



# R1702/R1710 Codes and Standards Assessment

FINAL REPORT

June 29, 2018

SUBMITTED TO: Connecticut Energy Efficiency Board  
Lisa Skumatz, Ralph Prah, and Bob Wirtshafter, EEB  
Evaluation Administrations

SUBMITTED BY:  
NMR Group, Inc.

**NMR**  
Group, Inc.

## Table of Contents

<b>ABSTRACT</b> .....	<b>I</b>
<b>EXECUTIVE SUMMARY</b> .....	<b>II</b>
FINDINGS .....	III
Compliance Results.....	III
Maximum Gross Potential Savings.....	III
Code Compliance Enhancement Programs .....	V
CONCLUSIONS AND CONSIDERATIONS.....	V
<b>SECTION 1    INTRODUCTION AND BACKGROUND</b> .....	<b>1</b>
1.1    BACKGROUND .....	1
1.2    PURPOSE OF THE STUDY .....	2
1.3    RESEARCH QUESTIONS .....	2
1.4    CHANGES IN CODE REQUIREMENTS .....	2
1.5    2015 IECC .....	3
<b>SECTION 2    METHODOLOGY</b> .....	<b>4</b>
2.1    SAMPLE .....	4
2.2    SCALING THE SAMPLE TO THE POPULATION.....	5
2.3    MA-REC ALGORITHM.....	6
2.3.1    MA-REC Algorithm Calculations .....	6
2.3.2    Assessing Compliance under MA-REC .....	9
2.4    GROSS POTENTIAL SAVINGS.....	9
<b>SECTION 3    RESULTS</b> .....	<b>10</b>
3.1    COMPLIANCE.....	10
3.1.1    Comparison to Compliance in Other States.....	12
3.2    MAXIMUM GROSS POTENTIAL SAVINGS .....	14
3.2.1    Comparison to Savings in Massachusetts .....	16
<b>SECTION 4    CODE COMPLIANCE ENHANCEMENT PROGRAMS</b> .....	<b>18</b>
4.1    PROGRAM DESIGN .....	19
4.2    CONSIDERATIONS FOR A CONNECTICUT PROGRAM.....	22
<b>APPENDIX A    ADDITIONAL RESULTS</b> .....	<b>A1</b>
A.1    MA-REC VS. REM/RATE COMPLIANCE.....	A1
A.2    COMPLIANCE DISTRIBUTIONS AND CORRELATIONS .....	A1
A.3    GROSS POTENTIAL SAVINGS DISTRIBUTIONS.....	A4

A.4 ADDITIONAL COMPLIANCE COMPARISONS ..... A4

    A.4.1 Comparison to Compliance in Massachusetts – Program Homes..... A4

    A.4.2 Comparison to Compliance in Massachusetts – Non-Program Homes..... A5

    A.4.3 Comparison to Compliance in Idaho..... A6

A.5 HISTORICAL CODE TRAININGS OFFERED BY THE COMPANIES..... A7

**Figures**

**FIGURE 1: R1702/R1710 OVERALL COMPLIANCE RATE ESTIMATES..... III**

**FIGURE 2: ESTIMATED GROSS POTENTIAL SAVINGS WITH 2012 IECC-CT (% OF AS-BUILT CONSUMPTION)..... IV**

**FIGURE 3: SAMPLE HOME DISTRIBUTION..... 5**

**FIGURE 4: SINGLE-UNIT NEW CONSTRUCTION PERMITS IN 2014..... 6**

**FIGURE 5: BEST PRACTICES EXAMPLES IN RHODE ISLAND FIELD GUIDE..... 21**

**FIGURE 6: DISTRIBUTION OF 2009 IECC PROGRAM & NON-PROGRAM COMPLIANCE ..... A2**

**FIGURE 7: DISTRIBUTION OF 2012 IECC-CT PROGRAM & NON-PROGRAM COMPLIANCE ..... A2**

**FIGURE 8: DISTRIBUTION OF PROJECTED GROSS POTENTIAL SAVINGS UNDER 2012 IECC-CT (% SAVINGS OVER BASELINE MMBTU CONSUMPTION) ..... A4**

**Tables**

**TABLE 1: BUILDING CODE COMPARISON ..... 3**

**TABLE 2: SINGLE-FAMILY NEW CONSTRUCTION PERMITS IN 2014 BY UTILITY ..... 6**

**TABLE 3: STATEWIDE AVERAGE ENERGY CONSUMPTION (WEIGHT) BY MEASURE ..... 9**

**TABLE 4: MEAN MA-REC COMPLIANCE FOR 2009 IECC<sup>%</sup> ..... 11**

**TABLE 5: MEAN MA-REC COMPLIANCE FOR 2012 IECC-CT, BUSINESS-AS-USUAL<sup>%</sup> ..... 11**

**TABLE 6: STATEWIDE MA-REC COMPLIANCE BY MEASURE ACROSS STATES<sup>!!</sup> ..... 13**

**TABLE 7: MAXIMUM GROSS POTENTIAL SAVINGS UNDER 2009 IECC<sup>!!,%</sup> ..... 15**

**TABLE 8: MAXIMUM GROSS POTENTIAL SAVINGS UNDER 2012 IECC-CT<sup>!!,%</sup> ..... 15**

**TABLE 9: MAXIMUM GROSS POTENTIAL SAVINGS BY MEASURE ACROSS STATES<sup>!!</sup> ..... 16**

**TABLE 10: ADJUSTED 2012 IECC-CT GROSS POTENTIAL SAVINGS<sup>!!</sup> ..... 17**

**TABLE 11: ALTERNATIVE COMPLIANCE CALCULATIONS ..... A1**

**TABLE 12: CROSS-MEASURE COMPLIANCE CORRELATIONS IN PROGRAM HOMES ..... A3**

**TABLE 13: CROSS-MEASURE COMPLIANCE CORRELATIONS IN NON-PROGRAM HOMES ..... A3**

**TABLE 14: PROGRAM MA-REC COMPLIANCE BY MEASURE ACROSS STATES<sup>!!</sup> ..... A5**

**TABLE 15: NON-PROGRAM MA-REC COMPLIANCE BY MEASURE ACROSS STATES<sup>!!</sup> ..... A6**

**TABLE 16: STATEWIDE 2009 IECC COMPLIANCE BY MEASURE ..... A7**

## A

## Abstract

This report estimates code compliance rates and potential savings from compliance enhancement for new single-family homes in Connecticut that were built at the end of the 2009 International Energy Conservation Code (IECC) cycle. The study also compares homes to the amended version of the 2012 IECC adopted in Connecticut (2012 IECC-CT). ***The 2012 IECC-CT results represent minimum compliance rates (a floor) and maximum potential savings (a ceiling) as the homes used for this assessment were built prior to the adoption of the 2012 IECC-CT (under the 2009 IECC).***

Statewide compliance with the 2009 IECC is 91% – 97% for program homes and 90% for non-program homes. Compliance with the 2009 IECC among non-program homes notably lags behind program home compliance in terms of ceiling, frame floor, wall, and foundation wall insulation. Statewide compliance is estimated to be between 79% and 86% when compared to the 2012 IECC-CT. The 79% compliance rate represents a compliance floor under a business-as-usual scenario where building practices remain the same even in the face of new code requirements. The 86% compliance rate is an adjusted calculation based on results seen in Massachusetts for homes built at the end of the 2009 IECC cycle and the beginning of the 2012 IECC cycle. Using the same compliance methodology, the 2012 IECC-CT compliance rates are comparable to rates that were recently developed in Massachusetts (86%) and Rhode Island (83%) for 2012 IECC compliance.<sup>1</sup>

The gross technical potential savings available from code compliance enhancement (i.e., bringing all non-compliant measures up to prescriptive code requirement levels) are 17% over the mean MMBtu consumption for the 2009 IECC (6% for the small subset of program homes and 17% for non-program homes), and are estimated to be between 20% and 33% for the 2012 IECC-CT. The 33% savings potential under the 2012 IECC-CT represent a ceiling under the business-as-usual scenario, while the 20% savings are adjusted using the 2009 IECC and 2012 IECC Massachusetts results previously mentioned. This study projects that air leakage and duct leakage measures have the largest opportunity for compliance enhancement savings under the 2012 IECC-CT.

In addition to Connecticut compliance and potential savings results, this report documents examples of code compliance enhancement programs in other jurisdictions. There are a few code compliance enhancement programs throughout the country (e.g., Massachusetts, Rhode Island, and California), which exemplify ways to design, implement, and evaluate code enhancement programs.

Up to this point, many states have focused on code compliance enhancement as opposed to advocating for more stringent energy codes or pushing for more aggressive equipment standards. While this study focuses on code compliance rates, code enhancement potential, and code enhancement programs, it should be noted that there are other avenues available for saving energy in this research area.

---

<sup>1</sup> All compliance rates in this study were calculated using the MA-REC compliance methodology.



## Executive Summary

This report details the results of a single-family, residential new construction (RNC) codes and standards study conducted for Eversource and United Illuminating (UI) Company (*the Companies*). The study, referred to as the R1702/R1710 study, projects the savings potential of creating a compliance enhancement program in Connecticut.

