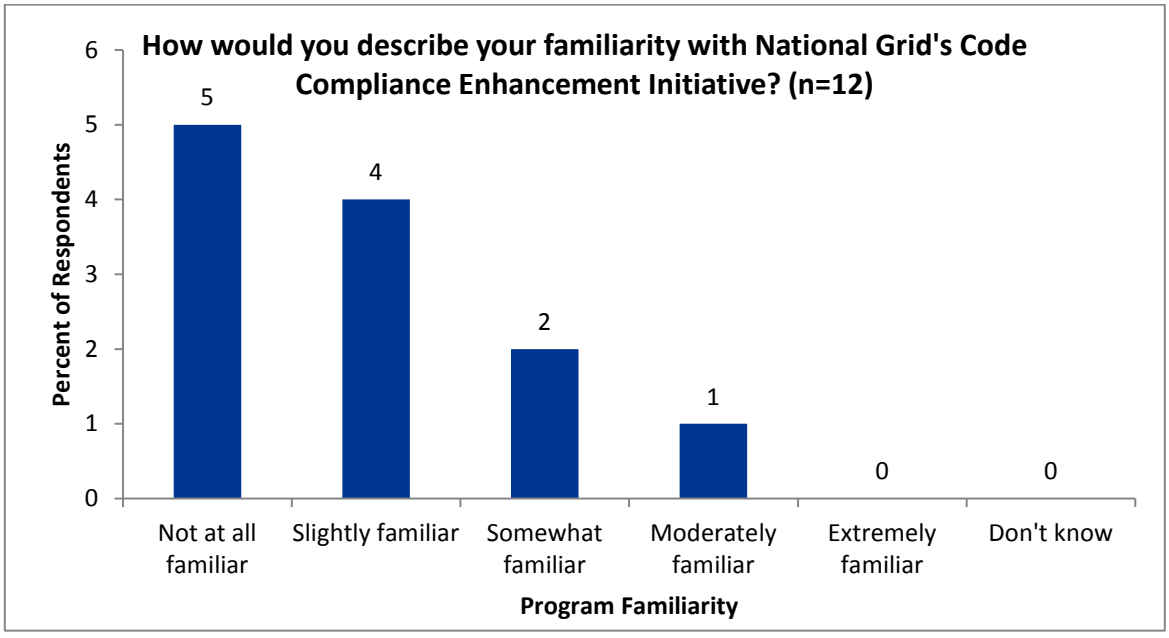
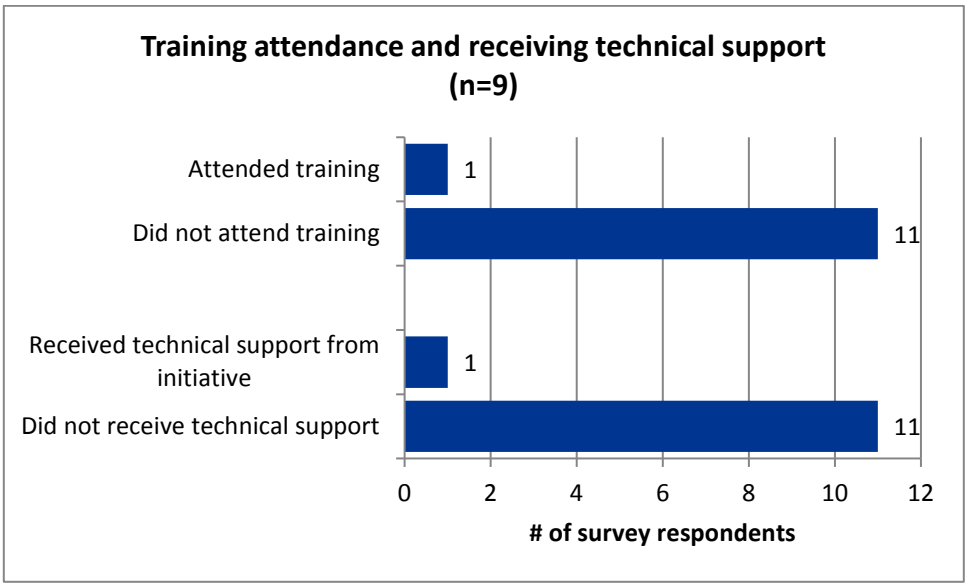


Table 21 shows that only 1 of 12 DT members interviewed (8%) indicated that they received training, while those that did not receive it were unaware the training was occurring. Similarly, 1 of 12 DT members (8%) received technical support, with 7 noting that they were unaware that technical support was being offered.

Table 21. CCEI training attendance and receiving technical support



A few DT members stated that they would have been attracted to the trainings if in-house trainings were available, or if DT members located far away could participate online.

DT members who were slightly or moderately familiar with the program stated that their interaction influenced their knowledge of the energy code. One respondent mentioned that it increased his knowledge mostly through new strategies and equipment. Another interview respondent mentioned that the advice from the program helped identify alternative ways to achieve energy code compliance.

Finally, several DT members provided overall feedback on the program. One DT member mentioned that budgetary restrictions limited the degree to which the design team can exceed code. Another DT member described the challenges associated with mold and dew point for historic buildings. He suggested that the CCEI needs to bring all the stakeholders together to discuss the issues of mold and dew point, hot and cold weather, building envelope, etc. He stated that it is a challenge to meet all the code requirements when there are conflicting objectives.

6 CONCLUSIONS AND RECOMMENDATIONS

This section integrates the findings from the site visits, code compliance estimation, and interviews to offer National Grid the DNV GL team's conclusions and recommendations.

6.1 Observations from site-level analysis

This section provides observations and conclusions based on the 2016 study and the 2012 baseline study, which are also informed by foundational code compliance work led by DNV GL team member ERS for the Massachusetts Program Administrators. As expected, several observations and conclusions have persisted across years and states. We provide general observations as well as observations concerning building envelope, lighting systems, and HVAC systems.

6.1.1 General observations

Some key observations include:

- In general, the compliance of newly constructed buildings is improving over time, even as the code gets more stringent. (This is a testament to the RI construction community—designing, building, training, enforcement, etc.).
- While we are confident that the compliance rate reported from our observation is accurate, it is equally important to note the self-selection bias of the building owners in this study. Building owners that are constructing high-performance buildings are more likely to agree to participate than owners and contractors who are knowingly not building to code or are relatively ignorant of energy code provisions. The DNV GL team made significant efforts to minimize this bias, but there is still likely to be some self-selection bias among the participants.
- In general, the 2009 IECC is 15% more energy efficient than the 2006 IECC code. The 2012 IECC code is 30% more efficient than 2006 IECC.[21]
- Most code compliance efforts occur during the design phase. Engineers add notes on their plans stating the current code and the goals of the basic design in terms of meeting or surpassing code. On multiple project plans, an early plan sheet shows a chart titled "Code Compliance," broken up by 3 columns labeled "Existing," "Proposed," and "Reference." Within this chart there is either a note saying "Base Code: RI State building code SBC-1, 2009 IBC International Building Code," or a row titled "Window" with the existing base code value and the proposed, recommended, or other for each applicable construction item. However, once you go deeper into the plans and look at the actual window specified, the u-value does not always meet code. It stands to reason that the engineer and/or architect used an older version of a cut sheet that has not been upgraded. Thus, although the first pages order code to be met, the inner details are not necessarily meeting code. It is unclear how contractors use this information or whether they are buying the same materials they used to. We surmise that the designers are aware of the codes and are encouraging the correct items to be installed, but are not always providing sufficient detail for specific items such as windows, insulation, and controls. By contrast, general contractors and code officials have less knowledge and understanding of the technical code details. Design-side compliance is particularly characteristic of larger facility projects, which typically include detailed design documents with equipment specifications.

[21] https://www.energycodes.gov/sites/default/files/documents/Comparison_2009to2012_IECC.pdf

- 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 Form 128 (“Project Certification”) as proof of energy code compliance.
- Although many code officials accept COMcheck as evidence of code compliance, this tool is inadequate for that purpose. COMcheck does not actually represent proof of compliance, but is simply a calculation tool that accepts user inputs of code provision details. Data entry in COMcheck must be checked against the plans and specs in order to verify compliance.
- On average, newly constructed commercial buildings meet 86% to 90% of the code requirements.
    - Here again, it is important to note the potential for self-selection bias of the building owners in this study. While the DNV GL team made significant efforts to minimize this bias, there is still likely to be some self-selection bias among the participants.
    - We found only one building that passed (100% compliance) using the DOE/PNNL method and two buildings that passed using the DNV GL team method. The other buildings failed code compliance. It is worth noting that five buildings were 90% to 99% compliant with the DOE/PNNL method. This means they were missing very few items (like an economizer but no energy recovery ventilator, which can result in larger than necessary usage, or no daylight controls in a single needed location, which can result in a negligible energy increase).
    - As expected, the DNV GL team method resulted in a higher compliance rate than the DOE/PNNL method, since the DNV GL team method awards partial credit for partial compliance while the DOE/PNNL method does not. This partial credit is most applicable to the building envelope.
    - Considering that efficiency programs often strive for 15-20% performance improvement compared to code, this represents a significant opportunity for improvement that can be, at least partially, addressed through programs and training.
- National Grid’s efforts over the past years have shifted the market in an energy efficient direction. It is undeniable that efforts at the utility level has driven the implementation of LEDs and raised the base efficiency of HVAC equipment. This study shows the next step is to push the architects and engineers to design more efficient overall systems, and to update their base plans and specifications to clearly state throughout the necessary levels of insulation values. Contractors need to be encouraged to raise the overall envelope quality of construction in a similar way they have increased the HVAC equipment and duct insulation over the past few years.
- Controls for the HVAC equipment need to be carefully, because many of the right components are installed but that does not mean they were commissioned correctly.
- Code officials should be taught basic building science, HVAC principals, and the use of controls systems, rather than being taught to memorize 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.
- A document similar to COMCheck that focuses on energy relating code items in a concise manner would greatly increase the code official’s ability to quickly find poor construction practices. One example of this document would be a simplified output of the energy model where applicable to show how and where the codes were used in the prescriptive path.

