Rhode Island Code Compliance Enhancement Initiative Attribution and Savings Study

DRAFT

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SUBMITTED TO:
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Executive Summary

National Grid Rhode Island's Code Compliance Enhancement Initiative (CCEI) is designed to improve compliance with the state's residential and commercial building energy codes. Since 2013, the CCEI has offered numerous classroom and in-field trainings, which educate building professionals on the building energy code and encourage them to employ efficient building practices. The overall goal of this study was to estimate the savings in the residential and commercial new construction markets that may be attributable to the CCEI due to enhanced code compliance.[1] The primary tasks were to determine the proportion of residential and commercial new construction savings that are attributable to the CCEI and to review and update the related CCEI savings models through 2020. The team has delivered an Excel workbook ("*RI CCEI Res and Comm Attribution Calculator Update-8.31.17.xlsx*") that contains the supporting calculations and assumptions for the gross and net savings estimates.

Findings

Highlights from the key findings are summarized below. The main body of the report explores these findings in more detail.

Residential Attribution

Based on our review of factors related to the extent to which residential new construction (RNC) savings could be attributed the CCEI program, we concluded that 23% is a reasonable overall estimate. The factors which contribute to this value include observed compliance improvements, changes to the building energy code, the relative importance of the related measures, the impact of the trainings on building practices, and the prevalence of naturally occurring market adoption (NOMAD).

The attribution assessment accounted for measure-level efficiencies. Our analysis estimated an attribution score of 60% for air leakage, 35% for above grade wall insulation, 45% for duct leakage and insulation, and 20% for lighting (Table 1). The overall attribution score of 23% is calculated by multiplying the measure-level attribution scores by their relative importance.

[1] Although residential and commercial retrofits projects represent a sizable portion of savings in these sectors, the C-team determined that, due to a lack of accurate data regarding retrofit activity in Rhode Island, it was not appropriate to estimate these related savings.

Table 1: Residential Attribution Scores for CCEI

Measures	Relative Importance of Measure (A)	% Attributable to CCEI (B)	Measure Attribution Score (A*B)
Window and skylight U-factor	20%	0%	0%
Air leakage	19%	60%	11%
Above grade wall insulation	17%	35%	6%
Ceiling insulation	12%	0%	0%
Duct leakage and insulation	10%	45%	5%
Frame floor insulation	8%	0%	0%
Lighting	8%	20%	2%
Slab insulation	3%	0%	0%
Foundation wall insulation	3%	0%	0%
Attribution Score (Sum of Component Scores)			***23%***

We calculated the percentage of maximum potential improvement attributable to CCEI to be 9.0% for 2018, 10.8% for 2019, and 12.6% for 2020 (Table 2). This is a calculated value that is ultimately used to calculate net savings. This value represents the compliance percentage that is attributable to the CCEI divided by the overall level of non-compliance that would exist in the absence of the program. Because it is unclear when Rhode Island will update the residential energy code, we assumed that it will remain unchanged throughout the 2018-2020 period and felt it appropriate to assume a stable attribution estimate (23%) for the projected timeframe. Based on this factor, and a number of other inputs (explained in greater detail in Section 2.2), we derived these estimates for 2018-2020.

Table 2: Residential CCEI Attribution Over Time

Year	CCEI Attribution	Percent of Maximum Potential Improvement
2018	23%	9.0%
2018		10.8%
2020		12.6%

Commercial Attribution

Using a similar logic as the residential attribution assessment, we determined that 46% is an appropriate level for the overall commercial attribution score. This assessment examined compliance improvements at the measure category level instead of the individual measure level. Based on this assessment, we estimated an attribution score of 55% for the building envelope, 45% for HVAC, and 25% for lighting (Table 3).

Table 3: Commercial Attribution Scores for CCEI

Measure Category	Relative Importance of Category (A)	% Attributable to CCEI (B)	Measure Category Attribution Score (A*B)
Lighting	15%	25%	4%
Building Envelope	39%	55%	21%
HVAC	46%	45%	21%
Attribution Score (Sum of Component Scores)			***46%***

For commercial new construction, we estimated the percentage of maximum potential improvement attributable to CCEI to be 33.5% for 2018, 35.5% for 2019, and 35.5% for 2020 (Table 4). Like the residential estimate, this value represents the compliance percentage that is attributable to the CCEI divided by the overall level of non-compliance that would exist in the absence of the program. The analysis, similar to the residential assessment, assumes a stable attribution estimate (46%) for the projected timeframe due to the uncertainty regarding upcoming changes to the building energy code. An explanation regarding how these estimates are derived is included in Section 2.4, Projecting Commercial Attribution Across the 2018-2020 Period.

Table 4: Commercial Compliance and CCEI Attribution Over Time

Year	CCEI Attribution	Percent of Maximum Potential Improvement
2018	46%	33.5%
2018		35.5%
2020		35.5%

Program Savings

Residential Savings: Our results estimate that the 2018-2020 RNC gross technical potential (GTP) savings will be 5,576 MWh for electric and 327,582 therms for gas. **Using the RNC attribution estimates, the estimated three-year net savings for electric and gas are projected to be 608 MWh and 35,812 therms, respectively.**

Commercial Savings: As projected, the 2018-2020 commercial new construction in GTP savings will be 2,338 MWh for electric and 28,955 therms for gas. **Based on the commercial attribution estimates, the three-year electric and gas savings are estimated at 815 MWh and 10,099 therms, respectively.**

Overall Savings: **The overall 2018-2020 electric and gas savings attributed the CCEI program are projected to be 1,423 MWh for electric and 45,911 therms for gas.** Table 5 shows the residential, commercial, and overall estimated savings for 2018-2020.

Table 5: Gross Technical Potential and Savings Attributable to CCEI

	Residential				Commercial				Total			
	Gross Technical Potential		Net Program Savings		Gross Technical Potential		Net Program Savings		Gross Technical Potential		Net Program Savings	
	Electric (MWh)	Gas (therms)	Electric (MWh)	Gas (therms)	Electric (MWh)	Gas (therms)	Electric (MWh)	Gas (therms)	Electric (MWh)	Gas (therms)	Electric (MWh)	Gas (therms)
2018	1,743	99,539	157	8,978	746	9,239	250	3,091	2,489	108,778	407	12,069
2019	1,866	108,678	202	11,762	779	9,646	277	3,429	2,645	118,324	479	15,191
2020	1,967	119,365	248	15,072	813	10,070	289	3,579	2,780	129,435	537	18,652
Total	**5,576**	**327,582**	**608**	**35,812**	**2,338**	**28,955**	**815**	**10,099**	**7,914**	**356,537**	**1,423**	**45,911**

RECOMMENDATIONS

Based on the findings from this study, we offer the following recommendations:

- **Maintain CCEI trainings and potentially target areas where compliance indicates room for improvement.** Results from the CCEI evaluations indicate the trainings lead to improved building practices. The trainees who attended the residential sessions reported increased understanding of a range of measures, equipment, and installation practices. In addition, the compliance results indicated improved efficiency in nearly all areas. The results from evaluations of the commercial trainings suggested that the greatest areas of impact include building envelope, followed by lighting, and HVAC. While the compliance results showed improved efficiency for both building envelope and HVAC measures, lighting showed a slight decrease despite the attention on this measure category during the trainings. Given the proportion of focus on lighting-related measures, program staff and implementers should assess the effectiveness of these specific areas of the trainings, and future evaluations should include more sensitive instruments to directly gauge the impact on training participants.
- **Consider combining CCEI and RNC program savings.** While there is evidence that both programs are improving efficiency, disaggregating and estimating the related savings is challenging and there does not seem to be a compelling reason for estimating them separately. Given the performance of both programs and fact that they both engage the same market actors, it would be prudent to maintain the programs and consider combining the savings estimates going forward.
- **Include retrofit savings in future studies.** Residential and commercial retrofit projects make up a substantial portion of the market; not claiming savings from these segments may underestimate the impact of the CCEI program. Program staff should consider tracking estimates on the number of retrofit projects that are energy-related and establishing a reasonable level of average savings that would result from those projects. This information would provide the groundwork for future assessments, and would more accurately reflect overall energy impacts of the CCEI program. In a sister memo to this report titled “RI CCEI Residential and Commercial Retrofit Attribution Logic” we provide a potential methodology as well as corresponding energy savings calculations should CCEI reconsider claiming savings for retrofits in the next few years.
- **Consider advocating for code advancement in Rhode Island.** Currently, the timeline for future building energy code changes in Rhode Island is uncertain. The state is still enforcing an amended version of the 2012 IECC that it adopted in 2013, and it is unclear when an improved code will be adopted. Operating under the existing code has resulted in lost energy savings opportunities. While this effort would require careful coordination with a range of stakeholders, advancing energy code adoption in Rhode Island would allow National Grid to potentially claim savings from both expediting the code update process and employing its regular compliance enhancement strategies in concert with the increase in potential savings accompanying a new, more efficient code.