Two steps were taken to achieve this goal: (1) code compliance rates for new homes in Connecticut were assessed using the “MA-REC” methodology, and (2) the gross technical potential savings available from code compliance enhancement in Connecticut were estimated.

The R1702/R1710 project leverages the 2017 R1602 RNC study, which included a baseline study, billing analysis, and process evaluation.

The R1702/R1710 study assessed the compliance of new homes against two code versions: the 2009 International Energy Conservation Code (IECC) and the amended 2012 IECC adopted in Connecticut (2012 IECC-CT).<sup>2</sup> The homes considered in this study were built at the end of the 2009 IECC cycle. ***As a result, the 2012 IECC-CT compliance results represent a compliance floor assuming a business-as-usual scenario where building practices remain the same even in the face of new code requirements.*** Section 3.1.1 offers an alternative view of compliance under the 2012 IECC-CT based on comparisons to recent Massachusetts results.

This study followed the MA-REC methodology (also recently used in Massachusetts and Rhode Island), which uses REM/Rate energy models to create compliance rates that are calibrated to energy consumption (detailed in Section 2.3). Using the MA-REC approach, homes are scored based on their performance against a hypothetical counterpart home built to prescriptive code requirements. Compliance scores were developed for a sample of homes that participated in the RNC program, as well as for the non-program homes inspected as part of the R1602 baseline study.

This study then extrapolated the compliance assessment results to estimate the gross potential savings available from increasing compliance with both the 2009 IECC and the 2012 IECC-CT. ***The 2012 IECC-CT potential savings results represent a theoretical maximum under the business-as-usual scenario described above.*** Section 3.2.1 offers an alternative view of these savings estimates.

Finally, this report documents the design and implementation of code compliance enhancement programs in other jurisdictions (Section 4), and provides recommendations for effectively incorporating code compliance enhancement programs into the Companies’ program portfolio.

---

<sup>2</sup> The version of the 2012 IECC adopted in Connecticut was amended to relax certain requirements. The complete list of changes are catalogued here: [http://portal.ct.gov/-/media/DAS/Office-of-State-Building-Inspector/2016\\_connecticut\\_state\\_building\\_code.pdf?la=en](http://portal.ct.gov/-/media/DAS/Office-of-State-Building-Inspector/2016_connecticut_state_building_code.pdf?la=en).

## FINDINGS

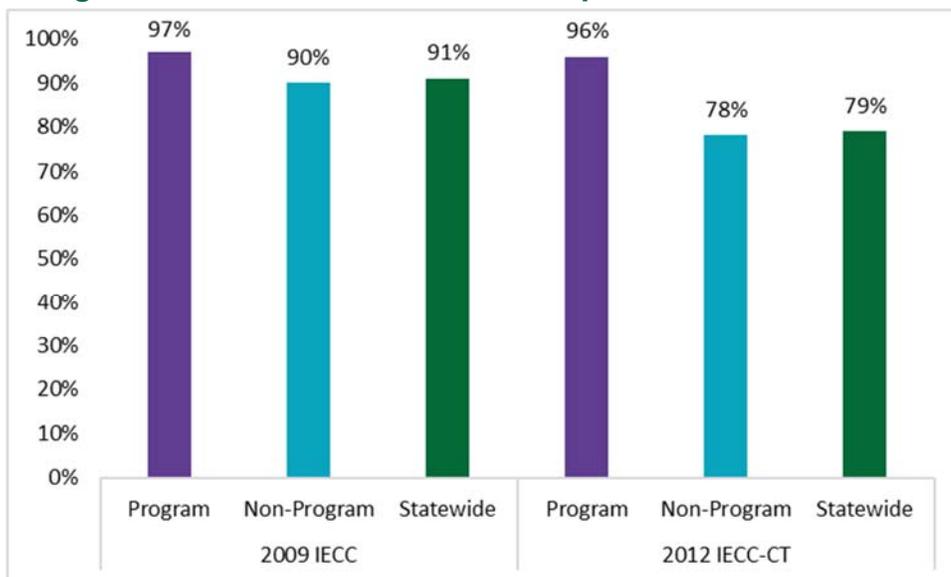
This section offers a high-level summary of the R1702/R1710 findings.

### Compliance Results

**Program homes perform much better than non-program homes.**

As shown in [Figure 1](#), program homes display significantly higher compliance rates than non-program homes under both the 2009 IECC (97% vs. 90%, respectively) and the 2012 IECC-CT (96% and 78%, respectively). Statewide compliance rates (91% under the 2009 IECC and estimated to be 79% under the 2012 IECC-CT) are much closer to the non-program rates due to the size of the non-program single-family new construction market in Connecticut. **As previously noted, the 2012 IECC-CT results represent a compliance floor under a business-as-usual scenario where building practices do not change in the face of new code requirements.** Statewide compliance with the 2012 IECC-CT is estimated to be 86% using adjustments that represent a scenario under which building practices change in the face of new code requirements (see [Section 3.1.1](#) for more detail).

**Figure 1: R1702/R1710 Overall Compliance Rate Estimates**



### Maximum Gross Potential Savings

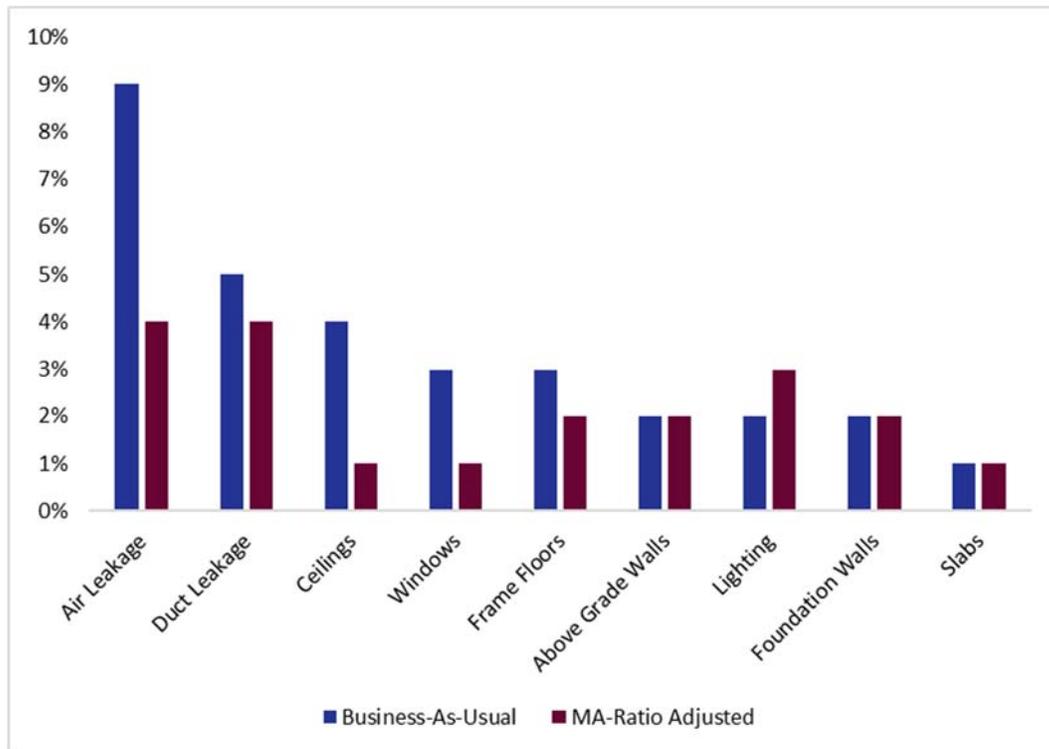
**The estimated savings from code compliance enhancement under the 2012 IECC-CT are substantial (between 20% and 33% savings over baseline MMBtu consumption).**

The gross potential savings associated with increasing compliance (i.e., bringing all non-compliant measures up to prescriptive code requirements) are estimated to be 17% statewide for the 2009 IECC and between 20% and 33% statewide for the 2012 IECC-CT. **The 33% potential savings using the 2012 IECC-CT represent a potential savings ceiling under a business-as-usual scenario assuming no change in building practices in the face of**

**new code requirements.** These savings percentages represent the percentage of MMBtu savings over baseline consumption estimates. However, these estimates are based on bringing non-compliant measures up to prescriptive code levels, which likely results in an overstatement of savings for homes that might use alternative compliance paths that do not require homes to meet all prescriptive code levels. The bulk of savings potential comes from non-program homes as program homes typically exhibit high compliance rates and, therefore, low compliance enhancement savings potential.

Figure 2 presents the gross potential savings for the 2012 IECC-CT using both the business-as-usual scenario and an adjusted scenario that accounts for changing building practices in the face of new code requirements. As shown, air leakage and duct leakage measures display the largest potential savings under both scenarios. However, the 2012 IECC-CT has been in effect in Connecticut for some time (since October 2016) and these savings are no longer achievable as these estimates represent the potential at the beginning of the code cycle. That said, these findings provide a useful reference point for savings under future code cycles.