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 numbers and/or performance data in the construction documents. Nevertheless, as required, labeling on those installed products is generally left in place during the construction phase.
- Lighting fixture details in the specifications and plans 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 details like insulation thickness, controls, and valves to isolate and pass boilers are often missing from the plans. This type of information would increase the construction quality and help to ensure the code compliant equipment is purchased.

In addition to the code requirement for design documentation, a concurrent provision requires the labeling of many products. As stated, this information is typically clear and available for the main HVAC components, most insulation products, and fenestrations (temporary labels) enabling the code official to assess the efficiency levels of installed systems. One area for improvement in labeling is in duct insulation. In many cases we observed ducts insulated properly but the R-value was not labeled in a way it could be easily seen. This is more of a manufacturer labeling issue than a design or installation item.

6.1.2 Building envelope observations

- **Building type** – Smaller buildings often scored higher than larger buildings in the DOE/PNNL method due to insulation mostly in ceilings. We saw multiple smaller building constructed with sloped roofs that were designed and built with double layers of insulation and/or spray foam. The larger buildings are often built with flat roofs covered in a rubber membrane. The insulated board under the rubber membrane meets older versions of code, but not the newer versions used with the DOE/PNNL method.
- The other reason was in larger buildings they often installed windows that do not meet the U-Values.
- **Continuous air barriers** – Air barriers are very difficult to verify unless the construction project can be visited at the appropriate time. We found that a continuous air barrier was typically specified by directly stating the requirement on the plans. The field team observed the seals around windows, doors, and looked for signs of air barriers by looking above the ceiling and at the base of the walls to determine whether the installation was in accordance with the design documents. We recommend that thermal imaging cameras be used to inspect the leakage as the majority cannot be properly verified. A thermal camera can help to identify the areas that are often not insulated well (around doors and windows, and at wall joints).
- **Air sealing** – In nearly all cases, exposed penetrations of the envelope were observed to be 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. We recommend thermal imaging cameras be used to inspect the leakage, as the majority cannot be properly verified. A thermal camera can help to identify the areas that are often not insulated well (around doors and windows, and at wall joints).

- **Insulation** – The insulation levels specified in the design plans met code standards and were verified whenever possible. However, as with all envelope assemblies, field verification following construction completion is difficult. The team observed multiple sites with spray expandable foam insulation. DNV GL team observed that insulation values at the roof and ceiling levels are often much greater than code. Seeing R-Values of 50 or more was not uncommon. This was only for angled roofs though. Flat roofs, often rubber material, still commonly use some sort of foam board with R-Values of 8 to 10. We observed enough sites to conclude that in general most non-flat roofs meet or surpass code. Flat roofs are as well insulated in most cases but the air barrier is often much greater which will help insulation. Either way, flat roofs are too often not meeting or surpassing code. We looked for signs of insulation by lifting ceiling tiles and any small breaks in the walls like at junction or fuse boxes.
- **Windows** – The majority of the windows were very difficult to confirm their comparison to code. The team also observed that the fenestration specifications (e.g., U-values, SHGC, and air leakage rate) were often missing in the construction or as-built plans and it is difficult to verify these values on site without the manufacturer labels. Very rarely, the U-values were identified solely on a review of the construction documents.

6.1.3 Lighting system observations

In contrast with envelope provisions, which are difficult to evaluate post-construction, DNV GL team, was 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. We used whole building method in our calculations rather than space-by-space. The following observations relate to the site data collected regarding lighting measures:

- **Lighting compliance** – In most cases when a facility did not pass the DOE/PNNL method it was due to controls. The new codes have mandatory measures in some cases for daylight controls, outdoor isolated wiring, timers, bi-level and other controls. IECC 20012 has additional measures compared to IECC 2009.
- **Lighting power density** – Majority of the sites evaluated LPDs were substantially better than code requirements for both interior and exterior. This was expected with the increasing use of LEDs in the buildings. Lighting is rarely designed to reduce the number of lighting fixtures in the space. The design is using the same method of lighting area per fixture. If designs focused on methods to reduce the number of fixtures by optimizing daylight and design layout along with LEDs the lighting usage could be reduced by significantly compared to code baseline. On average (unweighted), we observed that the LPDs were approximately 28% better than code.
- **Bi-Level and automatic controls** – The requirement that many space types have bi-level manual and/or automatic controls installed is often complied with. We found bi-level and occupancy lighting controls to be installed in many sites.
- **Exterior lighting control** – For exterior lighting, the provision that a timer or photocell control be installed was nearly always met. We could not usually verify the wattage of the lamps but we always were able to check the fixture type, i.e., if they were LED, T5s or other styles.
- **Daylighting zone controls** – The separate control of daylight zones is a provision introduced with IECC 2009. It requires that daylight zones within commercial buildings be circuited and controlled separately from interior lighting. 50% of the sites that were required by code to have day lighting controls did not install these controls. Many of the designs that do meet code do not clearly state the methodology

behind the control equipment and sequences. For example, if daylight controls are required they may show on the plans that there should be a sensor but they do not always clearly show where it should be mounted. The effect can be seen in sensors not being installed or installed in ineffective areas.

6.1.4 HVAC system observation

HVAC measures and requirements addressed through the energy code were found to be in compliance in the majority of cases. Most of the equipment is packaged rooftop units where the EER is commonly met by major manufacturers. There were a few larger building with custom HVAC equipment where the full load capability was not met but the part load values were substantially better than code. Normally an energy model is needed to verify the compliancy compared to the baseline.

- **System rated efficiency levels** – The majority of the equipment installed on site and specified in the drawings met or exceeded code requirements. 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.
- **Equipment failed the DOE/PNNL method for a few different reasons.** IECC 2009 requirements stipulate individual fan systems with a design supply air capacity of 5000 cfm or greater and minimum outside air supply of 70 percent or greater of the supply air capacity must have an energy recovery system with at least 50 percent effectiveness. Some sites did not meet this requirement. Other sites did not have demand control ventilation as required. There were two sites where the full load HVAC efficiency did not meet code in EER and kW/ton. It should be noted that these particular sites were larger ft^2 sites, and the equipment had much better than 2009 IECC code requirements for part load values. Significantly, the DNG GL team method allows us to manually assess the compliance of HVAC equipment. With this, we could give credit to a few sites based on the part-load efficiency. Thus, these sites passed code using the DNV GL team method.
- To properly compare to IECC, an energy model would be required.
- **HVAC system insulation measures** – Basic measures such as duct insulation, sealing, and pipe insulation were observed to be in compliance less than equipment efficiency levels but still higher than expected. In some cases we observed duct insulation was installed but the R-value could not be confirmed. Similarly, pipe insulation could not always be verified but under most cases we did see there was some level of pipe insulation.

6.2 Code official conclusions

Driven by the diversity of Rhode Island's villages, towns and cities, **code officials continue to experience a wide range in the number of commercial permits issued each year.** As such, many code officials have limited experience with commercial code compliance while others permit hundreds of commercials projects each year, making the need for appropriate training at every level of experience imperative for the CCEI to be successful.

Inadequate staffing resources continue to have an effect on code officials' ability to properly enforce the energy code. This conclusion is drawn from building official comments that low staffing levels can impede their ability to enforce the commercial energy code. Often this is exacerbated by the level of completeness of the documentation provided. When documentation is inadequate or incomplete, more time is required to adequately assess the project for code compliance. Further, many code officials report that

when resources are limited, **personal safety and structural integrity take precedence over the energy code.**

Training is essential to code compliance and the CCEI is working. A majority of code officials report that training is essential to proper code enforcement. Further, over 85% of the building officials reported having participated in training sponsored by the National Grid CCEI with nearly 70% of building officials stating that the CCEI influenced their knowledge of the current code and half of officials reporting that the CCEI had an effect on their code enforcement practices.

Opportunities still exist for increased training of code officials and design and construction professionals. Our interviews with code officials once again reveal that design and construction professionals share the responsibility of code compliance with building officials. In fact, the most frequently reported means of documenting code compliance during code review is the professional certification of design and construction professionals. Further, code officials themselves reported a need and desire for training in both the Green Buildings Act and any future versions of the IECC. Finally, when asked to identify specific areas of the energy code which present challenges to compliance, code officials noted HVAC calculations and specific systems including duct work, electrical and the building envelope.