1 Section 1 Introduction

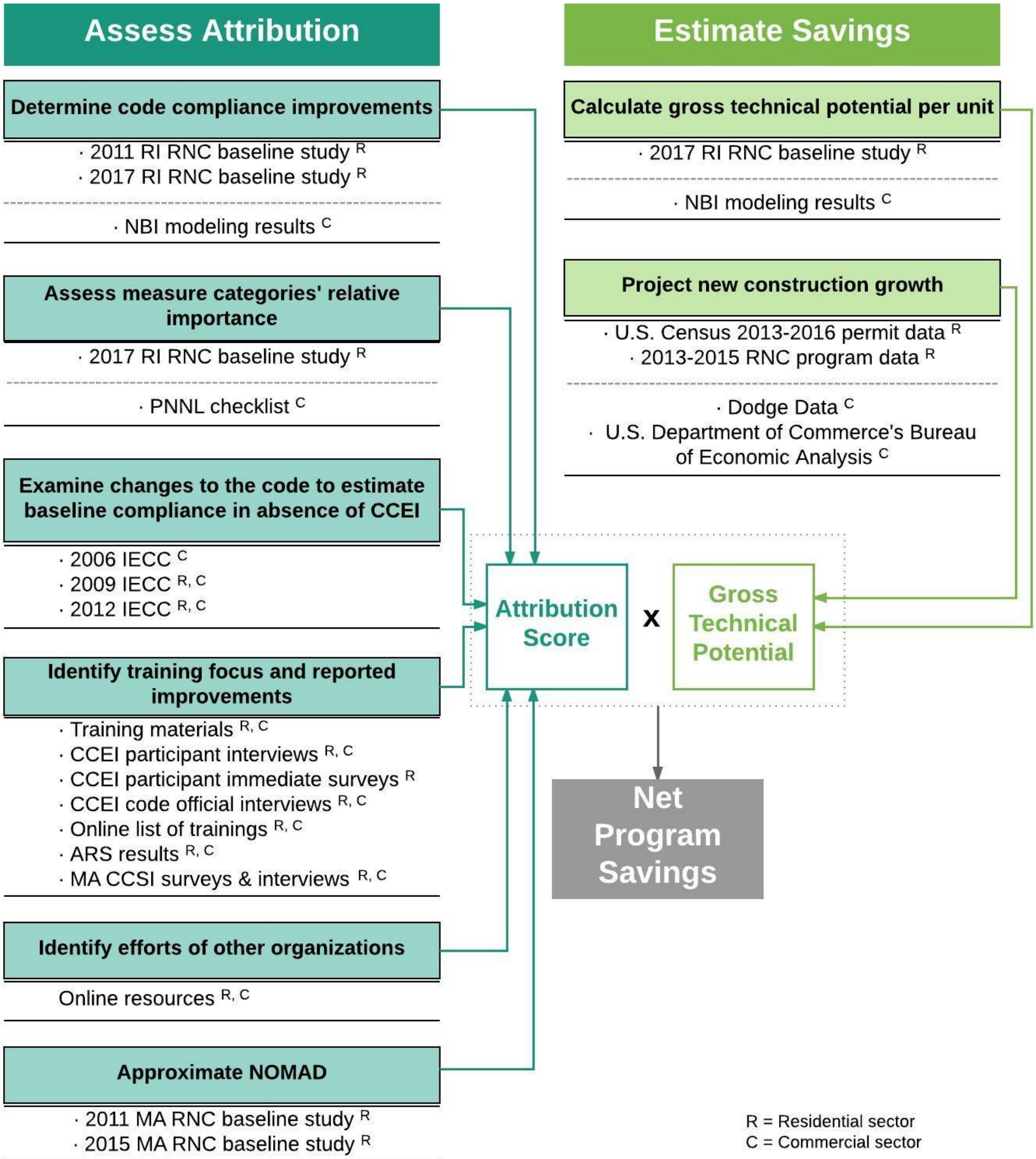
The primary purpose of National Grid Rhode Island's Code Compliance Enhancement Initiative (CCEI) is to improve the energy code compliance rates of residential and commercial buildings in Rhode Island, thereby achieving more electric and gas savings. The overall goal of this study was to estimate the savings that will be attributable to the CCEI in the 2018-2020 period due to enhanced code compliance in the residential and commercial new construction markets.[2]

1.1 Methodology

This report details the findings from the evaluation team's attribution analysis and estimates related to the proportion of savings that can be attributed to CCEI efforts in the residential and commercial new construction markets. This effort drew on multiple sources of data, which are described below in more detail. Figure 1 shows the major steps that we used in assessing attribution and calculating estimated savings. Within each step, we have indicated the source(s) that we used and noted whether it informed the residential or commercial estimates. The report provides more detail regarding underlying assumptions and further explains how each of these components contributed to the overall assessment.

[2] Although residential and commercial retrofits projects represent a sizable portion of savings in these sectors, the C-team determined that, due to a lack of accurate data regarding retrofit activity in Rhode Island, it was not appropriate to estimate these related savings.

Figure 1: Study Approach



1.1.1 Attribution Assessment

The attribution analysis outlines the primary steps involved in the process of estimating residential and commercial attribution values. Although the general logic was largely the same for both sectors, there were key differences based on the nature of the respective markets and key sources of data. The team used an iterative approach to derive the overall attribution scores for residential and commercial new construction, and subsequently projected attribution values for the 2018-2020 period.

1.1.2 Residential New Construction Savings Estimates

The residential savings estimates relied primarily on data from the residential baseline study. This study provided an update on compliance results under the 2012 International Energy Conservation Code (IECC). (Full results will be reported separately.) Results from this study were supplemented by additional data from recent lighting studies in Massachusetts to further refine estimated lighting savings.[3]

1.1.3 Commercial New Construction Savings Estimates

The commercial savings estimates were largely drawn from NBI modeled data from the DNV GL code compliance study. These estimates were used to calculate the technical potential associated with moving from baseline building practices to code compliant building practices. We used additional datasets, such as the Dodge Data and Analytics and the U.S. Department of Commerce's Bureau of Economic Analysis, to estimate market segments, growth, and other trends in the commercial new construction market.

1.2 Report Outline

This report combines the results from the above sources and is organized as follows:

- Section 2 outlines the attribution assessment and provides projected attribution rates for residential and commercial new construction for 2018-2020.
- Section 3 describes the RNC gross savings and net savings estimates.
- Section 4 summarizes the commercial new construction gross savings and net savings estimates.

The team has delivered an Excel workbook that contains the supporting calculations and assumptions for the gross and net savings estimates.

[3] More detail on the lighting savings can be found in Section 3.1.1.

2

Section 2 Attribution Assessment

NMR developed the criteria for attribution based on two key factors: (1) determining which building practices showed improvements from the earlier baseline study to the new baseline study (comparing 2011 and 2017 for residential new construction and comparing 2012 and 2016 for commercial new construction), and (2) assessing which areas were targeted by CCEI. The main steps involved in this process are as follows (some steps built upon or informed the others):

- Examine baseline efficiencies and code compliance results to determine which measures or measure categories have improved over time.
- Review changes to the code to estimate baseline compliance in the absence of the program.
- Summarize the areas of focus of CCEI trainings, and review results from the training evaluations to identify practices for which building professionals have reported improvements.
- Identify efforts of other organizations that may have contributed to enhanced compliance.
- Approximate naturally occurring market adoption (NOMAD) in Rhode Island based on results from two baseline studies in Massachusetts, which measured compliance prior to the implementation of the Massachusetts Code Compliance Support Initiative (CCSI). (Only applies to the residential attribution assessment.)

The main steps for the residential and commercial attribution assessment are largely the same. Table 6 outlines the steps involved in developing attribution estimates and the related sources that informed the assessment.

Table 6: Attribution Logic and Sources

Step	Source(s)	
	Residential	Commercial
Determine code compliance improvements	• NMR 2011 baseline study • NMR 2017 baseline study	• NBI modeling results from DNV GL's 2012 and 2016 baseline studies
Assess measure categories' relative importance	• NMR 2017 baseline study	• PNNL checklist
Examine changes to the code to estimate baseline compliance in the absence of the program	• 2009 IECC • 20012 IECC	• 2006 IECC • 2009 IECC • 2012 IECC
Identify training focus and areas where trainees reported improvements	• Training materials • CCEI immediate surveys • CCEI participant interviews • CCEI code official interviews • Online list of trainings • ARS results • MA CCSI immediate surveys and interviews	• Training materials • CCEI participant interviews • CCEI code official interviews • Online list of trainings • ARS results • MA CCSI immediate surveys and interviews
Identify efforts of other organizations that may have contributed to enhanced compliance	• Various online resources	• Various online resources
Approximate NOMAD	• 2011 MA RNC baseline study • 2015 MA RNC baseline study	• NA

The remainder of this section describes how the evaluation team developed the residential and commercial attribution measure-level or measure category attribution estimates and overall attribution scores, which were used to project savings across the 2018-2020 period.

2.1 Residential Attribution

2.1.1 Determining Code Compliance Improvements

Table 7 displays the measure categories that were considered in this assessment and the results of a measure-level comparison between the 2011[4] and 2017[5] residential baseline

[4] NMR Group, Inc. *Rhode Island 2011 Baseline Study of Single-Family Residential New Construction. Final Report.* October 2012. Available at: http://www.rieermc.ri.gov/documents/evaluationstudies/2012/Final-RI-RNC-2011-Baseline-Report-sent-10-8-12.pdf.

studies. The results show improved efficiencies for nearly all measures. Foundation wall insulation is the only measure that did not exhibit efficiency gains.

2.1.1.1 Measure Categories' Relative Importance

We calculated the relative importance of the nine measure categories based on their relative contributions to overall household energy consumption in the REM/Rate models that were developed as part of the 2017 residential baseline study. The consumption values were converted to percentages based on the proportional importance of each measure (Table 7).