**Figure 2: Estimated Gross Potential Savings with 2012 IECC-CT**  
(% of As-Built Consumption)



## Code Compliance Enhancement Programs

Other code compliance programs offer a range of program design, implementation, and evaluation examples for Connecticut to consider.

Various code compliance enhancement programs across the country offer program design ideas for Connecticut. Programs in Massachusetts, Rhode Island, California, and New York, among others, use diverse strategies to train market actors in both the residential and commercial sectors. These strategies include, but are not limited to, providing free training materials, offering continuing education credits to encourage attendance at trainings, offering various training styles with different topic areas and durations, and offering circuit-rider support for focused, customized training.

## CONCLUSIONS AND CONSIDERATIONS

**Code Compliance.** Statewide compliance levels were high for homes built under the 2009 IECC (91%) but decreased under the 2012 IECC-CT to between 79% and 86%. ***The 79% represents a compliance floor assuming a business-as-usual scenario where building practices remain the same even in the face of new code requirements.*** These results are similar to recent 2012 IECC compliance results measured in Massachusetts (86%) and Rhode Island (83%). These findings suggest that Connecticut homes are comparable to neighboring states in terms of compliance and building efficiency. In each of these states and samples, RNC program homes show significantly higher compliance rates than non-program homes.

- **Consideration.** The Companies should consider focusing any future code enhancement efforts on non-program homes given that compliance among program homes is already quite high and that is likely to continue to be the case.

**Code Enhancement Potential Savings.** The potential savings associated with the 2012 IECC-CT are non-trivial (ranging from 20% to 33% over baseline MMBtu consumption). ***The 33% savings represent a savings ceiling assuming a business-as-usual scenario where building practices remain the same even in the face of new code requirements.*** This study's results indicate that air leakage, duct leakage, and ceiling insulation represent the greatest opportunities for savings from compliance enhancement efforts. It should be noted that both Massachusetts and Rhode Island have compliance enhancement programs that have not yet exhibited a substantial impact based on home inspections conducted after the trainings were in place.

- **Consideration.** The Companies should consider monitoring the impacts associated with compliance enhancement programs across the country. While the maximum potential savings from compliance enhancement are non-trivial, neighboring states with programs have struggled to realize those savings up to this point.

**Program Design, Implementation, and Evaluation.** Other states have developed various strategies for influencing the RNC market. These strategies include developing stand-alone code enhancement training programs, incorporating code-enhancement trainings into

traditional RNC programs, and developing advanced building codes, among others. The experiences of other states offer a reference point for the Companies to consider when determining new methods for transforming the RNC market.

- **Consideration.** The Companies should consider continuing their current approach of incorporating residential code enhancement trainings into their RNC program. Under this approach, the Companies can claim code enhancement savings through net-to-gross (NTG) assessments of the RNC program.<sup>3</sup> The ongoing R1707 RNC NTG study is attempting to do just that, by treating these historical code trainings as one among many program activities. However, the information available regarding these trainings was somewhat limited, reducing the evaluators' ability to assess the trainings' impacts. Moving forward, the Companies should consider more detailed documentation of code training efforts, including follow-up surveys with attendees to identify how the training materials were applied to real-world practices.
  - The Companies have historically provided commercial trainings, but the savings from these trainings would not be captured through a NTG assessment for the residential program. Accordingly, the Companies may want to consider comparable strategies to claim the savings from any commercial training efforts.

---

<sup>3</sup> This approach is currently being used in Massachusetts, where the savings from the RNC program and code enhancement efforts are being considered together.

# 1

## Section 1 Introduction and Background

This report details the results of the R1702/R1710 Codes and Standards Assessment study, which was commissioned by Eversource, United Illuminating Company (*the Companies*), and the Connecticut Energy Efficiency Board (EEB). Focusing on new single-family homes in Connecticut, the study documented code compliance rates and gross technical potential savings available from code compliance enhancement. Compliance and potential savings were assessed relative to both the 2009 International Energy Conservation Code (IECC) and the 2012 IECC-CT, the amended version of the 2012 IECC adopted in Connecticut.<sup>4</sup> In addition to study details, this report documents the design and implementation of code compliance enhancement programs in other jurisdictions.

***Please note that the homes used for the analysis in this report were built under the 2009 IECC. The 2012 IECC-CT assessment is meant to provide insight into the maximum code compliance enhancement potential for homes built under the 2012 IECC-CT, based on current building practices.***

### 1.1 BACKGROUND

NMR recently completed a baseline study of residential new construction (RNC) building practices in Connecticut (the R1602 evaluation).<sup>5</sup> That study showed that baseline new construction practices have improved in Connecticut, which will affect the savings from the RNC program. In the face of advancing energy codes and deteriorating savings from traditional RNC programs, neighboring states have been implementing code compliance support programs. These programs are designed to allow program administrators to claim savings from increasing compliance with the energy code.

Up to this point, Connecticut has not measured compliance rates for the RNC market and does not offer a dedicated, stand-alone code compliance enhancement program. Code enhancement is, however, one of several topics covered by trainings offered by the Companies' RNC program that incentivizes high-efficiency construction practices, as discussed in the R1602 report. Details on the code trainings that have historically been offered by the Companies are shown in [Section A.5](#). This study serves as the starting point for measuring code compliance rates in Connecticut, thereby allowing the Companies to estimate the potential savings associated with creating a successful code compliance enhancement program.

---

<sup>4</sup> The version of the 2012 IECC adopted in Connecticut was amended to relax certain requirements. The complete list of changes are catalogued here: [http://portal.ct.gov/-/media/DAS/Office-of-State-Building-Inspector/2016\\_connecticut\\_state\\_building\\_code.pdf?la=en](http://portal.ct.gov/-/media/DAS/Office-of-State-Building-Inspector/2016_connecticut_state_building_code.pdf?la=en)

<sup>5</sup> NMR Group, Inc., "R1602 Residential New Construction Program Baseline Study", *Submitted to Connecticut EEB*, December 5, 2017. [https://www.energizect.com/sites/default/files/R1602\\_Residential%20New%20Construction%20Baseline%20Study\\_Final%20Report\\_12.5.17.pdf](https://www.energizect.com/sites/default/files/R1602_Residential%20New%20Construction%20Baseline%20Study_Final%20Report_12.5.17.pdf)

## 1.2 PURPOSE OF THE STUDY

The objective of this study was to assess the code compliance rates for new homes in Connecticut. This was done for homes built under the 2009 IECC, based on measured efficiency characteristics from the R1602 study. This study also estimated what minimum compliance might be for homes built under the 2012 IECC-CT. In addition, the study estimated the gross technical potential savings from code compliance enhancement for new single-family homes in Connecticut. Finally, this report documents the design, implementation, and savings associated with code compliance enhancement programs in other states. The Companies can use this report to determine whether a code enhancement program is appropriate in Connecticut, and to learn from the experiences of neighboring states.

## 1.3 RESEARCH QUESTIONS

This study sought to answer the following research questions:

- What is the level of compliance among single-family Connecticut homes built under the 2009 IECC? What is the minimum estimated compliance rate for homes built at the beginning of the 2012 IECC-CT?
  - How do the compliance rates vary between program and non-program homes? How do they compare to other states?
- What are the gross technical potential savings available from code compliance enhancement efforts under both the 2009 IECC and 2012 IECC-CT?
  - How do the potential savings estimates vary between program and non-program homes? How do they compare to other states?
- What is the design of code compliance enhancement programs in other jurisdictions?
- If the Companies decide to develop a compliance enhancement program, what program design, savings calculation approaches, and attribution methodologies should they adopt?
- What are areas where Connecticut may need to conduct research to develop or support a code enhancement program?

## 1.4 CHANGES IN CODE REQUIREMENTS

Table 1 compares the major code requirements in the 2009 IECC and the 2012 IECC-CT and identifies the handful of measures that remained constant across the two code versions. The most significant changes are as follows:

- Reducing (improving) the permissible level of air leakage by 57% for detached homes, by 39% for attached homes, and by 7% for attached homes less than or equal to 850 square feet
- Increasing the required amount of efficient lighting by 50%
- Reducing (improving) the permissible level of duct leakage by 33%

Table 1: Building Code Comparison

Building System	2012 IECC-CT Requirement <sup>1</sup>	2009 IECC	2012 IECC-CT
<i>Values that became more stringent under 2012 IECC-CT</i>			
Window U-factor	Path dependent	0.35	0.32
Skylight U-factor	Path dependent	0.60	0.55
Ceiling R-value	Path dependent	38	49
Air leakage (ACH50)	Mandatory	7	Detached home: 3
			Attached home <sup>2</sup> : 5
Duct leakage to the outside (CFM25/100 ft <sup>2</sup> )	Mandatory	8	N/A
Total duct leakage (CFM25/100 ft <sup>2</sup> )	Mandatory	12	8
% of Fixtures with efficient lighting	Mandatory	50%	75%
Foundation wall R-value (Continuous/Cavity)	Path dependent	10/13	15/19
<i>Values that remained constant between 2009 IECC and 2012 IECC-CT</i>			
Above-grade wall R-value (Cavity/Cavity + Continuous)	Path dependent	20/13+5	
Frame floor R-value	Path dependent	30	
Duct insulation R-value (Supply/Other)	Path dependent	8/6	
Slab R-value (Non-radiant/Radiant)	Path dependent	10/15	

<sup>1</sup> Measures listed as path dependent are only required when builders use certain compliance pathways. For example, prescriptive R-values are only required when builders use a prescriptive compliance path.