6.3 Market actor conclusions

6.3.1 Building owner conclusions

Our interviews indicated that 67% of owners had energy efficiency goals for their buildings. However, **this group did not have a lot of interaction with code officials**. Only 2 of 9 owners interviewed had a discussion with code officials about energy code compliance.

Owner satisfaction with building performance was high (average 8/10), and building performance met the expectations of a majority of owners interviewed. But 4 of 9 owners were not satisfied or did not know if their building was meeting performance expectations. One possible explanation is that these owners delegate code compliance responsibilities to their design team, specifically architects. This could also be why only 22% of building owners surveyed interacted with code officials about energy code.

Additionally, over half of the owners we surveyed were familiar with National Grid's CCEI. But 78% of these respondents have heard about the new construction energy efficiency rebate program. Therefore, surveyed owners had a higher awareness rate for programs where direct rebates were involved. Furthermore, almost all of the owners were unaware of the training and technical support offered through the CCEI. However, these owners would be interested in attending trainings to learn more about building operation efficiency, and HVAC system operations.

6.3.2 Design team conclusions

The design team members had higher instances of interaction with local code officials than building owners. Of the 12 DT members we interviewed, 10 had interaction with code officials. However, only four of these 10 actually discussed commercial energy code compliance.

Our interviews also indicated that seven of 12 DT members interviewed (58%) had experience working with the RI new construction energy efficiency incentive programs. Six of those 7 respondents contacted the staff of that program to receive technical assistance and program staff feedback in relation to these rebates.

Similarly, 7 of 12 DT members (58%) indicated that they had some familiarity with the National Grid's CCEI. However, **DT members had much less interaction with training and technical support with the CCEI compared to the other programs.** Only 1 of 12 DT members interviewed (8%) indicated that they received training, while those that did not receive it were unaware the training was occurring. Similarly, 1 of 12 DT members (8%) received technical support, with 7 noting that they were unaware that technical support was even being offered.

Finally, although very few DT members attended the CCEI training, **several felt that additional training was needed.** Six of 11 DT members interviewed (55%) indicated that more training would help demonstrate compliance with the energy code.

6.4 Recommendations

Through this report, the DNV GL team offers the following recommendations.

Consider using the DNV GL team method instead of the DOE/PNNL method when estimating code compliance, to more effectively reflect energy savings opportunities from increased compliance. The DNV GL method found statewide compliance to be a full 4 percentage points higher than that found using the DOE/PNNL methods. This is due to the DNV GL method's ability to recognize partial compliance and allow for trade-offs within the building envelope, as permitted by IECC.

Consider adjusting the baseline LPD assumptions to account for improved energy efficiencies of lighting measures. On average, LPD was approximately 28% better than code.

Increase focus on day lighting controls. Day lighting controls is one of the major provisions in the buildings that are not yet being properly implemented. About 50% of the sites did not comply with the code requirement of daylighting controls. There is a significant opportunity to promote these strategies to improve compliance.

Increase focus on Commissioning of HVAC and Lighting controls. Commissioning of HVAC and Lighting controls need to be properly commissioned per the design documentation. In many cases the HVAC systems design included the right control sequence of operations but they may not have always been installed correctly.

Focus on quality of insulation, continuous insulation is often designed lower than the code requirements especially in flat-roof buildings.

Maintain current CCEI training efforts. Code officials are aware of the need for training to maintain their understanding of current code practices and most recognize the value of a program like National Grid's CCEI. Removing the support of the CCEI would likely have an adverse effect on knowledge and awareness of proper code enforcement among code officials and subsequently diminish the energy code compliance levels in Rhode Island.

Expand CCEI training efforts to better reach design and construction professionals. These market actors play a significant role in code compliance by providing documentation and often certification of a buildings energy code compliance. By improving the knowledge and awareness of energy code compliance among this group of influencers is likely to have a positive effect on code compliance levels in Rhode Island.

Expand CCEI training efforts to better serve code officials. While this analysis finds that the current CCEI is effective, there remain opportunities for further education. In particular, National Grid should explore the opportunities for training on the particular aspects of energy code enforcement which are either difficult to enforce as reported by code officials themselves and/or aspects of energy code compliance which were found to be below overall compliance rates during the onsite analysis. This would particularly benefit those code compliance officials who have significant activity in the commercial sector in their jurisdictions and/or face complicated projects which require a high level of technical knowledge.

Market CCEI training to building owners around building performance. This includes how the CCEI can help an owner's design team make their building run more efficiently. The survey results indicated that building owners were interested in attending trainings to learn more about building operation efficiency, and HVAC system operations.

Encourage code officials to speak with owners specifically about energy code compliance. The low instances of code officials discussing energy code compliance with owners could be an indication of why building owners are not as engaged with the CCEI. The more the owners know about energy code compliance, the more likely they will seek out resources to help them comply.

Market the CCEI training and technical support to the design team members. It is clear from this survey that not a lot of design team members are aware of the CCEI training and technical support. Therefore, the CCEI should direct a marketing campaign at these market actors, selling the training as a way for these professionals to learn how the code is changing on a measure level, and comparing the previous code to changes in the new code.

Provide more webinar/online and classroom training options. Several design team members indicated that they need a lot of options to be able to find a training that fits their schedule and varying location. Recording online webinars is a way to reach a large audience, and have training available whenever the design team members are free.

Encourage design team members to discuss energy code compliance with building owners. The survey results indicated that building owners delegate energy code compliance to their design team. At the same time, owner budgetary restrictions limited the degree in which the design team can meet or exceed the energy code. Therefore, DT members should encourage the owners to stay involved in energy code compliance, and help identify trainings and technical support that will help the owner see the value in making their buildings as energy efficient as possible.

Set up stakeholder meetings for design team members and owners to voice their concerns. As mentioned earlier, one DT member described the challenges associated with mold and dew point for historic buildings. By holding regular stakeholder meetings, the CCEI can identify barriers that owners and design teams are facing when implementing the energy code, and CCEI training and technical support can be tailored to meet the concerns of these market actors.

APPENDIX A. SITE DATA COLLECTION TOOL

RI_Code_Study_Data
_Collection_Tool.pdf

APPENDIX B. LETTER OF INTRODUCTION FROM BUILDING COMMISSIONER'S OFFICE

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
Department of Administration
DIVISION OF CAPITAL PROJECTS AND PROPERTY MANAGEMENT
BUILDING CODE STANDARDS COMMITTEE
One Capitol Hill
Providence, RI 02908-5859
(401)-222-1129 FAX 222-2599

<<Date>>

<< Name of Building Official>>
<<Municipality of Building Official>>

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 in mind, the State of Rhode Island Office of the Building Commissioner and National Grid are asking local jurisdictions to participate in a statewide study to assess 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 Rhode Island. **The primary objective of the study is to estimate a statewide energy code compliance rate for commercial buildings for comparison to the compliance rate estimated in the baseline study completed in 2012.** The study will also provide feedback on patterns of compliance and non-compliance and identify opportunities for Rhode Island to help reach its statewide goal of a 90% compliance rate with the energy code. To achieve this, the study team will conduct on-site observations at randomly selected buildings and conduct a brief interview with the building officials involved in the design and construction of those 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 began in January 2016 and is continuing for six months. In total, we will visit a randomly generated sample of approximately 30 commercial building projects constructed in the last 3 years. National Grid has hired the firms, DNV GL 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/ compliance/evaluation.

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 was selected for a site visit, field research staff from DNV GL will contact you to set up a date and time to speak with you and conduct the 30 minute phone interview. At that time, the field researcher will 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 Interview. If scheduled for an interview, 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 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.

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 State of Rhode Island Office of the Building Commissioner and National Grid, we look forward to collaborating in the pursuit of energy savings and code compliance. If you have any questions or concerns, please don't hesitate to contact me, Muxi Yang of National Grid or Ryan Barry of DNV GL.

With kind regards,

John P. Leyden, CBO
State Building Code Commissioner

John P. Leyden, CBO
State Building Code Commissioner
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Office of the Building
Commissioner
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APPENDIX C. LETTER OF INTRODUCTION FROM NATIONAL GRID

nationalgrid

Dear Customer:

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 in mind, National Grid has contracted with independent consultant, DNV GL to contact a sample of customers to participate in a statewide study to assess construction practices in relation to building energy codes.

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 Rhode Island. The primary objective of the study is to estimate a statewide energy code compliance rate for commercial buildings for comparison to the compliance rate estimated in the baseline study completed in 2012. The study will also provide feedback on patterns of compliance and non-compliance and identify opportunities for Rhode Island to help reach its statewide goal of a 90% compliance rate with the energy code.

Your participation involves allowing the DNV GL field staff to perform a one-time on-site survey. The on-site data collection efforts will focus primarily on collecting information on the major building components, such as envelope/shell characteristics, lighting, heating and cooling systems. Information on refrigeration, compressed air and motor systems will also be collected for certain business types such as grocers, restaurants, or industrial facilities where these systems make up a significant portion of the load.