Table 7: Changes in Measure-Level Efficiencies and Relative Importance

Measures (Units)	2011 Efficiency	Current Efficiency	Improved Efficiency	Relative Importance
Window and skylight (U-factor)	0.34	0.31	Yes	20%
Air leakage (ACH50)	5.96	5.24	Yes	19%
Above grade wall insulation (R-value)	17.7	19.8	Yes	17%
Flat ceiling insulation (R-value)	34.6	36.1	Yes	12%
Duct leakage to the outside (CFM25/100 sq. ft. CFA)	20.0	8.6	Yes	10%[1]
Frame floor insulation (R-value)	18.3	20.0	Yes	8%
Lighting (% of fixtures)	16%	66%	Yes	8%
Slab insulation (R-value)	2.5	3.6	Yes	3%
Foundation wall insulation (R-value)	18.6	7.9	No	3%

[1] Includes insulation.

2.1.2 Code Changes and Baseline Assumptions

The primary purpose of reviewing Rhode Island's residential building energy code was to estimate baseline compliance in the absence of the program. For most measures, the code changes from the 2009 IECC to the 2012 IECC appear similar in terms of impact. The most notable changes between the 2009 IECC and 2012 IECC include the following:

- R-values for ceilings (R-38 in 2009 IECC and R-49 in 2012 IECC)[6]
- Air leakage (7 ACH50 in 2009 IECC and 3 ACH50 in 2012 IECC)[7]

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[5] NMR Group, Inc. *Rhode Island 2017 Baseline Study of Single-Family Residential New Construction. Forthcoming.*

[6] The Rhode Island SBC-8 State Energy Conservation Code which adopted the 2012 IECC in 2013, amended the 2012 IECC to require R-38 in ceilings as opposed to R-49

[7] The Rhode Island SBC-8 State Energy Conservation Code which adopted the 2012 IECC in 2013, amended the 2012 IECC to require blower door testing of air leakage but with no prescriptive threshold.

- Duct leakage (8 CFM25/100 sq. ft. of leakage to outside in 2009 IECC and 4 CFM25/100 sq. ft. of total leakage in 2012 IECC)[8]
- Lighting (50% efficient lighting in 2009 IECC and 75% efficient lighting in 2012 IECC)

The code changes in Rhode Island between the adoption of the 2009 IECC and the 2012 IECC are not as drastic as listed above because of amendments made to the 2012 IECC with the Rhode Island SBC-8 State Energy Conservation Code of 2013. In SBC-8, Rhode Island changed the R-49 ceiling requirement to maintain the 2009 IECC requirement of R-38, eliminated the air leakage requirement and replaced it with just a requirement for testing, and increased the duct leakage requirement from 4 CFM25/100 sq. ft. total leakage to 8 CFM25/100 sq. ft. total leakage.

The timeline for future code changes in Rhode Island is unclear. The state is still enforcing an amended version of the 2012 IECC that it adopted in 2013. Given that there is no indication that Rhode Island will be adopting a more stringent residential code in the near future, it is reasonable to assume that residential buildings completed in the 2018-2020 period will all be built under the 2012 IECC amended requirements.[9]

2.1.3 CCEI Training Focus and Effect on Practices

A key aspect of assessing which building practices were targeted by the CCEI involved a review of the training materials. CLEAResult offered three types of residential trainings: Envelope and Building Science, HVAC and Indoor Air Quality (HVAC-IAQ), and Overview (which covered multiple topics). Overall, roughly 100 hours of residential trainings were offered between 2014 and 2016. Air leakage received the greatest emphasis (approximately 44 hours or 44% of all training hours). Air leakage was covered in all of the classroom trainings and CLEAResult also offered a separate in-field training, which covered blower door test concepts and procedures. Other areas that were emphasized by the CCEI include ceiling insulation (12 hours or 12%), above grade wall insulation (11 hours or 11%), and duct leakage and insulation (11 hours or 11%).

[8] The Rhode Island SBC-8 State Energy Conservation Code which adopted the 2012 IECC in 2013, amended the 2012 IECC to require total duct leakage of 8 CFM25/100 sq. ft. as opposed to 4 CFM25/100 sq. ft.

[9] This assumption maintains consistency with the gross technical potential savings modeling effort and results in conservative estimates of projected compliance improvements and attribution.

Table 8: CCEI Residential Training Focus

Measure	Estimated Hours	Percentage
Air leakage	44.4	44%
Ceiling insulation	11.9	12%
Above grade wall insulation	11.3	11%
Duct leakage	11.5	11%
Window and skylight	4.3	4%
Slab insulation	2.6	3%
Lighting	1.0	1%
Frame floor insulation	0.2	0%
Foundation wall insulation	0.0	0%
Other (mechanical ventilation, fans, HVAC systems)	13.3	13%
Total	**100.5**	**100%**

To inform the proportion of code compliance that can be attributed to CCEI efforts, and to develop attribution factors for the program, we took into account training participants' assessment of the effects of the trainings on their professional practices. The primary sources of CCEI residential training data include immediate surveys from three 2017 residential trainings (n=53), participant interviews (n=3), code official interviews (n=28),[10] and Audience Response System (ARS) data from 2014 to 2016 (with n varying from 350 to 357). Appendix A includes brief summaries of each of these sources.

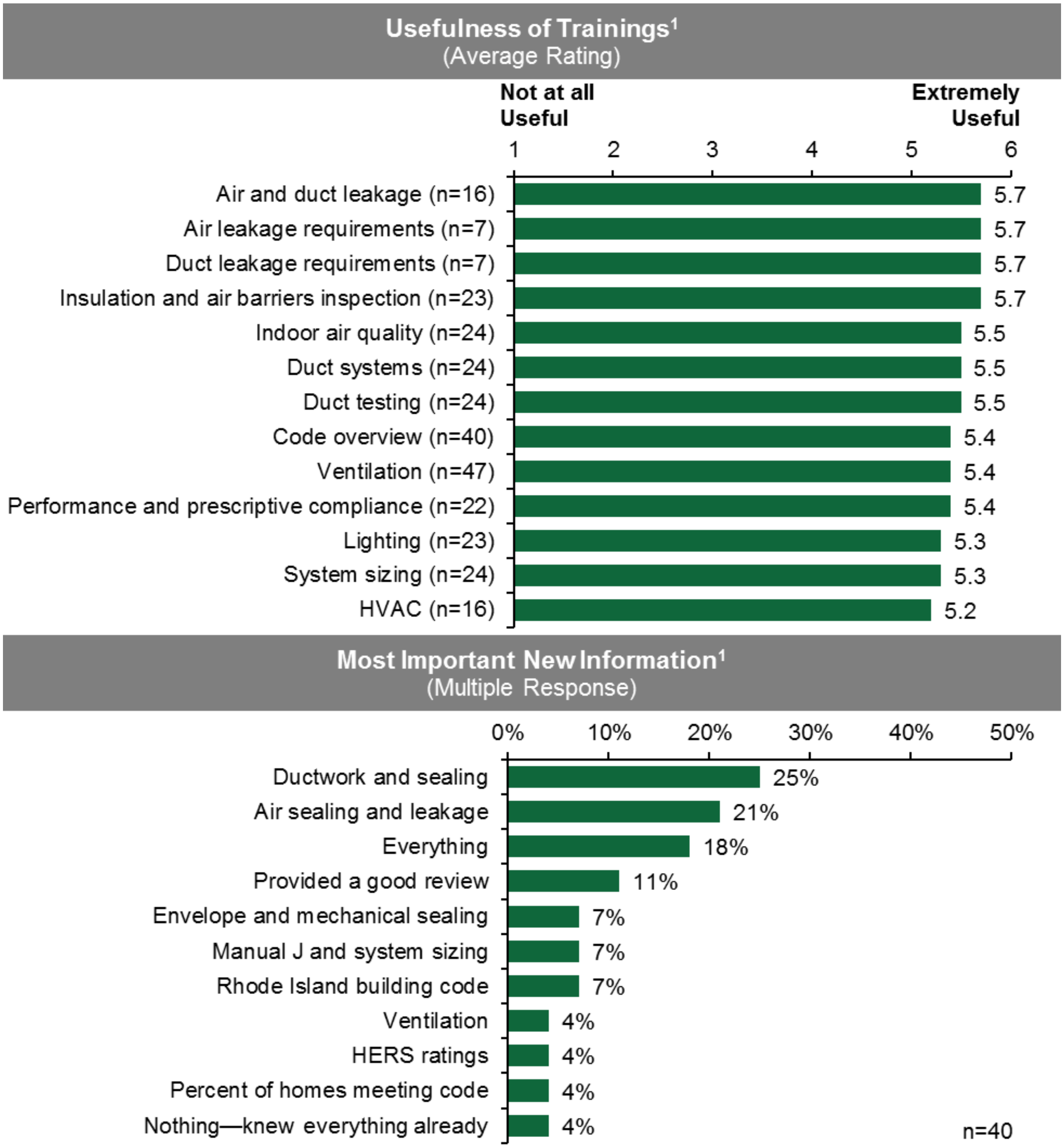
Overall, according to training evaluation results, the measures most directly affected by the trainings include air leakage, duct leakage, and insulation. Findings from the individual evaluation efforts are described in more detail below.

2.1.3.1 CCEI Immediate Surveys

Immediate survey results indicate that respondents felt that the training was useful and provided new information. The *most useful aspects of the training* (according to average ratings) are insulation and air barriers inspection and components addressing air and duct leakage (Figure 2). The immediate surveys did not distinguish type of insulation (e.g., wall, ceiling, floor, etc.), so we are limited in our ability to assess direct impacts in those specific areas. When asked about the *most important new information* provided by the trainings, respondents most often cited ductwork and sealing, followed by air leakage and sealing.