<sup>2</sup> 6.5 ACH50 for homes less than or equal to 850 ft<sup>2</sup>.

## 1.5 2015 IECC

Although Connecticut has not yet adopted the 2015 IECC, the base 2015 IECC contains no substantive changes to the requirements for residential buildings. Note, however, that the 2015 IECC does add a fourth compliance path, the Energy Rating Index path, which allows homes to meet code by achieving a HERS index value of 55 or less.

# 2

## Section 2 Methodology

In this study, the MA-REC methodology (described in [Section 2.3](#)) was used to calculate whole-house and measure-level compliance among new Connecticut homes. This method was previously employed in Massachusetts and Rhode Island code compliance studies.<sup>6</sup> In this study, the MA-REC approach was also used to calculate the gross potential savings available from implementing a code enhancement program by comparing actual, as-built homes to similar hypothetical homes built to prescriptive code requirements.

### 2.1 SAMPLE

As a part of the R1602 Baseline study, site visits were conducted at 70 new, non-program homes (24 custom-built and 46 spec-built) across all eight counties in Connecticut;<sup>7</sup> REM/Rate energy models were developed for all 70 homes. As a part of the R1602 study, the Companies also provided REM/Rate models for relevant program homes. Both sets of models were used to develop compliance and potential savings estimates; analyses were limited to detached and attached single-family homes. ***All the homes included in this study, both non-program and program, were built at the end of the 2009 IECC cycle in Connecticut.***

Analyses of program homes were limited to unique records with HERS ratings completed in 2015, yielding a relevant population of 198 single-family program homes. Of these, 18 could not be processed with REM/Rate v15.4.1, the most up-to-date version of REM/Rate at the time of this study.<sup>8</sup> This left 180 program homes for analysis.<sup>9</sup>

[Figure 3](#) presents the distribution of homes that were included in the R1602 study.

---

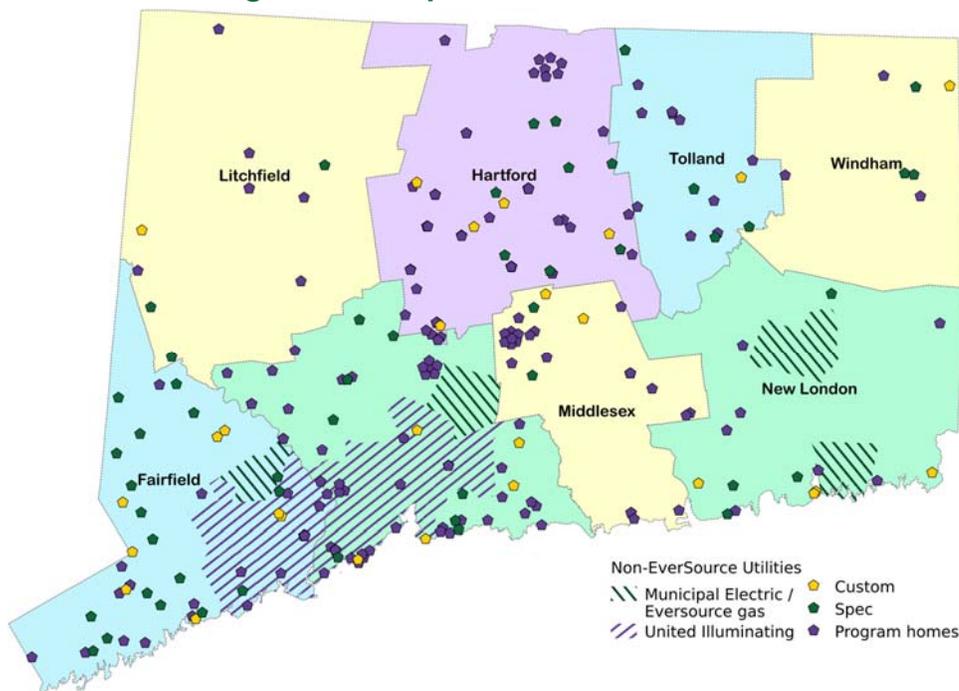
<sup>6</sup> Massachusetts: NMR Group, Inc, “2015-2016 Massachusetts Single-Family Code Compliance/Baseline Study: Volume 4,” Submitted to the Electric and Gas Program Administrators of Massachusetts, October 14, 2016, <http://ma-eeac.org/wordpress/wp-content/uploads/Single-Family-Code-Compliance-Baseline-Study-Volume-4.pdf>  
Rhode Island: NMR Group, Inc, “Rhode Island Baseline Study of Single-Family Residential New Construction,” Submitted to National Grid Rhode Island, January 18, 2018.

<sup>7</sup> Details about the sampling methodology used to select these homes can be found in the R1602 report. In short, sites were sampled at the county-level to match construction activity in each county, based on Census data.

<sup>8</sup> There are a variety of quality control calculations that were put in place in the most recent version of REM/Rate. If the software detects an error it will not allow the energy models to run. Previous versions of the software did not include these quality control components and allowed models to run even with errors in place. Most of the new quality control calculations are related to ensuring the square footages of different building components make sense when considered as a whole home energy model.

<sup>9</sup> The analysis included eight non-program townhouses, and nine program townhouses. These homes were treated separately for the 2012 IECC-CT analysis, given the unique air leakage requirements for attached homes.

Figure 3: Sample Home Distribution



## 2.2 SCALING THE SAMPLE TO THE POPULATION

The results of analyses of the 70 non-program homes included in the R1602 baseline study and the 180 program homes with available REM/Rate models were scaled up to estimate statewide results for the 2,760 single-unit housing starts in 2014.<sup>10</sup> The 180 program homes were each given a weight of 1.1 to calculate statewide values, so as to account for all 198 program homes.

Figure 4 presents the number of single-unit permits issued by Connecticut municipalities in 2014, according to the Connecticut Department of Economic and Community Development, used as the basis of this scaling.<sup>11</sup>

<sup>10</sup> U.S. Census Bureau “Building Permits Survey > Permits by State Annual” <https://www.census.gov/construction/bps/stateannual.html> (accessed August 24, 2017). Housing starts from 2014 were used to make comparisons to homes largely completed in 2015 to account for the estimated lag between the issuance of a permit and the completion of a home.

<sup>11</sup> [http://www.ct.gov/ecd/lib/ecd/housing\\_files/ct2014\\_final\\_permit\\_data.xlsx](http://www.ct.gov/ecd/lib/ecd/housing_files/ct2014_final_permit_data.xlsx) (accessed August 21, 2017).

**Figure 4: Single-Unit New Construction Permits in 2014**

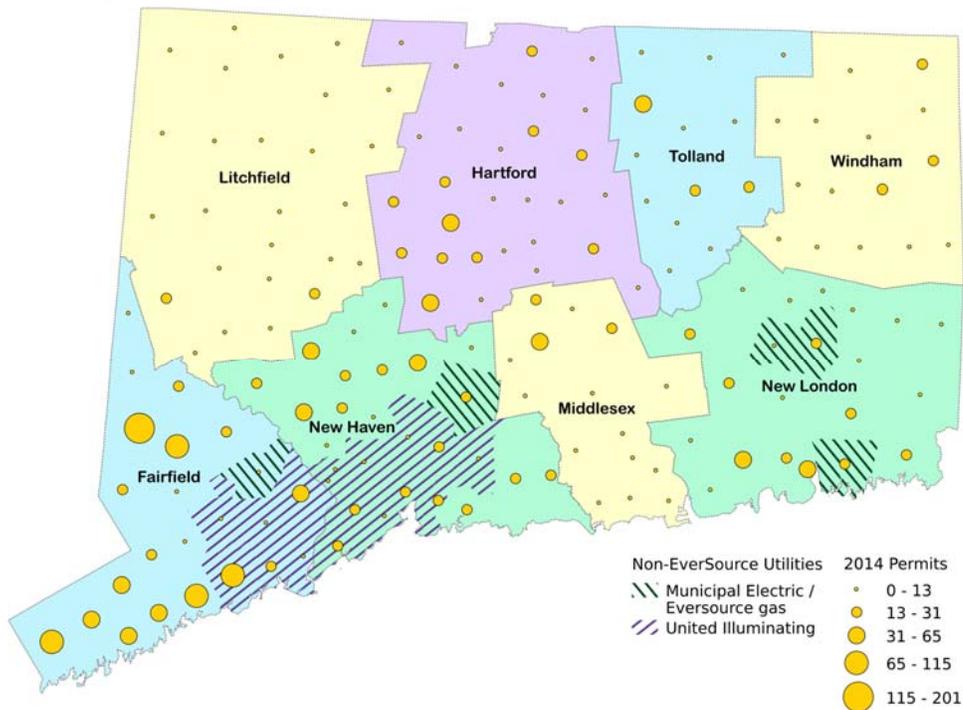


Table 2 shows the number of permits per utility based on the municipal boundaries shown in Figure 4; the vast majority are in Eversource territory.