The study has been designed for minimum disruption to your staff and operations. DNV GL field staff will typically need about 4 to 8 hours depending on the size of your business to conduct an on-site visit and about 20 minutes of your staff time to address questions on building operations. All the information obtained is confidential and the information collected about your building during this study will only be used in the aggregate to inform and expand Rhode Island's future energy efficiency programs. The results will not be used to identify any specific compliant or non-compliant buildings that are found in the course of the study.

In appreciation of your time and participation in this important study we are offering a $200 incentive. If you wish to verify the survey, or have any questions or concerns, please feel free to contact me at 781-907-1458.

The following page provides more detailed information about the study.

Muxi Yang
nationalgrid
RI Energy Efficiency Policy & Evaluation
40 Sylvan Road
Waltham, MA 02451
781-907-1458
Muxi.Yang@nationalgrid.com

nationalgrid

What to Expect: Field staff from DNV GL will contact you to set up a convenient date and time to visit your facility. Please note that buildings included in this study have been selected at random and any data collected by the staff during the interview and on-site visit is confidential.

Depending on the size and complexity of your facility site visits may require two field engineers. DNV GL staff is experienced in assessing and investigating commercial buildings and systems, including roof-top installations.

During the On-site Visit: Prior to the arrival to your facility DNV GL staff will attempt to review available building plans from public sources such as local town engineering files. Should building plans not be available to staff prior to our visit to your facility we may ask to review them on-site if they are available.

Staff will conduct a standardized interview with your building's facility manager or another staff member knowledgeable about the energy management systems located within your facility.

DNV GL field staff will also be collecting information pertaining to the heating and cooling, energy management systems, on-site generation equipment, motors & drives, hot water systems, lighting and whole building shell characteristics.

DNV GL field staff will NOT interfere with the operation of any equipment or building systems in any way. No meters requiring direct contact will be used nor will access panels be opened. DNV GL will not engage in any activities that require protective equipment beyond that required for your employees, nor will then enter any spaces not entered by your employees during their regular course of business. The one exception is the roof in cases where there is ready access (e.g. by stairs or permanently mounted ladder) AND energy using equipment, such as packaged HVAC systems.

Thank you in advance for your time and participation.

APPENDIX D. IN-DEPTH INTERVIEW SURVEY INSTRUMENTS

D.1 Draft CCEI code official in-depth interview guide

Memo to:
Muxi Yang, National Grid

From: Wendy Todd, DNV GL
Date: 7/20/2016
Prep. by: Jason Symonds, DNV GL
Wendy Todd, DNV GL

GOAL OF INTERVIEWS

DNV GL will interview the market actors associated with each of the projects receiving site visits. These markets actors fall into one of two groups, 1) Owners and Owners' project managers and 2) Design Team members including architects, builders, engineers and other building design professionals. This process will allow DNV GL to review the code compliance process in the context of an actual project. Project participants will also be able to describe in substantial detail their interactions with code officials and their understanding of how code provisions applied to the building.

The objectives of the interviews are to collect the following information:

- Energy Code Awareness
- Energy Code Compliance
- New Construction Program Support
- Building Testing & Performance
- Effectiveness and Opinions on the CCEI and its effects on Code Compliance
- Suggestions for Improving the Compliance Process

If respondents have questions about study, they can contact Muxi Yang of National Grid at muxi.yang@nationalgrid.com or 781-907-1458; or John Leyden, State Building Code Commissioner at John.Leyden@doa.ri.gov or 401-222-3529.

Calling instructions

1. Text in bold should be read.
2. Text in brackets [ ] are instructions for interviewer, minor programming such as skips, or answer choices and should NOT be read.
3. Unless specifically noted, do NOT read answer choices. [Other], [Don't know] and [Refused].

Voice mail message

Answering machine: Messages should be left the first time you call and every three calls after that. Here is a script for the answering machine:

INTRODUCTION

Hi, my name is _____ and I work for DNV GL, an energy consulting firm. We have been hired by National Grid with support from the State of Rhode Island Office of the Building Commissioner 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 Rhode Island. The objectives of the study are to understand current design and construction practices, the energy code compliance process, and the impacts of National Grid's Code Compliance Enhancement Initiative. I would like to talk with you to find out more about your recent experiences with the energy code.

The conversation should take approximately 1 hour. Your responses are confidential and the report will not include the names or jurisdictions of the individuals we interview.

[AGREES TO PARTCIPATE]	1	Intro4
[DOES NOT AGREE TO PARTCIPATE]	2	Thank & Terminate

[REPEAT IF NEEDED] All survey information collected including the results to this survey will be treated confidentially and reported in aggregate form.

[IF ASKED] If respondents have questions about study, they can contact Muxi Yang of National Grid at muxi.yang@nationalgrid.com or 781-907-1458; or John Leyden, State Building Code Commissioner at John.Leyden@doa.ri.gov or 401-222-3529.

Identify Roles and Responsibilities

RR1. What is your job title?

Record		RR2
Don't know	98	Terminate
Refused	99	

RR2. How long have you held this position?

Record		RR3
Don't know	98	
Refused	99	

RR3. What are your primary job responsibilities?

Record		RR3a
Don't know	98	
Refused	99	

RR3a. Do your job responsibilities involve residential, commercial and/or industrial buildings? [MARK ALL THAT APPLY. IF MENTIONED IN RR3, CONFIRM HERE.]

Residential Buildings	1	RR4
Commercial buildings	2	
Industrial buildings	3	
Don't know	98	
Refused	99	

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

Yes	1	RR4a
No	2	RR5
Don't know	98	
Refused	99	

RR4a. Please describe this experience. [Probe: Name of position, Length of time in role, Description of role pertaining to the energy code]

Record		RR5
Don't know	98	
Refused	99	

RR5. During the previous year, how many commercial building permits were issued by your department? [Include total number of permits for retrofit, renovations and new construction] [RECORD ALL THAT APPLY].

Commercial Retrofits		SECC1
Commercial Renovations		
Commercial New Construction		
Don't know	98	
Refused	99	

Staff Energy Code Compliance Processes and Training

In this section, I would like to ask you some questions about your office and training.

SECC1. How many staff work in your office?

Record		If > 1, Go to SECC2, otherwise Go to SECC3
Don't know	98	
Refused	99	

SECC2. What is the average number of years of experience of your staff?

Record		SECC3
Don't know	98	

Refused	99	

SECC3. Within the last two years, has anyone from your staff attended training on ***commercial*** energy code compliance and enforcement?

Yes	1	SECC3a
No	2	SECC4
Don't know	98	
Refused	99	

SECC3a. Who conducted the training?

Record		SECC3b
Don't know	98	
Refused	99	

SECC3b. What was reviewed during the training?

Record		SECC3c
Don't know	98	
Refused	99	

SECC3c. In what ways, if any, has this training changed your process of energy code enforcement?

Record		SECC3d
Don't know	98	
Refused	99	

SECC3d. Do you feel that this commercial training has been sufficient so you can understand and enforce all sections of the energy code?

Yes	1	SECC3e
No	2	SECC4
Don't know	98	
Refused	99	

SECC3e. Why do you say that?

Record		SECC4
Don't know	98	
Refused	99	

SECC4. How would you prefer to receive energy code training?

Webinar/online	1	SEEC5
Classroom	2	
In the field	3	
Other (Record)	4	
Don't know	98	
Refused	99	

SECC5. If offered, do you anticipate attending training on 2012 IECC?

Yes	1	SECC5a
No	2	
Don't know	98	
Refused	99	

SECC5a. Rhode Island is looking to adopt 2015 IECC this year. If offered, do you anticipate attending training on 2015 IECC?

Yes	1	SECC6
No	2	
Don't know	98	
Refused	99	

SECC6. How familiar are you with the Green Buildings Act?

Very familiar	1	SEEC6a
Somewhat familiar	2	SECC6a
A little familiar	3	SECC6a
Not familiar	4	SECC7
Don't know	98	SEEC7
Refused	99	SEEC7

SECC6a. Have any projects within your jurisdiction had to follow the requirements of the Green Buildings Act?

Yes	1	SECC6b
No	2	SECC7
Don't know	98	
Refused	99	

SECC6b. What project(s) followed the Green Building Act requirements?

Record		SECC6c
Don't know	98	
Refused	99	

SECC6c. Which code or rating system did the project follow? [Probe for IGCC, LEED, Green Globes or Northeast CHPS]

IGCC	1	SECC6d
LEED	2	
Green Globes	3	
Northeast CHPS (if project is a school)	4	
Other (record)	5	
Don't know	98	
Refused	99	

SECC6d. Have you have received sufficient training to enforce the Green Buildings Act and its provisions?

Yes	1	SECC6e
No	2	SECC6e
Don't know	98	SECC7
Refused	99	

SECC6e. Why do you say that?

Record		SECC7
Don't know	98	
Refused	99	

SECC7. How familiar are you with the International Green Construction Code (IGCC)?

Very familiar	1	SEEC7a
Somewhat familiar	2	SECC7a
A little familiar	3	SECC7a
Not familiar	4	ECCP1
Don't know	98	ECCP1
Refused	99	ECCP1

SECC7a. Have any projects within your jurisdiction had to follow the requirements of the IGCC?

Yes	1	SECC7b
No	2	ECCP1
Don't know	98	
Refused	99	

SECC7b. What project(s) followed the IGCC requirements?