[10] NMR reviewed the findings from 28 Rhode Island code officials' IDIs, conducted by DNV GL in the fall of 2016, that are applicable to the CCEI assessment.

Figure 2: Usefulness of Trainings and Importance of Information



[1] Not all topics were covered at each of the three trainings, and some surveys used slightly different phrasing. As a result, the number of respondents for each individual survey question is shown above.

2.1.3.2 CCEI Participant Interviews

All three of the interviewees indicated that they changed their practices as a result of the training. The builder who attended the HVAC-IAQ training provided the most detailed description. He reported improved practices related to duct work installation, and increased attention to efficient equipment and materials. The other two interviewees provided much

less detailed information, but generally expressed that the trainings contributed to their improved knowledge and understanding of efficient practices.

2.1.3.3 ARS Results

The ARS results strongly suggest that CCEI trainings would influence trainees' practices, but there were only slight differences by the focus of training. As Table 9 shows, respondents generally reported positive results in all areas associated with applying the training to their work. Although there were no ARS items related to specific measures, the positive and strong results, coupled with results from the immediate surveys, indicate that the trainings likely affected at least some of the attendees' building practices.

Table 9: Assessment of CCEI Trainings

Item	Building Envelope	HVAC-IAQ	Overview
I am better prepared to comply with/enforce energy code	80%	81%	81%
Information I learned will influence my work	85%	81%	84%
My knowledge of building science principles has increased	75%	76%	78%

Note: Results include respondents who reported 1 or 2 on a 6-point scale, where 1 equals strongly agree and 6 equals strongly disagree.

2.1.3.4 CCEI Code Official interviews

Twenty-three of the 28 code officials interviewed (82%) reported that they had attended a CCEI training, and a considerable proportion indicated that they had improved their knowledge or changed enforcement practices. Of the interviewees who attended the CCEI trainings, 69% said the trainings had influenced their knowledge of the current code and about one-half (48%) said the trainings had influenced their enforcement practices for the energy code. This suggests that 57% (0.82*0.69) of code officials improved their knowledge of the current code and 40% (0.82*0.48) changed their enforcement practices based on the trainings. While these results are not sector- or measure-specific, they do indicate that the trainings had an overall positive effect on code officials' professional practices.

2.1.3.5 MA CCSI Immediate Surveys and Interviews

In addition to reviewing evaluation results from Rhode Island, we examined findings from the Massachusetts' CCSI training evaluations since the trainings also are implemented by CLEAResult there. Overall, the evaluation results were generally consistent with CCEI and confirmed that the trainings are likely to have a positive effect on building practices.

2.1.4 Review of Other Rhode Island Compliance Efforts

In addition to reviewing the CCEI training efforts, NMR sought to identify other efforts designed to support code compliance in Rhode Island. The Rhode Island Building Code Compliance Commission links to the CCEI webpage from its website, and the Rhode Island Builders Association partners with the program to host trainings; however, it generally

appears that other entities have little to no direct impact on residential code compliance. As a result, there is no justification for incorporating these other entities into the residential attribution assessment. Below is a summary of the other organizations that we included in this review:

- **Rhode Island Building Code Compliance Commission (RIBCC):** The RIBCC advertises one Building Code course on their website, which was offered one time per week from February 1 – March 15 2017. However, according to the course syllabus, the class only covers Chapters 3-10 of SBC-2 and Chapters 3-10 of SBC-1, while the energy efficiency chapter of Rhode Island's state building code is covered in Chapter 13. Moreover, as of April 2017, there were no additional seminars listed online and a link on RIBCC's website directed users to National Grid's Energy Code Technical Support trainings.
- **Rhode Island Builders Association:** Current RIBA educational programs focus on OSHA safety standards and EPA lead certification. Many of National Grid RI's CCEI trainings were hosted at RIBA's headquarters in East Providence, which indicates indirect code compliance support.
- **Rhode Island American Institute of Architects (AIAri):** AIAri offers opportunities for architects to earn their continuing educations credits and lists CCEI's code compliance classes on their calendar, but AIAri offers no additional code compliance trainings of their own.
- **Apeiron Institute for Sustainable Living;** The Apeiron Institute is a sustainability education and advocacy non-profit based in Providence. However, it appears that the website has not been updated in the last two years, and the organization may no longer be active.
- **Rhode Island Department of Energy Resources (RI OER):** RI OER "provides a number of incentives and loan opportunities through the state's energy efficiency programs for homes, businesses, and municipalities." However, we did not find any compliance trainings listed on the RI OER website or any direct references to CCEI training opportunities**.**
- **Northeast Energy Efficiency Partnerships (NEEP):** NEEP supports RI's public policy initiatives, maintains the REED database, and offers trainings on strategic energy management and varied energy efficiency topics at their annual summit. While NEEP's efforts are notable for their research and reporting on energy efficiency topics, including building energy codes, their workshops are not focused on code compliance.

2.1.5 Naturally Occurring Market Adoption

To approximate the level of naturally occurring market adoption (NOMAD) for each measure, the team looked at baseline study results from two Massachusetts studies: the 2011 baseline and the 2015 baseline. The 2011 Massachusetts baseline included homes built during the beginning of the 2009 IECC code-cycle in Massachusetts (Table 10). The 2015 Massachusetts baseline included a sample of homes built at the end of 2009 IECC code-cycle in Massachusetts and a sample built at the beginning of the 2012 IECC code-cycle. Crucially, during the time of construction for homes in both baseline studies,

Massachusetts did not have a training-related program to increase code compliance. Therefore, by comparing baseline results from the 2011 baseline to the 2009 IECC group of the 2015 baseline, the team can estimate a proxy for NOMAD over the period of the 2009 IECC as builders and other market actors became more accustomed to the code requirements (column G in Table 10). Additionally, the early 2012 IECC sample can be compared to the late 2009 IECC sample to estimate a proxy for impacts resulting from the adoption of 2012 IECC requirements (column H). Such a proxy only works for measures in which Massachusetts and Rhode Island enforced similar 2012 IECC requirements. In other words, it does not apply to measures such as air leakage and ceiling insulation, which Rhode Island amended. *It should be noted that a substantial amount of non-participant spillover from the RNC program has been measured in Massachusetts. That said, if we assume that the RNC spillover was the same for the beginning and end of 2009 IECC baseline inspections in Massachusetts, then we can assume that the net efficiency change is still representative of NOMAD and can be applied to Rhode Island.* Table 10 compares measure-level results from the studies for the two states.

Table 10: Comparison of Rhode Island and Massachusetts Efficiency Changes

Measures (Units)	Rhode Island			Massachusetts					
	A	B	C	D	E	F	G	H	I
	2011 Efficiency	Current Efficiency	Relative Improvement B-A	2011 Baseline	2015 Baseline (End of 2009 IECC)	2015 Baseline (Beginning of 2012 IECC)	Relative improvement under 2009 IECC E-D	Change from 2009 IECC to 2012 IECC F-E	Overall Relative Improvement G+H
Window and skylight (U-factor)[1]	0.34	0.31	0.03	0.34	0.32	0.29	0.02	0.03	0.05
Air leakage (ACH50)[1]	5.96	5.24	0.72	4.78	4.80	3.60	-0.02	1.2	1.18
Above grade wall (R-value)	17.7	19.8	2.1	19.4	20.3	20.6	0.9	0.3	1.2
Flat ceiling (R-value)	34.6	36.1	1.5	36.8	39	42.4	2.2	3.4	5.6
Duct leakage to the outside (CFM25/100 sq. ft. CFA)[1]	20.0	8.6	11.4	12.4	6.3	3.9	6.1	2.4	8.5
Frame floor (R-value)	18.3	20	1.7	26.7	29.6	31.8	2.9	2.2	5.1
Lighting (% of efficient sockets)	16%	66%	50%	23%	45%	47%	22%	2%	24%
Slab (R-value)[1]	2.5	3.6	1.1	--	--	--	--	--	--
Foundation wall (R-value)	18.6	7.9	-10.7	--	--	--	--	--	--

[1] Lower values for window and skylight, air leakage, and duct leakage indicate improved efficiency. The relative improvement (absolute value) for all measures are reported above.

2.1.6 Estimated Attribution Values

It is difficult to quantify the exact proportions of improved measure efficiency that can be attributed to the CCEI, but our qualitative assessment, taking into consideration the various factors above, provides some general estimates. To determine the efficiency gains attributable to CCEI, baseline improvements between the 2011 baseline and 2017 baseline studies were compared to the following factors:

- Indications of naturally occurring market adoption (which would decrease the amount attributable to CCEI)
- Increases in code stringency (which would decrease the amount attributable to CCEI)
- The time spent on training for each measure in the CCEI program (which could affirm the amount attributable to CCEI)
- Program participant's responses to the training surveys (which could affirm the amount attributable to CCEI)

Based on our analysis, we assume that NOMAD accounts for virtually all the increased efficiency for the following measures:

- Window and skylight U-factor
- Frame floor insulation
- Ceiling insulation

In addition, based on the magnitude of the improved efficiency, the lower relative importance of the measure, and the relatively lower impact of the trainings, it is safe to assume that the CCEI program had little to no direct effect on the following measures:

- Slab insulation
- Foundation wall insulation

As a result, the CCEI appears to warrant attribution for the following select measures:

- **Air Leakage:** The CCEI trainings focused heavily on air sealing practices and the majority of the participants indicated that the trainings have or would positively affect their practices. Furthermore, NOMAD seems to have had little effect on this practice. The 2009 code-cycle NOMAD is near zero in Massachusetts. Additionally, there is almost no NOMAD or code-driven change from the switch from the 2009 IECC to the amended 2012 IECC in Rhode Island because the amended Rhode Island code does not have a prescriptive threshold.[11] Still, the team assumes some code-driven increases from the adoption of the 2012 IECC because of the requirement that buildings undergo a performance-based air leakage test. The team assumes that 25% of the air leakage improvements in Massachusetts between the end of the 2009 IECC and the beginning of the 2012 IECC are driven by the

[11] Based on trainings, it is safe to assume that builders knew only testing was required and that there was no prescriptive threshold.

requirement that all homes have a performance-based blower door test.[12] In Rhode Island, air leakage improved from 5.96 ACH50 to 5.24 ACH50. Given these factors, we estimate that 60% of this improvement is attributable to CCEI.