**Table 2: Single-Family New Construction Permits in 2014 by Utility**

Utility	Permits	%
Eversource	2,351	85%
Municipal Electric / Eversource Gas	76	3%
United Illuminating	333	12%
TOTAL	2,760	100%

### 2.3 MA-REC ALGORITHM

This section describes the actual calculations used in the MA-REC algorithm, and describes how the results are applied and interpreted.

#### 2.3.1 MA-REC Algorithm Calculations

This Connecticut study relied on the MA-REC approach to assess code compliance, a method that uses energy modeling results to estimate compliance. In the previously-cited Massachusetts and Rhode Island code compliance studies, code compliance was assessed using two methods: (1) the Pacific Northwest National Laboratory (PNNL) code compliance checklist approach and (2) the MA-REC approach. Unlike the PNNL approach, the MA-REC approach only focuses on code requirements that directly impact energy consumption. The

MA-REC methodology does not account for administrative or non-energy-related code requirements, and it does not consider the compliance path utilized by the builder.

The MA-REC methodology compares homes to the applicable IECC prescriptive requirements. Thus, the MA-REC approach does not account for trade-offs that may take place under the UA Trade-off and Performance paths for compliance. For this reason, it is possible that the MA-REC approach overstates the level of non-compliance and potential savings associated with homes that use the UA Trade-off or Performance paths for compliance. These paths allow for non-compliance with the prescriptive requirements of certain measures, assuming there are other measures that exceed the prescriptive requirements. The MA-REC approach does not attempt to address these complicating factors; this should be considered when reviewing the results associated with this methodology.

This approach utilizes REM/Rate energy consumption estimates to determine the relative importance of various code-related building components.<sup>12</sup> The consumption estimates of individual measure categories (e.g., lighting) are compared to the overall estimated consumption for a sample of homes to develop a scoring system that is calibrated to overall estimated energy consumption. Measures are scored based on the average percentage of total energy consumption a measure accounts for across all sample homes. The weighted statewide measure-level scoring allocations are shown in [Table 3](#).

$$\begin{aligned} APTC_{Measure} &= \text{Average Percentage of Total Consumption for a Measure} \\ &= \text{Mean} \left( \text{Consumption}_{Measure} / \text{Consumption}_{Home} \right) \end{aligned}$$

Once the scoring system is developed, two models are used to calculate compliance for each home. One is an as-built model that represents the home as it actually exists, and the other is a code-built model that represents the same home built to meet prescriptive code requirements. The percentage difference between the code-built models and as-built models for each measure is used to assign (partial) credit to each of the building components included in this methodology. If the as-built model meets or exceeds the code-built model for a given measure (less consumption), that measure is provided with the maximum score.<sup>13</sup> If the as-built model is less efficient than the code-built model, then the measure is provided with partial credit depending on the percentage change of the as-built consumption relative to the code-built consumption. The following formulas are used for these calculations:

$$\begin{aligned} PBC_{Measure} &= \frac{(CB_{Measure} - AB_{Measure})}{AB_{Measure}} \\ Compliance_{Measure} &= \begin{cases} (1 + PBC_{Measure}) & \text{if } PBC_{Measure} < 0 \\ 1 & \text{if } PBC_{Measure} \geq 0 \end{cases} \end{aligned}$$

<sup>12</sup> REM/Rate is an energy modeling tool that is used to calculate a home's performance relative to the Home Energy Rating System (HERS) index and to support many residential new construction programs.

<sup>13</sup> Capping of the score means that this method does not apply extra credit for exceeding prescriptive code requirements.

Where:

$PBC_{Measure}$  = Percentage difference between "code – built" and "as – built" models

$AB_{Measure}$  = Measure as – built consumption

$CB_{Measure}$  = Measure code – built consumption

Below is an example of how this step in the calculation would work for a home that does not meet the lighting code requirement from the 2009 IECC (i.e., the as-built model has a higher consumption than the code-built model).

$$PBC_{Lighting} = \frac{(3 \text{ MMBtu} - 5 \text{ MMBtu})}{5 \text{ MMBtu}} = -0.4$$

$$Compliance_{Lighting} = (1 + PBC_{Lighting}) = 60\%$$

Where:

$AB_{Lighting}$  = 5 MMBtu for as – built lighting Consumption

$CB_{Lighting}$  = 3 MMBtu for code – built lighting Consumption

The last step is to calculate the weighted sum of each measure's compliance to determine the home's compliance score.

$$Compliance_{Home} = Compliance_{Measure} \times APTC_{Measure}$$

Specifically, this methodology includes scoring and compliance calculations for the following building components:

- Above-grade wall insulation and installation quality
- Air leakage
- Duct leakage and insulation
- Foundation wall insulation and installation quality
- Frame floor insulation and installation quality
- Lighting efficiency
- Roof insulation and installation quality
- Slab insulation and installation quality
- Window efficiency

The fraction of a typical home's energy consumption applied to individual components varies depending on the sample of homes and the code that is under consideration. For example, the distribution for 2006 IECC compliance would differ from 2009 IECC compliance because certain measures, such as lighting efficiency, are not applicable to the 2006 IECC.

The statewide measure-level weights are shown in [Table 3](#).

Table 3: Statewide Average Energy Consumption (Weight) by Measure

Measure	Weight
Window and skylight U-factor	20%
Air leakage	18%
Above grade wall insulation and installation	18%
Duct leakage and insulation	11%
Ceiling insulation and installation	10%
Lighting	9%
Frame floor insulation and installation	7%
Slab insulation and installation	3%
Foundation wall insulation and installation	3%

### 2.3.2 Assessing Compliance under MA-REC

As discussed, the MA-REC approach assesses compliance at the measure level and overall, taking into account the relative impact of each measure category on overall consumption. **However, it is important to note that the compliance scores provided in this report do not represent the proportion of homes that comply with all applicable code requirements. Instead, the MA-REC scores are an indicator of the relative compliance of homes (i.e., partial code compliance), which is not accounted for in many compliance mechanisms.**

## 2.4 GROSS POTENTIAL SAVINGS

Potential savings were estimated using the energy models generated for MA-REC compliance calculations. Any measure category in an as-built home that consumed more energy than its prescriptive code-compliant counterpart was deemed to contribute to the pool of potential savings. These savings were normalized by conditioned floor area, and the mean normalized savings per measure across the sample was multiplied by the fraction of homes in the sample with available savings to find the average potential savings per square foot of conditioned floor area for each measure.

For example, in a hypothetical sample of five homes in which a 2,900 ft<sup>2</sup> home could save 689 kBTU/yr with improved windows, a 3,040 ft<sup>2</sup> home could save 827 kBTU/yr, and the three remaining homes have code compliant windows (i.e., no potential savings), the potential savings for the sample is:

$$\text{Mean} \left( \frac{689 \text{ kBTU/yr}}{2900 \text{ ft}^2}, \frac{827 \text{ kBTU/yr}}{3040 \text{ ft}^2}, 0, 0, 0 \right) = 0.10 \frac{\text{kBTU/yr}}{\text{ft}^2}$$

Multiplying this potential savings energy use intensity by the average home size (3,043 ft<sup>2</sup>), gives an average potential savings per home of 310 kBTU/yr for improved windows, which is reported as a fraction of average home energy use.

## 3

## Section 3 Results

Results in this section are presented with confidence intervals as absolute percentage *points* (%), not relative percentages. Therefore, 72%±3% represents a range of possible means from 69% to 75%. In addition, some confidence intervals are given in ***per mille***, or tenths of a percent (e.g., 7‰ = 0.7%).

***Please note that for the purposes of this study, all assessed homes were built under the 2009 IECC. Consequently, comparisons to the 2012 IECC-CT requirements represent minimum compliance estimates (a floor) and maximum potential savings estimates (a ceiling) since the 2012 IECC-CT code was not enforced during the construction of the sampled buildings.***

- Both program homes and non-program homes display high compliance rates with the 2009 IECC (97% and 90%, respectively), resulting in a statewide compliance rate of 91% (Table 4).
- The differences between program homes (96%) and non-program homes (78%) are intensified when considering the 2012 IECC-CT estimated compliance rates (Table 5).
- When adjusted to reflect measured results from Massachusetts, 2012 IECC-CT compliance rates (86%) are projected to be the same as compliance rates from homes built at the beginning of the 2012 IECC in Massachusetts (86%) (Table 6).
- The gross potential savings available from code compliance enhancement range from 20% to 33% for the 2012 IECC-CT. Air leakage and duct leakage account for the largest potential savings (Table 8 and Table 10).