Record		SECC7c
Don't know	98	
Refused	99	

SECC7c. Have you have received sufficient training to enforce the IGCC and its provisions?

Yes	1	SECC7d
No	2	SECC7d
Don't know	98	ECCP1
Refused	99	

SECC7d. Why do you say that?

Record		ECCP1
Don't know	98	
Refused	99	

Energy Code Compliance Practices

I want to find out more about energy code practices for commercial buildings in your jurisdiction. Thinking about any recent commercial new construction projects in your jurisdiction, as we continue our conversation, when applicable, please provide examples of your experiences.

EECP1. Are you more familiar with the 2009 IECC or ASHRAE 90.1 - 2007 standards?

2009 IECC	1	ECCP1a
ASHRAE 90.1 - 2007	2	
Equally familiar	3	ECCP2
Don't know about either	4	
Don't know	98	
Refused	99	

ECCP1a. Why is that?

Record		ECCP2
Don't know	98	
Refused	99	

ECCP2. Which parts of the commercial energy code are most difficult in determining compliance?

Record		ECCP2a
Don't know	98	
Refused	99	

ECCP2a. Why is that?

Record		ECCP3
Don't know	98	
Refused	99	

ECCP3. What types of educational or professional backgrounds are needed to comprehensively enforce the commercial energy code?

Record		ECCP4
Don't know	98	
Refused	99	

ECCP4. Who conducts **plan reviews** for energy code compliance? [Read responses and mark all that apply]

Not done	1	ECCP5
Interviewee (if single person code office)	2	
In-house staff	3	
3rd party entities (Please describe)	4	
Other jurisdictions or government agencies (Please describe)	5	
Other (Please describe)	6	

Don't know	98	
Refused	99	

ECCP5. Who conducts **field inspections** for energy code compliance? [Read responses and mark all that apply]

Not done	1	ECCP6
Interviewee (if single person code office)	2	ECCP5a
In-house staff	3	ECCP5a
3rd party entities (Please describe)	4	ECCP5a
Other jurisdictions or government agencies (Please describe)	5	ECCP5a
Other (Please describe)	6	ECCP5a
Don't know	98	ECCP6
Refused	99	ECCP6

ECCP5a. At what point during building construction are **field inspections** normally conducted? [READ OPTIONS IF NECESSARY. MARK ONLY ONE. WE ARE LOOKING FOR "NORMALLY CONDUCTED"]

When building is 100% complete	1	ECCP6
Completion of Structural Components	2	
Completion of Electrical	3	
Completion of Mechanical	4	
Completion of Plumbing	5	
Completion of Envelope (post-insulation)	6	
Completion of Lighting	7	
Other (Please describe)	8	
Don't know	98	
Refused	99	

ECCP6. What documentation and/or calculations do you require from applicants to demonstrate commercial energy code compliance? [MARK ALL THAT APPLY]

COMcheck reports	1	ECCP7
Building Envelope	2	
HVAC	3	
Interior Lighting	4	
Exterior Lighting	5	
Project certification	6	ECCP6a
Other (Please describe)	7	ECCP7
Don't know	98	
Refused	99	

ECCP6a. If you require project certification to demonstrate commercial energy code compliance, are the project certifications specific to the energy code or do they address all code provisions?

Certifications specific to the	1	ECCP5b

energy code		
Certifications for all but energy	2	
Certifications address all code provisions	3	
Other (record)	4	
Don't know	98	
Refused	99	

ECCP6b. What percentage of commercial buildings use the following methods to demonstrate energy code compliance?

[If examples of methods to demonstrate energy code compliance needed:]

- Prescriptive is a checklist.
- COMCheck is considered a trade-off method.
- Performance is submission of an energy model showing code building performance versus proposed building performance.]

Prescriptive %		ECCP6
Trade-off %		
Performance %		
Don't know	98	
Refused	99	

[Percentage should total 100%]

ECCP7. [If ECCP4 does not equal 1] Please provide an estimate of the range of time devoted to **plan review** for energy codes per commercial project. [MAKE SURE YOU ASK ABOUT LOW AND HIGH RANGE]

Low range- hours		ECCP7a
Low range- minutes		
High range- hours		
High range- minutes		
Don't know	98	
Refused	99	

ECCP7a. For commercial projects, what affects the number of hours devoted to **plan review** for energy codes? [Probe: Building size, building type and complexity, staff, resources]

Record response		ECCP7b
Don't know	98	
Refused	99	

ECCP7b. In regard to the energy code, what are you specifically looking for in the **plan reviews**? [MARK ALL THAT APPLY]

Air sealing detail – Continuous air barrier	1	ECCP8
Exterior wall thermal properties ((R-values and/or material type and dimensions)	2	
Attic / ceiling thermal properties ((R-values and/or material type and dimensions)	3	
Foundation/footing thermal properties ((R-values and/or material type and dimensions)	4	
Duct insulation	5	
Lighting (technology, wattage, count)	6	
Lighting controls	7	
Mechanical system specifications (HVAC, DHW) – (Efficiency, ENERGY STAR)	8	
Plumbing features (pipe insulation, low flow)	9	
Fenestration (windows, doors, skylights) specifications (- U-values, SHGC, thermal break, ENERGY STAR)	10	
Other (record)	11	
Don't know	98	
Refused	99	

ECCP8. [If ECCP5 does not equal 1] Please provide an estimate of the range of time devoted to **field inspection** for energy codes per commercial project. 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.

Low range- hours		ECCP8a
Low range- minutes		
High range- hours		
High range- minutes		
Don't know	98	
Refused	99	

ECCP8a. For **commercial** projects, what affects the number of hours devoted to **field inspection** for energy codes? [Probe: Building size, building type and complexity, staff, resources]

Record response		ECCP9
Don't know	98	
Refused	99	

ECCP9. Are there other provisions of the code that generally take precedence over the energy code?

Yes	1	ECCP9a
No	2	ECCP10
Don't know	98	
Refused	99	

ECCP9a. What provisions take precedence over the energy code?

Record response		ECCP9b
Don't know	98	
Refused	99	

ECCP9b. How much time is spent reviewing other code provisions versus the energy code?

Record response		ECCP10
Don't know	98	
Refused	99	

ECCP10. What resources do you use to help answer questions on energy code issues?

Record response		ECCP11
Don't know	98	
Refused	99	

ECCP11. Do you feel that the design and construction teams who work in your jurisdiction are familiar with the **commercial** energy code – including recent updates?

Yes	1	ECCP11a
No	2	
Don't know	98	ECCP12
Refused	99	

ECCP11a. Why do you say that?

Record		ECCP12
Don't know	98	
Refused	99	

ECCP12. What system does your department use to maintain permitting data? [Read responses and check all that apply]

Paper	1	ECCP13
Electronic	2	
Other (Please describe)	3	
Don't know	98	
Refused	99	

ECCP13. Are there any limitations that impede your ability to enforce the energy code?

Yes	1	ECCP13a
No	2	ECCP14
Don't know	98	
Refused	99	

ECCP13a. What limitations impede your ability to enforce the energy code?

Record		ECCP13b
Don't know	98	
Refused	99	

ECCP13b. What kind of assistance might help get around these impediments?

Record		ECCP14
Don't know	98	
Refused	99	

ECCP14. What percent of the time is all information submitted for commercial buildings adequate to determine energy code compliance?

% of time		If <100%, Go to ECCP15, other Go to ECCP16
Don't know	98	
Refused	99	

ECCP15. What information is most often missing from commercial plans, specifications and/or construction documents (as-built or working) that prevents you from determining compliance? [MARK ALL THAT APPLY]

Specifications for mechanical systems (HVAC, DWH) or equipment cut sheets with model numbers and energy ratings	1	
Fenestration specifications (NFC label, cut sheets, or U-values, SHGC, Rating)	2	
Continuous air barrier detail	3	
Substitutions for the originally specified material or equipment not reported, [e.g. fenestration, insulation, mechanicals]	4	
Detailed wall sections are not provided including thickness of insulation.	5	
Details on lighting fixtures (type, wattage, controls)	6	
DHW measures	7	
Other (record)	8	
Don't know	98	ECCP16
Refused	99	

ECCP16. Do you find there are certain commercial **plan review and/or field inspection** items that are most often not compliant with the energy code?

Yes	1	ECCP16a
No	2	ECCP17
Don't know	98	
Refused	99	

ECCP16a. Which of the following commercial **plan review and/or field inspection** items do you generally find do not comply with the energy code? [Read responses and mark all that apply]

Lack of air barrier	1	ECCP16b
Lack of continuity of air barrier (through different assemblies, joints, etc.)	2	
Envelope insulation levels	3	
Envelope sealing around fenestration	4	
Envelope sealing at building joints and seams	5	
Installation of insulation	6	
Fenestration	7	
Duct insulation	8	
Duct sealing	9	
Piping insulation	10	
Installed interior lighting power	11	
Installed exterior lighting power	12	
Lighting controls	13	
HVAC equipment	14	
HVAC system controls	15	
Other (Please describe)	16	
Don't know	98	
Refused	99	

ECCP16b. Why do these items not comply with the energy code?