- **Above grade wall insulation:** Since the requirement did not change between the 2009 IECC and the 2012 IECC, all baseline improvement over time in Massachusetts is assumed to be NOMAD. From the beginning of the 2009 code cycle to after the adoption of the 2012 IECC, NOMAD led to an increase in Massachusetts of R-1.2. In Rhode Island, the improvement over the same time period was R-2.2. Therefore, NOMAD appears to account for at least half of the improvement. Since NOMAD accounts for half of the change and survey responses only indicated a moderate impact on practices, we have estimated that 35% of the change in Rhode Island can be attributed to CCEI.
- **Duct leakage:** The CCEI trainings have a strong emphasis on duct sealing, which is an area that trainees mentioned improved practices. The NOMAD under the 2009 IECC in Massachusetts (6.1) would account for more than half the change in Rhode Island (11.4), and the adoption of 2012 IECC in MA accounts for an additional portion, although this entire amount is not completely applicable since the Rhode Island amended code has a different stringency. Thus, we have estimated that 45% of the increased efficiency can be attributed to CCEI.
- **Lighting:** In Rhode Island, there was a substantial increase in the percentage of efficient lighting between the baseline studies (66% from 16%); at the same time, there was a major increase in code stringency. In Massachusetts, the 2009 IECC code-cycle NOMAD resulted in a doubling of the percentage of efficient lighting; there was a slight increase in compliance after the adoption of the 2012 IECC. In Rhode Island, after accounting for a doubling of compliance due to NOMAD, a 34% increase in compliance is still unaccounted for. Factoring in the low impact of training, indicated by survey responses and training time spent on lighting, we estimate that a 20% increase in efficiency is attributable to CCEI.

[12] In Massachusetts, there was a decrease of 1.2 ACH50 between the late 2009 IECC sample and the early 2012 IECC sample. In Rhode Island, there was a decrease of 0.72 ACH50 between the 2009 IECC and amended 2012 IECC. Since the amended 2012 IECC in Rhode Island only included a requirement of performance testing and did not include an actual ACH50 threshold, only 25% (0.3) of the Massachusetts proxy is considered applicable. Therefore, we assume 0.42 ACH50 or about 60% of the decrease in ACH50 in Rhode Island is attributable to the program.

Table 11 summarizes the factors related to the measure-level attribution assessment that are described above.

Table 11: Factors Related to Measure-Level Attribution

Measures (Units)	Improved Efficiency	Measure's Relative Importance	Impact of Training	Is improved efficiency in RI > NOMAD?
Window and skylight	Yes	20%	Low	No
Air leakage	Yes	19%	High	No
Above grade wall insulation	Yes	17%	Medium	Yes
Ceiling insulation	Yes	12%	Medium	No
Duct leakage	Yes	10%	High	Yes
Frame floor insulation	Yes	8%	Medium	No
Lighting	Yes	8%	Low	Yes
Slab insulation	Yes	3%	Low	--
Foundation wall insulation	No	3%	Low	--

High/Yes	Medium	Low/No

Based on this information, as noted above, it seems reasonable to apply an attribution score of 60% to air leakage, 35% to above grade wall insulation, 45% to duct leakage and insulation, and 20% to lighting. The overall attribution score of 23% is calculated by multiplying the measure-level attribution scores by their relative importance (Table 12).

Table 12: Residential Attribution Scores for CCEI

Measures	Relative Importance of Measure (A)	% Attributable to CCEI (B)	Measure Attribution Score (A*B)
Window and skylight U-factor	20%	0%	0%
Air leakage	19%	60%	11%
Above grade wall insulation	17%	35%	6%
Ceiling insulation	12%	0%	0%
Duct leakage and insulation	10%	45%	5%
Frame floor insulation	8%	0%	0%
Lighting	8%	20%	2%
Slab insulation	3%	0%	0%
Foundation wall insulation	3%	0%	0%
Attribution Score (Sum of Component Scores)			***23%***

2.2 Projecting Residential Attribution Across the 2018-2020 Period

- The compliance rates and attribution estimates are based on information that reflects evaluation results from trainings that took place between 2014 and 2016 and buildings that were completed in 2015, 2016, and 2017 (as part of the 2017 residential baseline study). That said, the purpose of this evaluation is to project the savings attributable to the CCEI for the 2018-2020 period.

Table 13 presents the calculations that are used to project compliance and CCEI attribution over time. The following bullets explain the values that are included in this table and the logic that was used to develop the values.

- **Beginning of 2012 IECC Compliance Estimate:** This value is assumed to be 74% based on the results of the code compliance analyses that were conducted as part of the 2017 residential baseline study. The Team calculated two compliance scores—one using the MA-REC compliance methodology and one using the PNNL compliance methodology. Compliance scores from the current study were 80% using the MA-REC approach and 63% using the PNNL approach. The 2011 study only calculated compliance using the PNNL approach; the compliance score in that study was 58%. We used a ratio of MA-REC-to-PNNL compliance scores from the current study to estimate what the MA-REC compliance score would have been in the 2011 study. Those calculations result in a compliance estimate of 74% using the MA-REC methodology for the 2011 sample of homes. The 2011 study homes were built at the beginning of the 2009 IECC cycle. We assume that in the absence of the CCEI program, compliance at the beginning of the 2012 IECC cycle would have been the same as at the beginning of the 2009 IECC cycle.
- **Annual Compliance Estimates:** The 2016 compliance estimate is the MA-REC compliance score that was calculated as part of the residential baseline study. Homes in the baseline study were built in 2015, 2016, and 2017. Based on this, we believe the average compliance score most represents homes built in 2016.[13] We project compliance to increase slightly over time since we expect that the code will not be changing in Rhode Island. We assume a compliance cap of 88% will be achieved by 2020. Compliance is capped based on the relatively modest improvement that has taken place between the 2011 and 2017 residential baseline studies and the fact that we anticipate there will always be a certain level of non-compliance in the residential new construction market.
- **Annual Non-Compliance Estimates:** This is simply the remaining non-compliance in the residential new construction market each year.
- **Attribution Estimate:** This is the overall score that is detailed in Table 12. Rhode Island appears to be in a state of flux regarding an updated energy code, and, as a result, we assume that the residential code is unlikely to change for the projected attribution period. We also anticipate that trainings will continue during the projected

[13] Forty homes were inspected as part of this study. Of those 40 homes, 12 were built in 2015, 25 were built in 2016, and three were built in 2017.

period. Based on these factors, we feel it is appropriate to assume a stable attribution estimate for the projected attribution period.

- **Compliance without the CCEI:** This is a calculated value based on the variables that are discussed above. This value represents NOMAD.
- **Compliance Attributable to CCEI:** This is the difference between measured compliance rates with CCEI influence and our estimate of compliance without the program.
- **Percentage of Maximum Potential Improvement Attributable to CCEI:** This is a calculated value that is ultimately used to calculate net savings. This value represents the compliance percentage that is attributable to the CCEI divided by the overall level of non-compliance that would exist in the absence of the program.

Table 13: Residential Compliance and CCEI Attribution Over Time

	2014	2015	2016	2017	2018	2019	2020
Beginning of 2012 IECC Compliance Estimate (A)	74%						
Compliance Estimate (B)	76%	78%	80%	82%	84%	86%	88%
Non-Compliance Estimate (C) *Calculation: (1-B)*	24%	22%	20%	18%	16%	14%	12%
Attribution Estimate (D)	23%						
Compliance without the CCEI (E) *Calculation: ((B-A)*(1-D))+A*	75.5%	77.1%	78.6%	80.1%	81.7%	83.2%	84.7%
Compliance Attributable to CCEI (F) *Calculation: (B-E)*	0.5%	0.9%	1.4%	1.9%	2.3%	2.8%	3.3%
Percentage of Maximum Potential Improvement Attributable to CCEI ***Calculation: F/(1-A)***	**1.8%**	**3.6%**	**5.4%**	**7.2%**	**9.0%**	**10.8%**	**12.6%**

2.3 Commercial Attribution

2.3.1 Determining Code Compliance Improvements

The team reviewed DNV GL's 2016 Code Compliance Study and the related energy modeling results from the New Buildings Institute (NBI) to determine which individual measures and measure categories (e.g., Lighting, Building Envelope, and HVAC) displayed improved efficiencies between the 2012 and 2016 commercial code compliance studies. The NBI modeling results assess gross technical potential savings from compliance enhancement by comparing the baseline building practices to the 2009 IECC and 2012 IECC code requirements. This modeling effort was conducted for both the 2012 baseline study buildings and the 2016 baseline study buildings. Using these results, we are able to identify which measures have improved between the two baseline studies. If a measure displayed lower potential savings in 2016 than in 2012, then the measure showed improvement and warrants inclusion in the attribution assessment. Alternatively, if a measure displayed the same potential savings or higher potential savings, then the measure did not improve in efficiency and therefore warrants little consideration in the attribution assessment.