### 3.1 COMPLIANCE

**2009 IECC.** The residential new construction program in Connecticut appears to be highly effective, as shown by the significant difference in compliance rates for all measures compared to non-program homes in Table 4, which shows measure-level compliance with the 2009 IECC. On average, program homes are 97% compliant with the 2009 IECC and non-program homes are 90% compliant, resulting in an average compliance with the 2009 IECC of 91% across the entire population of new Connecticut homes.

Non-program compliance most notably lags behind program homes in terms of ceiling and frame floor insulation, followed by above-grade walls and foundation wall insulation.<sup>14</sup> Table 4 shows all of the measures included in the MA-REC analysis' point system; the measure categories are sorted in descending order of their relative energy consumption.<sup>15</sup>

<sup>14</sup> As noted in the R1602 Baseline Report, non-program homes may be more likely to have conditioned basements, and for these basements to be uninsulated.

<sup>15</sup> The descending order is based on average results across the program and sampled non-program homes.

Table 4: Mean MA-REC Compliance for 2009 IECC<sup>‰</sup>

Building System	Program		Non-Program		Statewide (Weighted)	
	Compliance	Weight	Compliance	Weight	Compliance	Weight
<i>n</i>	180		70		2,880	
Windows	<b>99%*</b> ±4‰	22%	<b>94%*</b> ±1%	20%	95% ±2‰	20%
Air Leakage	<b>100%*</b> ±0‰	10%	<b>98%*</b> ±1%	19%	98% ±2‰	18%
Above Grade Walls	<b>96%*</b> ±1%	24%	<b>88%*</b> ±2%	18%	89% ±2‰	18%
Ducts	<b>100%*</b> ±1‰	9%	<b>95%*</b> ±2%	11%	96% ±3‰	11%
Ceilings	<b>98%*</b> ±1%	10%	<b>78%*</b> ±4%	10%	80% ±6‰	10%
Lighting	<b>100%*</b> ±5‰	12%	<b>90%*</b> ±2%	8%	91% ±4‰	9%
Frame Floors	<b>86%*</b> ±3%	7%	<b>72%*</b> ±3%	7%	73% ±5‰	7%
Foundation Walls	<b>92%*</b> ±2%	4%	<b>85%*</b> ±5%	3%	85% ±7‰	3%
Slabs	<b>99%*</b> ±1%	3%	<b>94%*</b> ±2%	3%	94% ±3‰	3%
<b>OVERALL</b>	<b>97%*</b> ±4‰		<b>90%*</b> ±9‰		91% ±1‰	

\* Significantly different at the 90% confidence level.

‰ Some confidence intervals are given in *per mille*, or tenths of a percent.

**2012 IECC-CT.** The disparity between program and non-program homes is starker in [Table 5](#). **Note, this business-as-usual scenario assumed no changes in builder practices even in the face of new code requirements.** Adjustments to these values are explored further in [Section 3.1.1](#). Nevertheless, program homes fare quite well, with an average overall compliance score of 96%.

Table 5: Mean MA-REC Compliance for 2012 IECC-CT, Business-as-Usual<sup>‰</sup>

Building System	Program		Non-Program		Statewide (Weighted)	
	Compliance	Weight	Compliance	Weight	Compliance	Weight
<i>n</i>	180		70		2,880	
Windows	<b>99%*</b> ±4‰	22%	<b>85%*</b> ±1%	20%	86% ±2‰	20%
Air Leakage	<b>90%*</b> ±2%	10%	<b>64%*</b> ±4%	19%	65% ±7‰	18%
Above Grade Walls	<b>98%*</b> ±1%	25%	<b>89%*</b> ±2%	20%	89% ±2‰	18%
Ducts	<b>99%*</b> ±1%	9%	<b>76%*</b> ±4%	11%	77% ±6‰	11%
Ceilings	<b>94%*</b> ±1%	10%	<b>70%*</b> ±4%	10%	72% ±6‰	10%
Lighting	<b>100%*</b> ±4‰	11%	<b>79%*</b> ±4%	9%	81% ±5‰	9%
Frame Floors	<b>89%*</b> ±2%	7%	<b>75%*</b> ±3%	7%	76% ±5‰	7%
Foundation Walls	<b>89%*</b> ±2%	4%	<b>80%*</b> ±5%	3%	80% ±8‰	3%
Slabs	<b>99%*</b> ±1%	3%	<b>92%*</b> ±2%	3%	93% ±4‰	3%
<b>OVERALL</b>	<b>96%*</b> ±4‰		<b>78%*</b> ±2%		79% ±3‰	

\* Significantly different at the 90% confidence level.

‰ Some confidence intervals are given in *per mille*, or tenths of a percent.

Additional compliance findings, including the correlation of compliance across measures and graphs of compliance distributions, can be found in [Appendix A](#).

### 3.1.1 Comparison to Compliance in Other States

This section compares Connecticut compliance rates to recent results from Massachusetts and Rhode Island. These states offer an excellent comparison point for Connecticut because (1) the compliance methodology is the same for each state and (2) compliance was measured with comparable energy codes in each state. In addition to these comparisons, [Appendix A](#) presents compliance comparisons with a study from Idaho, where an analogous compliance methodology was used.

#### 3.1.1.1 Massachusetts Compliance Comparisons

This subsection compares MA-REC compliance rates between the Connecticut sample and a sample of new Massachusetts homes that were recently included in a comparable study.<sup>16</sup> We present the comparisons using two Connecticut compliance numbers:

1. Modeled compliance rates assuming *a business-as-usual scenario for the 2012 IECC-CT with the assumption of no changes in construction practices in the initial stages of new code adoption*, labeled “BAU” in [Table 6](#).
  - a. These estimates represent a compliance floor for the 2012 IECC-CT.
2. Estimates derived from the ratio of compliance rates observed in Massachusetts at the end of the 2009 IECC cycle and the beginning of the 2012 IECC cycle, labeled “MA Ratio” in [Table 6](#).<sup>17</sup>
  - b. The team applied the ratio of compliance rates seen in Massachusetts for the end of the 2009 IECC and the beginning of the 2012 IECC to the Connecticut business-as-usual compliance rates.
  - c. These represent a more realistic 2012 IECC-CT compliance value as they are adjusted to account for changing building practices in the face of a new code.

**2009 IECC.** [Table 6](#) shows that statewide compliance levels with the 2009 IECC are identical for Connecticut and Massachusetts (91% for each). However, there are key differences in measure-level compliance levels between the states. Windows, lighting, frame floor insulation, and foundation wall insulation all show significant differences between the two states – some measures display higher compliance in Connecticut, while others display higher compliance in Massachusetts.

**2012 IECC.** [Table 6](#) also shows that overall, projected compliance rates in Connecticut under the 2012 IECC-CT using the business-as-usual scenario (labeled “BAU”) are lower than early 2012 IECC compliance rates in Massachusetts (79% vs. 86%, respectively). When the Connecticut rates are adjusted using the ratio of compliance results from the end of the 2009 IECC and beginning of 2012 IECC from Massachusetts (labeled “MA Ratio”), the compliance rates are identical between the two states (86%). It is important to recognize that the

---

<sup>16</sup> NMR Group, Inc. & Dorothy Conant “2015-16 Massachusetts Single-Family Code Compliance/Baseline Study: Volume 4” <http://ma-eeac.org/wordpress/wp-content/uploads/Single-Family-Code-Compliance-Baseline-Study-Volume-4.pdf> (accessed August 22, 2017).

<sup>17</sup> This ignores any effects of the code enhancement program in Massachusetts, and assumes Connecticut has comparable naturally occurring market adoption rates (NOMAD).

Connecticut version of the 2012 IECC is amended and less stringent than the version in Massachusetts.<sup>18</sup>

**Table 6: Statewide MA-REC Compliance by Measure Across States<sup>!!</sup>**

Building System	Connecticut					Massachusetts		
	Late 2009 IECC	Early 2012 IECC-CT				Late 2009 IECC	Early 2012 IECC	Δ
		BAU	Δ	MA Ratio	Δ			
Windows	<b>95%*</b>	86%	-9%	94%	-1%	<b>98%*</b>	97%	-1%
Air Leakage	98%	65%	-33%	81%	-17%	99%	85%	-14%
<i>Above Grade Walls</i>	89%	89%	0%	88%	-1%	91%	90%	-1%
Ducts <sup>‡</sup>	96%	77%	-19%	78%	-18%	91%	75%	-16%
Ceilings	80%	72%	-8%	87%	7%	83%	89%	6%
Lighting	<b>91%*</b>	81%	-10%	76%	-15%	<b>82%*</b>	72%	-10%
<i>Frame Floors</i>	<b>73%*</b>	76%	3%	73%	0%	<b>81%*</b>	83%	2%
Foundation Walls	<b>85%*</b>	80%	-5%	80%	-5%	<b>91%*</b>	86%	-5%
<i>Slabs</i>	94%	93%	-1%	92%	-2%	94%	92%	-2%
OVERALL	91%	79%	-12%	86%	-5%	91%	86%	-5%

\* Significantly different between Connecticut and Mass. at the 90% confidence level.