Record		CCEI1
Don't know	98	
Refused	99	

Effectiveness of CCEI

These final questions are about National Grid Rhode Island's Energy Code Compliance Technical Support Initiative, and its influence on changes in building code compliance.

CCEI1. How would you describe your familiarity National Grid's Energy Code Technical Support Initiative? [IF NEEDED: The initiative offers technical assistance and training on current building energy codes][READ LIST]

Not at all familiar	1	CCEI2
Slightly familiar	2	
Somewhat familiar	3	
Moderately familiar	4	
Extremely familiar	5	
Don't know	98	
Refused	99	

CCEI2. Have you been through any training for the initiative?

Yes	1	CCEI2a
No	2	CCEI2b
Don't know	98	CCEI3
Refused	99	

CCEI2a. How many trainings have you attended?

Record		CCEI2aa
Don't know	98	
Refused	99	

CCEI2aa. How many were trainings on the residential code and how many on the commercial code?

Residential		CCEI3
Commercial		
Don't know	98	
Refused	99	

CCEI2b. What prevented you from attending the trainings?

Didn't know about the training	1	CCEI2c
Didn't think I'd learn anything	2	
Other (Record)		
Don't know	98	
Refused	99	

CCEI2c. What would have attracted you to these trainings?

Record		CCEI3
Don't know	98	
Refused	99	

CCEI3. Have you received any technical support from the initiative?

Yes	1	CCEI3a
No	2	CCEI3b
Don't know	98	CCEI4
Refused	99	

CCEI3a. What technical support did you receive?

Record		CCEI4
Don't know	98	
Refused	99	

CCEI3b. What prevented you from receiving technical support?

Didn't know about the technical support	1	If CCEI2 and CCEI3 =2(NO), then CC1, otherwise go to CCEI4
Other (Record)		
Don't know	98	
Refused	99	

CCEI4. Did your interaction with the initiative **influence your knowledge** of current energy code? [PROBE for similar information re: Residential & Commercial code]

Yes	1	CCEI4a
Somewhat	2	
No	3	CCEI5
Don't know	98	
Refused	99	

CCEI4a. How so?

Record		CCEI5
Don't know	98	
Refused	99	

CCEI5. Did your interaction with the initiative **influence your energy code enforcement practices**? [PROBE for similar information re: Residential & Commercial code]

Yes	1	CCEI5a
Somewhat	2	
No	3	CCEI6
Don't know	98	
Refused	99	

CCEI5a. How so?

Increased rigor		CCEI6
Increased attention		
Decreased confusion		
Other (Record)		
Don't know	98	
Refused	99	

CCEI6. What aspects of the technical support initiative, if any, have been successful?

Record		CCEI7
Don't know	98	
Refused	99	

CCEI7. What aspects of the technical support initiative, if any, could use improvement? [PROBE for how the implementers/program managers can be more helpful to code officials]

Record		CC1
Don't know	98	
Refused	99	

CCEI8. Which parts of the commercial building code TRAINING(S) did you find the most useful? [PROBE for why]

Record		CC9
Don't know	98	
Refused	99	

CCEI9. Can you think of additional topics you wish the trainings had included?

Record		CC10
Don't know	98	
Refused	99	

CCEI10. Would you recommend that your colleagues attend the National Grid Energy Code Technical Support Initiative trainings?

Record		CCEI10a
Don't know	98	
Refused	99	

CCEI10a.Why do you say that?

Record		CC1
Don't know	98	
Refused	99	

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 or suggestions on how to improve code compliance?

Record		End
Don't know	98	
Refused	99	

END. Thank you for your time and patience. Unless you have any questions, we've completed all our questions for today. There's a chance we might have a few follow up questions for you once we've reviewed our notes from this interview. Would it be ok for one of my colleagues to call you back if we do?

D.2 CCEI building owner/property manager in-depth interview guide

Memo to:
Muxi Yang, National Grid

From: Wendy Todd, DNV GL
Date: 7/12/2016
Prep. by: Jason Symonds, DNV GL
Wendy Todd, DNV GL

DRAFT CCEI BUILDING OWNER/PROPERTY MANAGER IN-DEPTH INTERVIEW GUIDE

GOAL OF INTERVIEWS:

DNV GL will interview the market actors associated with each of the projects receiving site visits. These markets actors fall into one of two groups, 1) Owners and Owners' project managers and 2) Design Team members including architects, builders, engineers and other building design professionals. This process will allow DNV GL to review the code compliance process in the context of an actual project. Project participants will also be able to describe in substantial detail their interactions with code officials and their understanding of how code provisions applied to the building.

The objectives of the interviews are to collect the following information:

- Energy Code Awareness
- Energy Code Compliance
- New Construction Program Support
- Building Testing & Performance
- Effectiveness and Opinions on the CCEI and its effects on Code Compliance
- Suggestions for Improving the Compliance Process

If respondents have questions about study, they can contact Muxi Yang of National Grid at muxi.yang@nationalgrid.com or 781-907-1458; or John Leyden, State Building Code Commissioner at John.Leyden@doa.ri.gov or 401-222-3529.

Calling instructions

1. Text in bold should be read.
2. Text in brackets [ ] are instructions for interviewer, minor programming such as skips, or answer choices and should NOT be read.
3. Unless specifically noted, do NOT read answer choices. [Other], [Don't know] and [Refused].

Voice mail message

Answering machine: Messages should be left the first time you call and every three calls after that. Here is a script for the answering machine:

Hi _____, my name is _____ and I work for DNV GL, an energy consulting firm. We have been hired by National Grid with support from the State of Rhode Island Office of the Building Commissioner to conduct research on energy code compliance in new commercial building construction.

We would like to schedule a time to speak with you about your recent experiences with energy code design and construction practices, as well as get you feedback on energy code processes and compliance. Please feel free to give me a call at _____. Thank you for your time, and I look forward to speaking with you soon.

INTRODUCTION

Hi, my name is _____ and I work for DNV GL, an energy consulting firm. We have been hired by National Grid with support from the State of Rhode Island Office of the Building Commissioner to conduct research on energy code compliance in new commercial building construction.

This interview is part of a statewide effort to study common construction practices and the impacts of National Grid's Code Compliance Enhancement Initiative. 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.

In appreciation of your time and feedback in completing the interview, we would like to offer you a $50 visa gift card.

The conversation will take approximately 1 hour. Your responses are completely confidential.

[AGREES TO PARTCIPATE]	1	Intro4
[DOES NOT AGREE TO PARTCIPATE]	2	Thank & Terminate

[REPEAT IF NEEDED] All survey information collected including the results to this survey will be treated confidentially and reported in aggregate form.

[IF ASKED] If respondents have questions about study, they can contact Muxi Yang of National Grid at muxi.yang@nationalgrid.com or 781-907-1458.

Identify 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??

Record		RR2
Don't know	98	Terminate
Refused	99	

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

Record		RR3
Don't know	98	
Refused	99	

Awareness of Energy Efficiency Programs

EEP1. Are you familiar with the Rhode Island new construction energy efficiency programs?

Yes	1	EEP2
No	2	
Don't know	98	
Refused	99	

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?

Yes	1	EEP2a
No	2	EEP2b
Don't know	98	SAT1
Refused	99	

EEP2a. Please describe your experience with the new construction program?

Record		SAT1
Don't know	98	
Refused	99	

EEP2b. Why not?
[Probe: Not a priority? Too late in the design process? Incentives not worth the effort?]

Record		SAT1
Don't know	98	
Refused	99	

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	1	SAT1a
No	2	SAT2
Don't know	98	
Refused	99	

SAT1a. What were the goals?

Record		SAT1b
Don't know	98	
Refused	99	

SAT1b. What motivated you to set goals?

Record		SAT2
Don't know	98	
Refused	99	

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?

Record		SAT2a
Don't know	98	
Refused	99	

SAT2a. Why do you say that?

Record		SAT3
Don't know	98	
Refused	99	

SAT3. Does the energy consumption of the building meet your expectations?

Yes	1	SAT3a
No	2	SAT3a
Don't know	98	SAT4
Refused	99	

SAT3a. Why do you say that?

Record		SAT4
Don't know	98	
Refused	99	

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	1	SAT4a
No	2	SAT5
Don't know	98	
Refused	99	

SAT4a. What are they?

Record		SAT5
Don't know	98	
Refused	99	

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	1	SAT5a
No	2	ECC1
Don't know	98	
Refused	99	

SAT5a. What changes have occurred?

Record		ECC1
Don't know	98	
Refused	99	

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 Rhode Island commercial energy code during the design of the building?

Record		ECC2
Don't know	98	
Refused	99	

EEC2. During the design and construction of <COMMERCIAL PROJECT>, did you have any interactions with local code officials?

Yes	1	EEC2a
No	2	EEC3
Don't know	98	
Refused	99	

EEC2a. 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?]

Record		EEC2b
Don't know	98	
Refused	99	

EEC2b. Did code officials discuss compliance with the commercial energy code?

Yes	1	EEC2c

No	2	
Don't know	98	
Refused	99	

EEC2c. Did code officials seem knowledgeable about the commercial energy code?

Yes	1	EEC2d
No	2	
Don't know	98	EEC3
Refused	99	

EEC2d. Why do you say that?