Table 14 displays the measures and measure categories that were considered in this assessment, along with the results of the NBI comparison between the 2012 and 2016 studies. The "Delta kBtu/sf" column displays the change in savings potential between the 2012 and 2016 studies when compared to the 2009 IECC requirements. These values were calculated by subtracting the 2016 potential savings from the 2012 potential savings. Positive savings indicate that the potential savings decreased between the two studies; therefore, the efficiency of the measure category improved. Negative savings indicate an increase in potential savings and a decrease in efficiency. Our review of the NBI data revealed improved efficiencies for building envelope and HVAC measures, but not for lighting (see Table 14). These results from the NBI data are supported by the 2016 DNV GL study, which showed that the lighting measure category only displayed a 1% improvement in compliance between the 2012 and 2016 compliance studies. Based on these findings, we determined that the savings that may be attributed to lighting are relatively small.

2.3.1.1 Measure Categories' Relative Importance

We calculated the relative importance of the three measure categories from the DNV GL compliance report and the NBI analysis using the Pacific Northwest National Laboratory (PNNL) code compliance checklist point system, which provides building energy code compliance guidelines. The PNNL checklist uses a three-point system to value various building characteristics that contribute to overall building efficiency and compliance. The three tiers include the following: 1=High Impact (Tier 1), 2=Medium Impact (Tier 2), 3=Low Impact (Tier 3). Adding up the points for individual measures that match with those included in the DNV GL report and the NBI data revealed that HVAC has the greatest relative value (46% of all points), followed by Building Envelope and Lighting (39% and 15%, respectively).

Table 14: Changes in Code Compliance and Relative Importance

Measure Category	Individual Measures	Delta kBtu/sf	Improved Efficiency Over Time	Relative Importance
Lighting	LPD	-0.60	No	15%
	Light controls			
	Exterior lighting			
Building Envelope	Wall insulation	1.15	Yes	39%
	Roof insulation			
	Slab			
	Fenestration			
	Infiltration			
HVAC	Cooling efficiency	2.72	Yes	46%
	Heating efficiency			
	Fan horsepower			
	Duct leakage			
	Economizer			
	DHW			

	DCV			

2.3.2 CCEI Training Focus and Effect on Practices

As with the residential attribution assessment, a key aspect of assessing which building practices were targeted by the CCEI involved a review of the training materials. The commercial trainings ranged from one to three hours and were conducted in the field, in a classroom setting, or online. Aligning the training topics with the measure categories from the commercial baseline studies shows that building envelope received the greatest emphasis (roughly 38 out of 93 hours or 41%), followed by lighting (31 hours or 41%) and HVAC (24 hours or 25%).

To inform the proportion of code compliance that can be attributed to CCEI efforts, and to develop attribution factors for the program, we considered training participants' assessment of the effects of the trainings on their professional practices. The primary sources of CCEI commercial training data include participant interviews (n=3), ARS data (n varies between 18 and 305), and code official interviews (n=28).[14] In addition to these sources, the team reviewed results from evaluations of Massachusetts' Code Compliance Support Initiative (CCSI) commercial training, which included immediate surveys (n=100) and in-depth interviews (n=30).

The findings from the CCEI-related surveys and interviews indicated that the trainings increased trainees' knowledge and understanding of code compliance issues and that the trainings influenced their professional practice. The ARS results provided the most detail regarding the focus of the trainings. These results show that the greatest areas of impact include building envelope, followed by lighting and HVAC.

2.3.2.1 CCEI Participant Interviews

Based on interviews with the three commercial training participants, the CCEI generally had a positive impact. Two out of three respondents reported that they found the training useful, would share the information with others, and would recommend the training. All three participants were aware of the technical support provided by the program. Only one of the three interviewees (a lighting designer) indicated that they changed their practices as a result of the training.

2.3.2.2 ARS Results

The ARS results strongly suggest that CCEI trainings would influence trainees' practices. Examining the data by type of training shows that the building envelope trainings had the highest ratings for this item, followed by lighting-related trainings, then HVAC trainings (Table 15). Respondents generally reported positive results in all areas associated with applying the training to their work. Ratings for lighting-related trainings were generally

[14] Appendix A: Sources of Evaluation Data for the CCEI Trainings provides brief descriptions of each of these sources.

higher than the others, but as noted above, there was only a 1% increase in compliance in this area.

Table 15: Assessment of CCEI Trainings

Item	Training Focus		
	Building Envelope	HVAC	Lighting
Better prepared to comply with/enforce energy code	86%	80%	89%
Information will influence my work	89%	83%	84%
Knowledge of building science principles has increased	84%	80%	84%
Knowledge of [training topic] has increased	Not asked	78%	90%

Note: Results include respondents who reported 1 or 2 on a 6-point scale where 1 equals strongly agree and 6 equals strongly disagree.

2.3.2.3 CCEI Code Official interviews

As noted in the discussion of the residential attribution assessment (Section 2.1.3.4), 23 of the 28 code officials interviewed (82%) reported that they had attended a CCEI training. Of the interviewees who attended the CCEI trainings, we estimate that 57% of code officials improved their knowledge of the current code and 40% (0.82*0.48) changed their enforcement practices based on the trainings. Although these results are not specific to a particular sector or measure, they do generally indicate that code officials reported positive outcomes as a result of the training.

2.3.2.4 MA CCSI Immediate Surveys and Interviews

Results from the MA CCSI commercial training surveys and interviews with trainees supported the findings from the CCEI commercial trainings. For example, results from the immediate surveys suggest that the largest relative influence was on knowledge of building envelope practices. In addition, 50% of building professional interviewees stated that they had changed their practices as a result of the training.

2.3.3 Review of Other Rhode Island Compliance Efforts

As noted in the discussion of the residential attribution assessment (Section 2.1.4), the team sought to identify other organizations designed to support code compliance in Rhode Island. The results from our review of these entities and their efforts indicate that they have little or no direct impact on commercial (or residential) code compliance, and, therefore, are not included in our attribution assessment.

2.3.4 Code Changes and Baseline Assumptions

The primary purpose of reviewing the code is to estimate baseline compliance in the absence of the program. Overall, the code changes from the 2006 IECC to the 2009 IECC and from the 2009 IECC to the 2012 IECC appear similar in terms of impact. The DNV GL

study found an overall compliance rate of 78% for the 2012 study buildings, which is our best estimate of baseline compliance for buildings built at the beginning of the 2012 IECC cycle. The timeline for code changes in RI is unclear, but given the lag time in commercial construction (assumed to be one to five years), it is reasonable to assume that commercial buildings completed in the 2018-2020 period will all be built under the 2012 IECC requirements.

2.3.5 Estimated Attribution Values

These various sources of information provide insight into the factors that contribute to attribution and their relative importance. While it is difficult to quantify the exact proportions, our qualitative assessment indicates that, on average, the building envelope category should have the highest attribution rate, followed by HVAC and lighting. Table 16 shows the relative rankings on the individual factors.

Table 16: Factors Related to Attribution and Relative Measure Category Contribution

Measure Category	Attribution Assessment Rankings			
	Improved Efficiency	Measure Category's Relative Importance	Training Focus	Impact of Training
Building Envelope	Medium	Medium	High	Medium
HVAC	High	High	Low	Low
Lighting	Low	Low	Medium	High

Based on this evidence, we feel a general starting point for overall CCEI attribution would be 50% for the building envelope and HVAC measure categories. While lighting has shown little to no improvement between the 2012 and 2016 baseline studies (a 1% increase in compliance), we feel an attribution score of 25% is appropriate. This score is influenced by the fact that the CCEI has held lighting specific trainings and the training evaluation results indicate that attendees find the lighting trainings the most useful. We assume that lighting compliance will increase over the 2018-2020 period, a portion of which will be attributable to CCEI. Given that the trainings focused more on building envelope rather than HVAC, it seems the attribution score should be different for the two groups. Furthermore, the increase in code compliance for building envelope items specifically was much larger than for HVAC and lighting. The immediate survey results also suggest that building envelope training has been the most valuable, which would justify a slightly higher attribution level. Based on these results, it seems reasonable to apply a 55% attribution score to building envelope, 45% to HVAC, and 25% to lighting. The overall attribution score of 46% is calculated by multiplying the measure category attribution scores by their relative importance (Table 12).

Table 17: Commercial Attribution Scores for CCEI

Measure Category	Individual Measures	Relative Importance of Category (A)	% Attributable to CCEI (B)	Measure Category Attribution Score (A*B)
Lighting	LPD	15%	25%	4%
	Light controls			
	Exterior lighting			
Building Envelope	Wall insulation	39%	55%	21%
	Roof insulation			
	Slab			
	Fenestration			
	Infiltration			
HVAC	Cooling efficiency	46%	45%	21%
	Heating efficiency			
	Fan horsepower			
	Duct leakage			
	Economizer			
	DHW			
	DCV			
Attribution Score (Sum of Component Scores)				***46%***

2.4 Projecting Commercial Attribution Across the 2018-2020 Period

Table 18 presents the calculations that are used to project compliance and CCEI attribution over time. The following explain the values that are included in this table and the logic that was used to develop the related values.