!! Italics denote measures with unchanged prescriptive requirements between codes.

‡ Non-amended 2012 IECC duct leakage requirements are stricter in Massachusetts.

A detailed comparison of program versus non-program compliance between Massachusetts and Connecticut can be found in [Appendix A](#).

### 3.1.1.2 Comparison to Compliance in Rhode Island

Rhode Island recently completed a compliance study of new single-family homes.<sup>19</sup> The study used the MA-REC compliance methodology and measured compliance in homes built in the middle of the 2012 IECC cycle. Like Connecticut, Rhode Island has an amended version of the 2012 IECC that is less stringent than the base code.<sup>20</sup> Compliance in Rhode Island was found to be 83%, which is in between the compliance range of 79% and 86% for the 2012 IECC-CT.

<sup>18</sup> As previously discussed, the Connecticut homes included in this study were built under the 2009 IECC; assessing these homes under the requirements of the 2012 IECC-CT serves as a reasonable proxy for code compliance early in the newer code cycle, given the lag between the code adoption and changes in builder practices.

<sup>19</sup> NMR Group, Inc., "Rhode Island Baseline Study of Single-Family Residential New Construction" Submitted to National Grid Rhode Island, January 16, 2018. [http://rieermc.ri.gov/wp-content/uploads/2018/03/ri-rnc-baseline-study\\_16jan2018\\_final.pdf](http://rieermc.ri.gov/wp-content/uploads/2018/03/ri-rnc-baseline-study_16jan2018_final.pdf)

<sup>20</sup> The Rhode Island code has conflicting information regarding prescriptive R-values versus prescriptive U-factors. The Rhode Island results referenced here are compared to the more stringent 2012 IECC-derived U-factor requirements that are identified in the code.

### 3.2 MAXIMUM GROSS POTENTIAL SAVINGS

Given the similar compliance rates for program homes under both codes (97% for 2009 IECC and 96% for 2012 IECC-CT), the potential savings for improving code compliance are similar and modest: 7% of annual energy use per home. The disparity in compliance of non-program homes (90% for 2009 IECC and 78% for 2012 IECC-CT under the business-as-usual scenario) indicates that there may be significant potential savings under the new code (up to 33% of annual energy use per home); this compares to only 17% under the 2009 IECC. ***However, it must be emphasized that this represents a maximum potential savings based on the assumption of no change in builder practices under the new code, since it compares models of homes constructed under the 2009 IECC to 2012 IECC-CT requirements.*** The magnitude of the maximum potential savings among non-program homes is further underscored by the differences in the average annual energy consumption of program and non-program homes: 44 MMBTU/yr and 79 MMBTU/yr, respectively (76 MMBTU/yr statewide).

These results do not account for trade-offs that are permissible under the UA Trade-off and Performance compliance paths. Further emphasizing that these results should be considered the *maximum* achievable savings.

[Table 7](#) and [Table 8](#) present the gross potential savings associated with both the 2009 IECC and the 2012 IECC. The measures are ordered based on the magnitude of potential savings under each code. Finally, the highlighted rows indicate measures that are mandatory code requirements with which builders must meet the prescriptive code requirement, regardless of the compliance path that is used to achieve compliance. Gross potential savings are calculated by determining the decreased energy consumption that takes place when non-compliant measures are brought up to prescriptive code requirement levels. As such, the sample sizes in these tables represent the number of homes in our sample that fall below code for a given measure.

**Table 7: Maximum Gross Potential Savings under 2009 IECC<sup>!!,%</sup>**  
(% of As-Built Consumption)

Building System	Requirement <sup>1</sup>	Program		Non-Program		Statewide
		Potential	n	Potential	n	Potential
Ceilings	Path dependent	<b>&lt;1%*</b> ±1‰	29	<b>4%*</b> ±1%	53	4% ±9‰
<i>Frame Floors</i>	<i>Path dependent</i>	2% ±6‰	120	4% ±2%	63	4% ±2%
<i>Above Grade Walls</i>	<i>Path dependent</i>	1% ±3‰	99	3% ±4‰	62	3% ±4‰
Duct Leakage	Mandatory	<1% ±0‰	1	2% ±8‰	19	2% ±8‰
Windows	Path dependent	<1% ±1‰	11	1% ±3‰	54	1% ±3‰
Lighting	Mandatory	<1% ±0‰	1	1% ±3‰	33	1% ±3‰
Air Leakage	Mandatory	1% ±3‰	0	1% ±5‰	11	1% ±5‰
Foundation Walls	Path dependent	1% ±3‰	48	2% ±1%	31	1% ±1%
<i>Slabs</i>	<i>Path dependent</i>	<1% ±1‰	32	<1% ±2‰	23	<1% ±2‰
<b>TOTAL</b>		<b>6%*</b> ±9‰		<b>17%*</b> ±2%		17% ±2%

<sup>1</sup> Measures listed as path dependent are only required when builders use certain compliance pathways.

\* Significantly different at the 90% confidence level.

<sup>!!</sup> Italics denote measures with unchanged prescriptive requirements between codes.

‰ Some confidence intervals are given in *per mille*, or tenths of a percent.

Program and non-program home potential savings are significantly different for every measure that was revised in 2012 IECC-CT (non-italicized entries), except foundation walls.

**Table 8: Maximum Gross Potential Savings under 2012 IECC-CT<sup>!!,%</sup>**  
(% of As-Built Consumption)

Building System	Requirement <sup>1</sup>	Program		Non-Program		Statewide
		Potential	n	Potential	n	Potential
Air Leakage	Mandatory	<b>1%*</b> ±3‰	85	<b>10%*</b> ±2%	60	9% ±1%
Duct Leakage	Mandatory	<b>&lt;1*</b> ±1‰	24	<b>6%*</b> ±1%	49	5% ±1%
Ceilings	Path dependent	<b>1%*</b> ±2‰	96	<b>5%*</b> ±1%	61	4% ±9‰
Windows	Path dependent	<b>&lt;1%*</b> ±2‰	16	<b>4%*</b> ±4%	67	3% ±4‰
<i>Frame Floors</i>	<i>Path dependent</i>	2% ±6‰	123	3% ±1%	62	3% ±1%
<i>Above Grade Walls</i>	<i>Path dependent</i>	1% ±3‰	67	2% ±4‰	60	2% ±4‰
Lighting	Mandatory	<b>&lt;1%*</b> ±1‰	1	<b>3%*</b> ±5‰	50	2% ±5‰
Foundation Walls	Path dependent	1% ±4‰	69	2% ±1%	31	2% ±1%
<i>Slabs</i>	<i>Path dependent</i>	<1% ±1‰	31	1% ±3‰	30	<1% ±3‰
<b>TOTAL</b>		<b>7%*</b> ±9‰		<b>34%*</b> ±3%		33% ±3%

<sup>1</sup> Measures listed as path dependent are only required when builders use certain compliance pathways.

\* Significantly different at the 90% confidence level.

<sup>!!</sup> Italics denote measures with unchanged prescriptive requirements between codes.

‰ Some confidence intervals are given in *per mille*, or tenths of a percent.

Additional details on the distribution of these savings by measure can be found in [Appendix A](#).

### 3.2.1 Comparison to Savings in Massachusetts

Table 9 presents a comparison of the statewide gross potential savings between Connecticut (2012 IECC-CT) and Massachusetts (2012 IECC). **As previously mentioned, the 2012 IECC-CT savings represent a maximum possible savings potential since these homes were built prior to the implementation of the 2012 IECC-CT in Connecticut, and the models assume no change in builder practices.** On the other hand, the Massachusetts results are based on homes that were built at the beginning of the 2012 IECC cycle after enforcement of the code had taken place, further anchoring the range of reasonably expected potential savings from increased code compliance in Connecticut.<sup>21</sup>

**Table 9: Maximum Gross Potential Savings by Measure Across States<sup>!!</sup>**

Building System	Requirement <sup>1</sup>	2012 IECC-CT	MA Early 2012 IECC
Air Leakage	Mandatory	9%	3%
Duct Leakage <sup>2</sup>	Mandatory	5%	4%
Ceilings	Path dependent	4%	1%
Windows	Path dependent	3%	1%
<i>Frame Floors</i>	<i>Path dependent</i>	3%	2%
<i>Above Grade Walls</i>	<i>Path dependent</i>	2%	2%
Lighting	Mandatory	2%	3%
Foundation Walls	Path dependent	2%	1%
<i>Slabs</i>	<i>Path dependent</i>	<1%	<1%
<b>TOTAL</b>		<b>33%</b>	<b>18%</b>

<sup>1</sup> Measures listed as path dependent are only required when builders use certain compliance pathways. For example, prescriptive R-values are only required when builders use a prescriptive compliance path.

<sup>2</sup> Non-amended 2012 IECC duct leakage requirements are stricter in Massachusetts

<sup>!!</sup> Italics denote measures that are unchanged between 2009 and 2012 IECC.