Record		EEC3
Don't know	98	
Refused	99	

EEC3. Were there any particular **challenges** that the **design team** had to overcome to meet energy code?

Yes	1	EEC3a
No	2	EEC4
Don't know	98	
Refused	99	

EEC3a. Please explain.

Record		EEC4
Don't know	98	
Refused	99	

EEC4. Were there any particular **challenges** that the **construction team** had to overcome to meet energy code?

Yes	1	EEC4a
No	2	EEC5
Don't know	98	
Refused	99	

EEC4a. Please explain.

Record		TN1
Don't know	98	
Refused	99	

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	1	TN1a

No	2	TN1c
Don't know	98	MP1
Refused	99	

TN1a. Who offered the training?

Record		TN1b
Don't know	98	
Refused	99	

TN1b. For which systems was training offered?

Record		MP1
Don't know	98	
Refused	99	

TN1c. Is there a need for training on building systems at <COMMERCIAL PROJECT>??

Yes	1	TN1d
No	2	MP1
Don't know	98	
Refused	99	

TN1d. Please indicate the types of building systems training needed.

Record		MP1
Don't know	98	
Refused	99	

Maintenance Procedures

Now 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	1	MP2
No	2	
Don't know	98	
Refused	99	

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

Yes	1	MP2a
No	2	MP3
Don't know	98	
Refused	99	

MP2a. What are your reasons for regularly testing and balancing your air and hydronic systems?

Record		MP3
Don't know	98	

Refused	99	

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

Yes	1	MP3a
No	2	MP3b
Don't know	98	MP4
Refused	99	

MP3a. Why was commissioning completed?

Record		MP4
Don't know	98	
Refused	99	

MP3b. Why wasn't commissioning completed?

Record		MP4
Don't know	98	
Refused	99	

Effectiveness of CCEI

These final questions are about National Grid Rhode Island's Energy Code Compliance Technical Support Initiative, and its influence on changes in building code compliance.

CCEI1. How would you describe your familiarity National Grid's Energy Code Technical Support Initiative? [IF NEEDED: The initiative offers technical assistance and training on current building energy codes][READ LIST]

Not at all familiar	1	CCEI2
Slightly familiar	2	
Somewhat familiar	3	
Moderately familiar	4	
Extremely familiar	5	
Don't know	98	
Refused	99	

CCEI2. Have you been through any training for the initiative?

Yes	1	CCEI2a
No	2	CCEI2b
Don't know	98	CCEI3
Refused	99	

CCEI2a. How many trainings have you attended?

Record		CCEI3
Don't know	98	

Refused	99	

CCEI2b. What prevented you from attending the trainings?

Didn't know about the training	1	CCEI2c
Didn't think I'd learn anything	2	
Other (Record)		
Don't know	98	
Refused	99	

CCEI2c. What would have attracted you to these trainings?

Record		CCEI3
Don't know	98	
Refused	99	

CCEI3. Have you received any technical support from the initiative?

Yes	1	CCEI3a
No	2	CCEI3b
Don't know	98	CCEI4
Refused	99	

CCEI3a. What technical support did you receive?

Record		CCEI4
Don't know	98	
Refused	99	

CCEI3b. What prevented you from receiving technical support?

Didn't know about the technical support	1	If CCEI2 and CCEI3 =2(NO), then CC1, otherwise go to CCEI4
Other (Record)		
Don't know	98	
Refused	99	

CCEI4. Did your interaction with the initiative **influence your knowledge** of current energy code?

Yes	1	CCEI4a
Somewhat	2	
No	3	CCEI5
Don't know	98	
Refused	99	

CCEI4a. How so?

Record		CCEI5
Don't know	98	
Refused	99	

CCEI5. Did your interaction with the initiative **influence your energy code enforcement practices**?

Yes	1	CCEI5a
Somewhat	2	
No	3	CCEI6
Don't know	98	
Refused	99	

CCEI5a. How so?

Increased rigor		CCEI6
Increased attention		
Decreased confusion		
Other (Record)		
Don't know	98	
Refused	99	

CCEI6. What aspects of the technical support initiative, if any, have been successful?

Record		CCEI7
Don't know	98	
Refused	99	

CCEI7. What aspects of the technical support initiative, if any, could use improvement? [PROBE for how the implementers/program managers can be more helpful to code officials]

Record		CC1
Don't know	98	
Refused	99	

CCEI8. On a scale of 1 to 10, where 1 is very ineffective and 10 is very effective, how effective was National Grid's Energy Code Technical Support Initiative in helping you comply with building energy code practices?

Record		CC1
Don't know	98	
Refused	99	

Closing Comments

CC1. Do you have any other comments – suggestions, improvements, other observations to share with the Rhode Island Energy Efficiency Program Administrators?

Record		End
Don't know	98	
Refused	99	

End. Those are all the questions I wanted to ask. Thank you for your time and participation.

D.3 CCEI design professional in-depth interview guide

Memo to:

Muxi Yang, National Grid

From: Wendy Todd, DNV GL
Date: 7/12/2016
Prep. by: Jason Symonds, DNV GL
Wendy Todd, DNV GL

DRAFT CCEI BUILDING DESIGN PROFESSIONAL IN-DEPTH INTERVIEW GUIDE

GOAL OF INTERVIEWS:

DNV GL will interview the market actors associated with each of the projects receiving site visits. These markets actors fall into one of two groups, 1) Owners and Owners' project managers and 2) Design Team members including architects, builders, engineers and other building design professionals. This process will allow DNV GL to review the code compliance process in the context of an actual project. Project participants will also be able to describe in substantial detail their interactions with code officials and their understanding of how code provisions applied to the building.

The objectives of the interviews are to collect the following information:

- Energy Code Awareness
- Energy Code Compliance
- New Construction Program Support
- Building Testing & Performance
- Effectiveness and Opinions on the CCEI and its effects on Code Compliance
- Suggestions for Improving the Compliance Process

If respondents have questions about study, they can contact Muxi Yang of National Grid at muxi.yang@nationalgrid.com or 781-907-1458; or John Leyden, State Building Code Commissioner at John.Leyden@doa.ri.gov or 401-222-3529.

Calling instructions

4. Text in bold should be read.
5. Text in brackets [ ] are instructions for interviewer, minor programming such as skips, or answer choices and should NOT be read.
6. Unless specifically noted, do NOT read answer choices. [Other], [Don't know] and [Refused].

Voice mail message

Answering machine: Messages should be left the first time you call and every three calls after that. Here is a script for the answering machine:

Hi _____, my name is _____ and I work for DNV GL, an energy consulting firm. We have been hired by National Grid with support from the State of Rhode Island Office of the Building Commissioner to conduct research on energy code compliance in new commercial building construction.

We would like to schedule a time to speak with you about your recent experiences with energy code design and construction practices, as well as get you feedback on energy code processes and compliance. Please feel free to give me a call at _____. Thank you for your time, and I look forward to speaking with you soon.

INTRODUCTION

Hi, my name is _____ and I work for DNV GL, an energy consulting firm. We have been hired by National Grid with support from the State of Rhode Island Office of the Building Commissioner 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 already completed an onsite survey with our team. 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.

In appreciation of your time and feedback in completing the interview, we would like to offer you a $50 visa gift card.

The conversation will take approximately 1 hour. Your responses are completely confidential.

[AGREES TO PARTCIPATE]	1	Intro4
[DOES NOT AGREE TO PARTCIPATE]	2	Thank & Terminate

[REPEAT IF NEEDED] All survey information collected including the results to this survey will be treated confidentially and reported in aggregate form.

[IF ASKED] If respondents have questions about study, they can contact Muxi Yang of National Grid at muxi.yang@nationalgrid.com or 781-907-1458; or John Leyden, State Building Code Commissioner at John.Leyden@doa.ri.gov or 401-222-3529.

Identify Roles and Responsibilities

RR1. What is your job title?

Record		RR2
Don't know	98	Terminate
Refused	99	

RR2. How long have you held this position?

Record		RR3
Don't know	98	
Refused	99	

RR3. What are your primary job responsibilities?

Record		RR3a
Don't know	98	
Refused	99	

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?

Record		EEC2
Don't know	98	
Refused	99	

EEC2. What is the typical process that your firm and related consultants use to document compliance with the Rhode Island commercial energy code during design??

Record		EEC3
Don't know	98	
Refused	99	

EEC3. 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?

Record		EEC4
Don't know	98	
Refused	99	

EEC4. What documentation was required by the building official to demonstrate compliance with the energy code?

Record		EEC4
Don't know	98	
Refused	99	

EEC5. During the design and construction of <COMMERCIAL PROJECT>, did you or members of your firm have any interactions with local code officials?

Yes	1	EEC5a
No	2	EE6
Don't know	98	
Refused	99	

EEC5a. 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?]?

Record		EEC5b
Don't know	98	
Refused	99	

EEC5b. Did code officials discuss compliance with the commercial energy code?

Yes	1	EEC5c
No	2	
Don't know	98	
Refused	99	

EEC5c. Did code officials seem knowledgeable about the commercial energy code?

Yes	1	EEC5d
No	2	
Don't know	98	EEC5e
Refused	99	

EEC5d. Why do you say that?