- **Beginning of 2012 IECC Compliance Estimate:** This value is assumed to be 78% based on the commercial baseline compliance studies. This was the overall compliance value identified in the 2012 baseline study, which included buildings permitted at the end of the 2006 IECC and the beginning of the 2009 IECC. The 2016 study includes buildings that were permitted at the end of the 2009 IECC and the beginning of the 2012 IECC. The current study shows that the compliance rate, under the PNNL method, is identical when comparing the 2016 study homes to the 2009 IECC and the 2012 IECC. If we assume the same relationship existed in the previous study, then the 78% value, which included buildings from the beginning of the 2009 IECC cycle, can be applied as an estimate for compliance from the beginning of the 2012 IECC cycle that does not include influence from the CCEI.
- **Annual Compliance Estimates:** The 2014 compliance estimate comes directly from the 2016 commercial code compliance baseline study. This study includes buildings that were completed in 2013, 2014, and 2015. As a result, we assume the

average compliance rate from the study mostly represents buildings completed in 2014. We project compliance to increase slightly over time since the code is not changing in RI. We assume a compliance cap of 95% (to be achieved by 2019). Compliance is capped because we assume that there will always be a certain level of non-compliance in the commercial new construction market.

- **Annual Non-Compliance Estimates:** This is simply the remaining non-compliance in the commercial new construction market each year.
- **Attribution Estimate:** This is the overall value that is detailed in Table 12. We assume attribution to be stable over the evaluation period. We assume a stable attribution rate because we anticipate that trainings will continue and we also assume that commercial new construction has a lag time of one to five years from permit to construction completion. Due to the lag time, we assume that trainings from 2014, 2015, and 2016 could impact construction practices through the 2018-2020 period.
- **Compliance without the CCEI:** This is a calculated value based on the variables that are discussed above. This value represents NOMAD.
- **Compliance Attributable to CCEI:** This is the difference between measured compliance rates with CCEI influence and our estimate of compliance without the program.
- **Percentage of Maximum Potential Improvement Attributable to CCEI:** As with the residential attribution, this is a calculated value that is ultimately used to calculate net savings. This value represents the compliance percentage that is attributable to the CCEI divided by the overall level of non-compliance that would exist in the absence of the program.

Table 18: Commercial Compliance and CCEI Attribution Over Time

	2014	2015	2016	2017	2018	2019	2020
Beginning of 2012 IECC Compliance Estimate (A)	78%						
Compliance Estimate (B)	86%	88%	90%	92%	94%	95%	95%
Non-Compliance Estimate (C) *Calculation: (1-B)*	14%	12%	10%	8%	6%	5%	5%
Attribution Estimate (D)	46%						
Compliance without the CCEI (E) *Calculation: ((B-A)*(1-D))+A*	82.3%	83.4%	84.5%	85.6%	86.7%	87.2%	87.2%
Compliance Attributable to CCEI (F) *Calculation: (B-E)*	3.7%	4.6%	5.5%	6.4%	7.3%	7.8%	7.8%
Percentage of Maximum Potential Improvement Attributable to CCEI *Calculation: F/(1-A)*	**16.7%**	**20.9%**	**25.0%**	**29.2%**	**33.4%**	**35.5%**	**35.5%**

3 Section 3 Residential New Construction Savings Estimates

This section describes the residential new construction gross technical potential (GTP) savings and net savings (i.e., the savings attributable to the CCEI program). Our results indicate that the residential new construction (RNC) gross technical potential (GTP) savings for 2018-2020 will be 5,576 MWh for electric and 327,582 therms for gas. Using the residential attribution estimates described above, the three-year electric and gas savings attributable to CCEI is projected to be 608 MWh and 35,812 therms, respectively.

3.1 Calculating Gross Technical Potential

The RNC GTP is calculated from two main inputs: weighted savings and projected growth in in this sector (see tab labeled "Res. Savings Results" in the accompanying Excel Workbook). The estimate is simply a formula which multiplies weighted savings by projected RNC permits for 2018-2020 (Table 19).

Table 19: 2018-2020 RNC GTP

Year	Electric (MWh)				Gas (therms)			RNC Projects Less Program Projects
	Heating	DHW	Cooling	Lighting	Heating	DHW	Cooling	
	A	B	C	D	E	F	G	H
2018				0.288				990
2019	1.233	0.016	0.225	0.254	96	5	-	1,080
2020				0.184				1,187
Gross Technical Potential								
Year	**A*H**	**B*H**	**C*H**	**D*H**	**E*H**	**F*H**	**G*H**	
2018	1220	16	222	285	94,805	4,734	-	
2019	1332	17	243	274	103,509	5,169	-	
2020	1463	19	267	219	113,688	5,677	-	
3-year Total	**4,014**	**52**	**732**	**778**	**312,002**	**15,580**	**-**	
	5,576				**327,582**			

3.1.1 Weighted Savings

The weighted savings, calculated by ICF using REM/Rate, are based on results from the 2017 RNC baseline study. Specifically, the savings represent the GTP associated with moving from baseline new construction practices to the prescriptive requirements of the 2012 IECC. The results are weighted by weather location, home type, heating and cooling system type, and fuel type.

The lighting savings were calculated outside REM/Rate to account for the impacts of the Energy Independence and Security Act (EISA) on lighting savings for the 2018-2020 period.

To calculate lighting savings, the team identified the average number of inefficient bulbs per home that could be swapped out for high-efficacy bulbs to meet the 2012 IECC requirement of 75% high-efficacy hard-wired fixtures. The number of potential bulbs was then multiplied by the delta watts for LED bulbs[15] and hours of use[16] for residential lighting recently identified in two separate Massachusetts studies. Using these values, the team was able to calculate the GTP associated with increasing compliance with lighting in the RNC market (see the “Res. Analysis-Lighting” tab).

3.1.2 Estimating RNC Growth

Table 20 outlines the estimates for the growth in the RNC market. We calculated this growth by first obtaining permit data for 2013-2016. The projected permits for 2017-2019 are based on the average growth rates for single-family and multifamily markets, and assume a 1-year completion. The averages are 4% for single-family stemming from the 2014-2016 rates and 24% for multifamily based on 2014-2015. (The projected 86% increase for multifamily from 2015 to 2016 seemed unreasonable and was excluded from the average.) Based on the data for 2013-2015, it appears that between 20-25% of homes participate in the RNC program. As a result, we applied an estimated 22.5% penetration rate to the projections. These various assumptions and calculations informed the estimated RNC permits for 2018-2020 (in bold below). (The “Res Data-Permits” includes these calculations.)

[15] NMR Group, Inc. *Final 2015 Report Market Adoption Model Weighting Scheme Implications*. Memo delivered to the Massachusetts Electric Program Administrators and Energy Efficiency Advisory Council. March 2, 2016. Available at: http://ma-eeac.org/wordpress/wp-content/uploads/Final-2015-Report-Market-Adoption-Model-Weighting-Scheme-Implications.pdf.

[16] NMR Group, Inc. *Residential Lighting Hours-of-use Update*. Memo delivered to the Massachusetts Electric Program Administrators and Energy Efficiency Advisory Council. November 7, 2016. Available at: http://ma-eeac.org/wordpress/wp-content/uploads/Residential-Lighting-Hours-of-Use-Update.pdf.

Table 20: Residential New Construction Growth Estimates

Permit Year	Estimated Completion Year	1 Unit	Multifamily[1]	Total Residential Units	Program Homes (1-year lag)	Program Penetration (SF only)[2]	NC Project Less Program Projects
		A	B	C=A+B	D	E=D/A	C*(1-E)
2013	2014	812	90	902	207	25.5%	672
2014	2015	796	112	908	179	22.5%	704
2015	2016	841	138	979	175	20.8%	775
2016	2017	919	257	1,176	*207*	*22.5%*	*911*
2017	*2018*	*959*	*318*	*1,277*	*216*	*22.5%*	***990***
2018	*2019*	*1,000*	*394*	*1,394*	*225*	*22.5%*	***1,080***
2019	*2020*	*1,043*	*488*	*1,531*	*235*	*22.5%*	***1,187***

[1] Multifamily counts are the sum of 2 unit projects, 3 to 4 unit projects, and half of the 5 or more unit projects. Half of the 5 or more units are excluded to account for high rise buildings that would be covered under the commercial program.

[2] Program data for Completion Years 2014 and 2016 were missing December data. Thus, only 2015 is used as an estimate for future penetration. Multifamily is excluded from the program penetration assessment due to the complexity of coming up with an accurate number given the lag time in multifamily construction.

Estimated

3.2 Projecting RNC Net Savings

To estimate the proportion of savings that can be attributed to CCEI, we multiplied the GTP by the percentage of maximum potential improvement attributable to CCEI (see Table 13). As noted above, the percentage attributable to CCEI represents the proportion of savings associated with the program divided by the overall level of non-compliance that would exist in the absence of the program. Table 21 shows the projections for 2018-2020 and the three-year total. (See the "Res Attribution Table" and "Res Savings Results" tabs.)