Record		EEC5e
Don't know	98	
Refused	99	

EEC5e. Were there any difficulties in dealing with the code officials or in gaining approvals for energy code compliance?

Yes	1	EEC5f
No	2	EEC5g
Don't know	98	
Refused	99	

EEC5f. Please explain.

Record		EEC5g
Don't know	98	
Refused	99	

EEC5g. During construction, how often did building officials conduct an inspection of the building?

Record		EEC5h
Don't know	98	
Refused	99	

EEC5h. Were you present during the inspections?

Yes	1	EEC5i
No	2	EEC5j
Don't know	98	
Refused	99	

EEC5i. Please describe the interaction you had with the building officials during the on-site inspections.

Record		EEC5j
Don't know	98	
Refused	99	

EEC5j. What were the main components that the building officials focused on during the inspection?

Record		EEC6
Don't know	98	
Refused	99	

EEC6. Were there any particular **challenges** that the **design team** had to overcome to meet energy code?

Yes	1	EEC6a
No	2	EEC7
Don't know	98	
Refused	99	

EEC6a. Please explain.

Record		EEC7
Don't know	98	
Refused	99	

EEC7. Were there any particular **challenges** that the **construction team** had to overcome to meet energy code?

Yes	1	EEC7a
No	2	EEC8
Don't know	98	
Refused	99	

EEC7a. Please explain.

Record		EEC8
Don't know	98	
Refused	99	

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?

Yes	1	NCPS1a
No	2	NCPS1c
Don't know	98	NCPS2
Refused	99	

NCPS1a. What were the goals?

Record		NCPS1b
Don't know	98	
Refused	99	

NCPS1b. What motivated your firm to set goals?

Record		NCPS2
Don't know	98	
Refused	99	

NCPS1c. Why wasn't energy efficiency a goal?

Record		NCPS2
Don't know	98	
Refused	99	

NCPS2. Have you or your firm ever worked with the Rhode Island new construction/major renovation efficiency programs? [Prompt: Did you have any interaction with National Grid?]

Yes	1	NCPS2a
No	2	NCPS4
Don't know	98	
Refused	99	

NCPS2a. Did you submit documentation to the program that could also be used to show code compliance? [Prompt: Such as COMcheck, energy models]

Yes	1	NCPS2b
No	2	NCPS3
Don't know	98	
Refused	99	

NCPS2b. What documentation did you use to show code compliance?

Record		NCPS3
Don't know	98	
Refused	99	

NCPS3. 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: National Grid?]

Yes	1	NCPS3a
No	2	NCPS3d

Don't know	98	NCPS4
Refused	99	

NCPS3a. Did you receive any assistance that helped you comply with the energy code?

Yes	1	NCPS3b
No	2	NCPS4
Don't know	98	
Refused	99	

NCPS3b. What assistance did you receive?

Record		NCPS3c
Don't know	98	
Refused	99	

NCPS3c. Did you receive the assistance from program staff or their technical assistance vendors?

Program staff	1	NCPS4
Technical assistance vendors	2	
Other	3	
Don't know	98	
Refused	99	

NCPS3d. 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?]

Record		NCPS4
Don't know	98	
Refused	99	

NCPS4. Is there training or other types of support that you could have used to help demonstrate compliance with the energy code?

Yes	1	NCPS4a
No	2	ICP1
Don't know	98	
Refused	99	

NCPS4a. What other types of support could you have used to help demonstrate compliance with the energy code?

Record		ICP1
Don't know	98	
Refused	99	

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?

Yes	1	ICP1a
No	2	ICP2
Don't know	98	
Refused	99	

ICP1a. How would you prefer to receive training? [Read responses and check all that apply]

Webinar / Online	1	ICP1b
Classroom	2	
In the field	3	
Other (Please describe)	4	
Don't know	98	
Refused	99	

ICP1b. What additional topic areas would you like to receive training on regarding the commercial energy code?

Record		ICP2
Don't know	98	
Refused	99	

ICP2. Are there policies and/or actions that could have been implemented to improve code compliance process for this project?

Yes	1	ICP2a
No	2	CC1
Don't know	98	
Refused	99	

ICP2a. Please explain.

Record		CC1
Don't know	98	
Refused	99	

Effectiveness of CCEI

These final questions are about National Grid Rhode Island's Energy Code Compliance Technical Support Initiative, and its influence on changes in building code compliance.

CCEI1. How would you describe your familiarity National Grid's Energy Code Technical Support Initiative? [IF NEEDED: The initiative offers technical assistance and training on current building energy codes][READ LIST]

Not at all familiar	1	CCEI2
Slightly familiar	2	
Somewhat familiar	3	

Moderately familiar	4	
Extremely familiar	5	
Don't know	98	
Refused	99	

CCEI2. Have you been through any training for the initiative?

Yes	1	CCEI2a
No	2	CCEI2b
Don't know	98	CCEI3
Refused	99	

CCEI2a. How many trainings have you attended?

Record		CCEI3
Don't know	98	
Refused	99	

CCEI2b. What prevented you from attending the trainings?

Didn't know about the training	1	CCEI2c
Didn't think I'd learn anything	2	
Other (Record)		
Don't know	98	
Refused	99	

CCEI2c. What would have attracted you to these trainings?

Record		CCEI3
Don't know	98	
Refused	99	

CCEI3. Have you received any technical support from the initiative?

Yes	1	CCEI3a
No	2	CCEI3b
Don't know	98	CCEI4
Refused	99	

CCEI3a. What technical support did you receive?

Record		CCEI4
Don't know	98	
Refused	99	

CCEI3b. What prevented you from receiving technical support?

Didn't know about the technical support	1	If CCEI2 and CCEI3 =2(NO), then CC1, otherwise go to CCEI4
Other (Record)		
Don't know	98	
Refused	99	

CCEI4. Did your interaction with the initiative **influence your knowledge** of current energy code?

Yes	1	CCEI4a
Somewhat	2	
No	3	CCEI5
Don't know	98	
Refused	99	

CCEI4a. How so?

Record		CCEI5
Don't know	98	
Refused	99	

CCEI5. Did your interaction with the initiative **influence your energy code enforcement practices**?

Yes	1	CCEI5a
Somewhat	2	
No	3	CCEI6
Don't know	98	
Refused	99	

CCEI5a. How so?

Increased rigor		CCEI6
Increased attention		
Decreased confusion		
Other (Record)		
Don't know	98	
Refused	99	

CCEI6. What aspects of the technical support initiative, if any, have been successful?

Record		CCEI7
Don't know	98	
Refused	99	

CCEI7. What aspects of the technical support initiative, if any, could use improvement? [PROBE for how the implementers/program managers can be more helpful to code officials]

Record		CC1

Don’t know	98	
Refused	99	

CCEI8. On a scale of 1 to 10, where 1 is very ineffective and 10 is very effective, how effective was National Grid's Energy Code Technical Support Initiative in helping you comply with building energy code practices?

Record		CC1
Don’t know	98	
Refused	99	

Closing Comments

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

Record		End
Don’t know	98	
Refused	99	

End. Those are all the questions I wanted to ask. Thank you for your time and participation.

APPENDIX E. EXPANDED TABLE 5: COMPARISON OF FRAME AND SAMPLE BY BUILDING TYPE AND SIZE, 2012 AND 2016

Stratum Frame Projects	Less than 25,000 sq.ft.				25,000 to 60,000 sq.ft.				60,000 to 250,000 sq.ft.				250,000 to 400,000 sq.ft.				Greater than 400,000 sq.ft.			
Building Type	2012		2016		2012		2016		2012		2016		2012		2016		2012		2016	
Frame/Sample	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n
Amusement, Social and Recreational Bldgs	7	0	6	1	1	1	4	1	3	1	1	0	1	1	0	0	0	0	0	0
Apartments	7	0	2	0	6	2	3	1	2	0	4	0	1	0	0	0	0	0	0	0
Dormitories	1	0	0	0	1	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0
Government Service Buildings	8	1	1	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Hospitals and Other Health Treatment	6	0	4	0	3	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0
Hotels and Motels	1	1	0	0	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0
Manufacturing Plants, Warehouses, Labs	2	0	0	0	0	0	0	0	1	1	3	0	0	0	0	0	0	0	0	0
Miscellaneous Nonresidential Buildings	4	3	1	1	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Office and Bank Buildings	22	1	9	2	5	4	0	0	2	1	1	0	1	0	0	0	1	0	0	0
Parking Garages and Automotive Services	1	0	3	1	1	0	2	0	1	0	1	0	2	0	0	0	2	1	0	0
Religious Buildings	5	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Schools, Libraries, and Labs (nonmfg)	9	0	4	3	4	3	3	2	3	3	1	1	2	2	0	0	0	0	0	0
Stores and Restaurants	23	5	27	4	2	0	2	1	6	0	1	0	1	1	0	0	0	0	0	0
Warehouses (excl. manufacturer owned)	6	0	2	1	2	1	0	0	2	1	0	0	0	0	0	0	0	0	0	0
Total	**102**	**11**	**59**	**14**	**26**	**11**	**16**	**6**	**25**	**7**	**12**	**1**	**6**	**3**	**1**	**0**	**2**	**1**	**0**	**0**

DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter, and greener.