Table 21: RNC
Gross Technical Potential and Savings Attributable to CCEI

Year	Gross Technical Potential							Percentage Attributable to CCEI
	Electric (MWh)				Gas (therms)			
	Heating	DHW	Cooling	Lighting	Heating	DHW	Cooling	
	A	B	C	D	E	F	G	H
2018	1,220	16	222	285	94,805	4,734	-	9%
2019	1,332	17	243	274	103,509	5,169	-	11%
2020	1,463	19	267	219	113,688	5,677	-	13%
3-year Total	**4,014**	**52**	**732**	**778**	**312,002**	**15,580**	**-**	
Net Savings								
Year	**Electric (MWh)**				**Gas (therms)**			
	H*(A+B+C)				**H*(D+E+F+G)**			
2018	157				8,978			
2019	202				11,762			
2020	248				15,072			
3-year Total	**608**				**35,812**			

4 Section 4 Commercial New Construction Savings Estimates

NMR estimates that commercial new construction GTP savings for 2018–2020 will be 2,338 MWh for electric and 28,955 therms for gas. Based on the attribution estimates above, the three-year total attributable to CCEI is projected to be 815 MWh for electric and 10,099 therms for gas. This section describes the savings calculations derived for these projections.

4.1 Calculating Gross Technical Potential

Like the RNC GTP, the commercial estimate is calculated from technical potential and the projected growth in commercial new construction. Each of these inputs involves multiple components. The overall results for 2018-2020 are displayed in Table 22. Below, we explain the data sources, calculations, and assumptions for each input.

Table 22: Commercial New Construction GTP

<table>
<tr><th rowspan="3">Year</th><th colspan="2">Technical Potential (EUI)</th><th rowspan="2">New Construction Growth (ksf)</th><th colspan="2">Gross Technical Potential</th></tr>
<tr><th>Electric (kWh/sf)</th><th>Gas (kBtu/sf)</th><th>Electric (MWh)</th><th>Gas (therms)</th></tr>
<tr><th>A</th><th>B</th><th>C</th><th>A*C</th><th>B*C*10</th></tr>
<tr><td>2018</td><td rowspan="3">0.7</td><td rowspan="3">0.9</td><td>1,026</td><td>746</td><td>9,239</td></tr>
<tr><td>2019</td><td>1,071</td><td>779</td><td>9,646</td></tr>
<tr><td>2020</td><td>1,118</td><td>813</td><td>10,070</td></tr>
<tr><td colspan="4">3-year Total</td><td>2,338</td><td>28,955</td></tr>
</table>

4.1.1 Baseline Technical Potential

We used NBI modeled data from the DNV GL code compliance study to identify the GTP (in terms of energy use intensity) for non-compliant buildings compared to the 2012 IECC code; the savings are presented for natural gas, electric, and all fuels. The NBI data includes three building types: office, retail, and school. The data also includes up to four HVAC systems, depending on the building type. We assumed an even distribution of HVAC types to calculate one savings value per building type. Using Dodge data on the building types in Rhode Island, we weighted building types to calculate one overall value based on the distribution of office, retail, and school buildings. The Dodge data includes the average square footage of commercial new construction for 11 building types. We identified those closely aligned with the three categories in the NBI modeled data for 2015. Ultimately, the team used a weight of 20% for office and government buildings, 40% for retail buildings, and 41% for schools. (See the tab labeled “Comm. Data-Dodge.”)

4.1.2 Estimating the Growth in Commercial New Construction

To estimate the growth in commercial new construction, we used Dodge data, which reports new construction starts in thousands of square feet (ksf). To project through 2020, we assumed a 4.4% growth rate for Rhode Island (from the U.S. Department of Commerce's Bureau of Economic Analysis[17]) and further assumed that commercial new construction projects take between one and five years to complete, applying an even distribution for each five-year period (20%). The starting point is for these projections is 2013. Since IECC 2012 went into effect in Rhode Island on July 1, 2013, it is assumed that half of the project starts in 2013 fall under that code and all the project starts in 2014 fall under that code. The calculations assume that the commercial energy code is unlikely to change for the projected period. The overall results from these calculations are shown in Table 23. (See the tab labeled "Comm Anlysis-Sq Ft.")

Table 23: Commercial New Construction Growth Estimates

Year	New Construction Started (ksf)[1] (Previous year + 4.4%[2])	New Construction Completed (ksf)[3]							
		2013	2014	2015	2016	2017	2018	2019	2020
2013	939.5	0%	20%	20%	20%	20%	20%	0%	0%
2014	980.8	0%	0%	20%	20%	20%	20%	20%	0%
2015	1024.0	0%	0%	0%	20%	20%	20%	20%	20%
2016	1069.1	0%	0%	0%	0%	20%	20%	20%	20%
2017	1116.1	0%	0%	0%	0%	0%	20%	20%	20%
2018	1165.2	0%	0%	0%	0%	0%	0%	20%	20%
2019	1216.5	0%	0%	0%	0%	0%	0%	0%	20%
2020	1270.0	0%	0%	0%	0%	0%	0%	0%	0%
Total		**0**	**188**	**384**	**589**	**803**	**1,026**	**1,071**	**1,118**

[1] The 2013 figure is based on totals from Dodge data. This represents the four-year average of all projects started between 2012-2015.
[2] The 2014-2020 figures assume a 4.4% annual increase based on data from the U.S. Department of Commerce's Bureau of Economic Analysis.
[3] Assumes projects take between one and five years to complete, and an equal distribution of ksf is completed over that time span.

4.2 Projecting Commercial New Construction Net Savings

To calculate the savings attributable to CCEI, we multiplied the GTP by the percentage of maximum potential improvement attributable to CCEI (see Table 18). The estimates for 2018-2020 and the three-year total are shown in Table 24.

[17] Specifically, the 4.4% new construction growth rate is based on the average annual increase in RI construction gross domestic product from 2013-2016.

Table 24: Commercial New Construction Gross Technical Potential and Savings Attributable to CCEI

Year	Gross Technical Potential		Percentage Attributable to CCEI	Net Savings	
	Electric (MWh)	Gas (therms)		Electric (MWh)	Gas (therms)
	A	B	C	A*C	B*C
2018	746	9,239	33.5%	250	3,091
2019	779	9,646	35.5%	277	3,429
2020	813	10,070	35.5%	289	3,579
3-year Total	**2,338**	**28,955**		**815**	**10,099**

A Appendix A Sources of Evaluation Data for the CCEI Trainings

To determine the impact of the training on building professionals' practices, this study leveraged evaluation results and other data and documentation from the CCEI trainings. Below are brief descriptions of each of these sources.

A.1 CLEARESULT TRAINING MATERIALS

In order to assess the focus of the residential and commercial trainings, the team obtained copies of the slides that CLEAResult used in their various trainings. In addition, we compiled a list of residential and commercial trainings conducted between 2014 and 2016, determined how long each training lasted, identified the focus of the training, and estimated how much time was spent on specific measures or measure categories.[18] These results pinpointed which measures where emphasized during the training and helped inform our analysis of the impact of the trainings.

A.2 ARS RESULTS

CLEAResult, the CCEI implementation contractor, used an Audience Response System (ARS) to collect data during the classroom trainings held from 2014 through 2016. The team examined results from key questions from the trainings, such as, "I am better prepared to comply with/enforce energy code," "The information that I learned will influence my work," and "My knowledge of building science principles has increased." The results helped inform our assessment of the impact of the training on participants' knowledge and understanding of building practices.

A.3 CCEI PARTICIPANT INTERVIEWS

NMR interviewed six non-code official individuals who had attended the CCEI classroom trainings from May through December of 2015; three had attended residential trainings and three had attended commercial trainings. The interviews took place in October and November of 2016 and covered the following areas:

- Activities, such as projects the interviewees have worked on, since the training
- Whether, and how, this work done has made use of the training; which parts of the training were most useful
- Whether they have shared what they have learned with others and with whom they have shared this knowledge
- What, if anything, they would have done differently if they had not attended the training

[18] Available at: https://www.eventbrite.com/o/clearesult-on-behalf-of-national-grid-4691466985.

- Other trainings they have attended and sources of information used
- Whether they would recommend the trainings to others; suggestions for improving the trainings

A.4 CCEI Residential Training Immediate Surveys

NMR collected single-page paper forms filled out after the following trainings and presentations provided by the CCEI:

- A presentation for code officials attending the Rhode Island Building Officials Association (RIBOA) conference on February 17, 2017
- A presentation for attendees at the Journal of Light Construction (JLC LIVE) Conference held in Providence on March 24, 2017
- A training for weatherization contractors and energy auditors held in Cranston on May 3, 2017

The immediate surveys were filled out by seven RIBOA attendees, 22 JLC LIVE attendees, and 24 attendees at the May 3 training. Of the 53 survey respondents, seven were building code officials and the remaining 46 fell into the general category of builders, architects, contractors, program managers, auditors, and others. The RIBOA training had 21 attendees; there were 40 attendees at JLC LIVE and 27 at the May 3 training. The surveys covered the following topics:

- Quality of the presentations, slides, and handling of questions
- How the trainees rate the five or so major areas covered by the training in terms of usefulness and new material presented
- Most important part of the training
- When and how attendants expect to use what was learned in the training
- Whether they would recommend the training to others
- Suggestions for improving the trainings.

A.5 CCEI Code Official Interviews

DNV GL interviewed 28 Rhode Island code officials in the fall of 2016 primarily focusing on enforcement issues for the commercial energy code.[19] These interviews also sought feedback about CCEI trainings and how they are used in enforcing energy codes. These topics included:

- Whether the interviewees attended any CCEI trainings and any other interactions they have had with the CCEI

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[19] DNV GL, *Rhode Island Commercial Energy Code Compliance Study*, October 25, 2016. Available at: http://www.rieermc.ri.gov/documents/2016%20Evaluation%20Studies/20161025_RI_Commercial_Code_Compliance_Study.pdf.

- If applicable, whether and how interactions with the CCEI have influenced their enforcement of the commercial and residential building energy codes
- Suggestions for improving the trainings.