Ignoring any effects of the code enhancement program in Massachusetts, and assuming Connecticut has comparable naturally occurring market adoption rates (NOMAD), it is possible to determine a gross potential savings floor for Connecticut to complement the modeled savings ceiling in Table 8 and Table 9 by multiplying the ratio of 2009 compliance rates in both states multiplied with the reported gross potential savings for early-cycle 2012 IECC built homes in Massachusetts. Coincidentally, the statewide results of these calculations in Table 10 are nearly identical – within rounding – to the reported savings potential for Massachusetts.

<sup>21</sup> Since the prescriptive code requirements for slabs and frame floors have remained unchanged between the 2009 IECC and the 2012 IECC/2012-IECC-CT, one might expect that the compliance rates for these measures would remain constant as well. However, due to inter-measure synergies and other unknown effects, small changes are observed in both Connecticut and Massachusetts.

**Table 10: Adjusted 2012 IECC-CT Gross Potential Savings<sup>¶</sup>**

Building System	Requirement <sup>1</sup>	Program	Non-Program	Statewide
Air Leakage	Mandatory	<1%	4%	4%
Duct Leakage <sup>2</sup>	Mandatory	2%	4%	4%
Ceilings	Path dependent	1%	2%	1%
Windows	Path dependent	<1%	1%	1%
<i>Frame Floors</i>	<i>Path dependent</i>	1%	2%	2%
<i>Above Grade Walls</i>	<i>Path dependent</i>	1%	2%	2%
Lighting	Mandatory	0%	3%	3%
Foundation Walls	Path dependent	1%	3%	2%
<i>Slabs</i>	<i>Path dependent</i>	<1%	<1%	<1%
<b>TOTAL</b>		<b>6%</b>	<b>21%</b>	<b>20%</b>

<sup>1</sup> Measures listed as path dependent are only required when builders use certain compliance pathways.

For example, prescriptive R-values are only required when builders use a prescriptive compliance path.

<sup>2</sup> Non-amended 2012 IECC duct leakage requirements are stricter in Massachusetts.

<sup>¶</sup> Italics denote measures that are unchanged between 2009 and 2012 IECC.

## 4

## Section 4 Code Compliance Enhancement Programs

As improvements to the building code continue to raise the floor for minimum efficiency levels in new construction, it becomes increasingly difficult for utilities to satisfy their regulatory requirements for energy efficiency. Consequently, many utilities are driven to expand outside of their traditional purview with new efforts, such as code enhancement programs. These code enhancement programs can take many forms, including the following:

- Training for architects, tradespeople, and building department staff  
*e.g.*, Massachusetts Code Compliance Support Initiative (CCSI), Rhode Island Code Compliance Enhancement Initiative (CCEI)
- Fostering peer exchange via networking events  
*e.g.*, Home Energy Pros,<sup>22</sup> Better Buildings Residential Network Peer Exchange<sup>23</sup>
- Educational materials, including websites, field guides, etc.  
*e.g.*, National Grid Energy Code Technical Support<sup>24</sup> in Rhode Island; see [Figure 5](#)
- Support Hotlines  
*e.g.*, National Grid Energy Code Technical Support RI, Efficiency Vermont<sup>25</sup>
- Marketing to build consumer demand for efficient homes  
*e.g.*, Bonneville Power Authority & Northwest Power and Conservation Council<sup>26</sup>
- Inspection and testing fee support  
*e.g.*, Washington State Utility Codes Group,<sup>27</sup> Austin Energy<sup>28</sup>
- Making participation in other programs by the builder, such as appliance or HVAC rebates, contingent upon code compliance  
*e.g.*, MidAmerican Energy's Advanced Builder Option Package<sup>29</sup>

<sup>22</sup> Formerly of the U.S. Department of Energy's Lawrence Berkley Labs, <http://homeenergypros.org/> is now hosted by the Home Performance Coalition.

<sup>23</sup> <https://energy.gov/eere/better-buildings-residential-network/better-buildings-residential-network> (accessed January 29, 2018).

<sup>24</sup> National Grid, "Technical and Design Assistance" <https://www.nationalgridus.com/ProNet/Technical-Resources/Technical-Assistance> (accessed September 1, 2017).

<sup>25</sup> Stellberg, S., *et al.*, "Role for Utilities in Enhancing Building Energy Code Compliance", 2012, <http://aceee.org/files/proceedings/2012/data/papers/0193-000174.pdf> (accessed September 1, 2017).

<sup>26</sup> The Edison Foundation Institute for Energy Efficiency, "Integrating Codes and Standards into Electric Utility Energy Efficiency Portfolios", August 2011, [http://www.edisonfoundation.net/iee/Documents/IEE\\_IntegratingCSintoEEPportfolios\\_final.pdf](http://www.edisonfoundation.net/iee/Documents/IEE_IntegratingCSintoEEPportfolios_final.pdf) (marketing p. 13, testing p. 10) (accessed September 1, 2017).

<sup>27</sup> The Cadmus Group, Inc. "Impact Evaluation Report for the Illinois Building Energy Codes Education and Technical Assistance Program" June 1, 2017 [http://ilsagfiles.org/SAG\\_files/Evaluation\\_Documents/Draft%20Reports%20for%20Comment/DCEO\\_EPY8GPY5/Department\\_of\\_Commerce\\_Building\\_Energy\\_Code\\_s\\_Program\\_EPY8\\_GPY5\\_Draft.docx](http://ilsagfiles.org/SAG_files/Evaluation_Documents/Draft%20Reports%20for%20Comment/DCEO_EPY8GPY5/Department_of_Commerce_Building_Energy_Code_s_Program_EPY8_GPY5_Draft.docx) (accessed August 28, 2017).

<sup>28</sup> Stellberg, S., *et al.*

<sup>29</sup> MidAmerican Energy, "Energy Efficiency for Iowa Residents - New Homes" <https://www.midamericanenergy.com/ia-res-new-homes.aspx> (accessed September 1, 2017).

***If the public became educated as to why they would want the improved homes, then they will want them and the builders will be happy to build them. — MA CCSI attendee***

---

However, these efforts are several steps removed from implementation and may occur alongside market forces or the influence of other actors, complicating the requisite assessment and apportioning of energy savings to code enhancement efforts. Therefore, careful consideration in program design and evaluation plans is required to detect and quantify impacts.

#### 4.1 PROGRAM DESIGN

The most effective programs are likely to include several approaches to reach the widest audience and increase saliency. For example, the Rhode Island CCEI includes training sessions and freely available online materials, as do similar programs in California and New York.

In recent evaluations of code enhancement training sessions in Rhode Island and Massachusetts, coverage of air leakage/air barriers and duct leakage requirements were ranked among the most useful modules by attendees; insulation inspection, indoor air quality, and ventilation were also highly ranked. This is particularly noteworthy for any future enhancement program in Connecticut because air leakage and duct leakage are among the measures with the greatest potential for improved compliance and energy savings, as shown in [Table 5](#) and [Table 8](#), respectively.

Additional findings reveal a need for multiple session styles of differing duration, as well as a mixture of topics to suit audience schedules and interests. These recommendations were foreshadowed in 2012 by California's Compliance Improvement Advisory Group (CIAG) whitepaper "Preparing Industry for New Standards,"

*More training, more targeted training, variations in training session length, training at times and in locations that better fit the trainees' schedules (including possible on-site training), capping the cost of training, involving the targeted trades and professionals in both the creation and delivery of training, side-by-side (with trades and inspectors together) as well as role-based training, and on-the-job training.<sup>30</sup>*

It was also found in the Massachusetts and Rhode Island compliance enhancement evaluations that the potential to earn continuing education credits (CEU) encourages greater

---

<sup>30</sup> <http://www.caciag.com/Documents/Preparing%20Industry%20for%20New%20Code%20DRAFT%2011%2021%2012.pdf> (accessed March 26, 2018).

attendance.<sup>31</sup> This is a benefit that is also offered by the New York State Energy Research and Development Authority's (NYSERDA's) Energy Code Training and Support Services.

While targeted at policy makers, the U.S. Department of Energy Building Technologies Program's recommendation to "inquire with local municipalities into the enforcement challenges they face"<sup>32</sup> is sound advice, and is key to offering the "circuit-rider" style customized training offered in New York and highlighted in the Massachusetts and Rhode Island evaluations. In 2014, the Southeast Energy Efficiency Alliance's circuit rider conducted a series of visits with building departments across the state to determine technical assistance needs, revealing two key findings: (1) unlike the electrical or fire safety codes, energy efficiency is cross-functional and (2) there is little understanding of the rationale behind energy code requirements (there may even be less of an understanding of rationale than of what is required to comply with the energy code).<sup>33</sup> Both of these factors contribute to resistance to implement required practices by builders and under-enforcement by officials.

***It's important to make the sections of the code as simple as possible. Make it more user friendly. There should be commentary on the IECC code books to help code officials and builders interpret it. Break down the intent of the sections. They need to come out with something that shows this more clearly.***  
***— MA CCSI attendee***

---

Code books are commonly provided in training sessions, and attendees frequently report that they are used as a first reference. These cover both the *what's* of energy code requirements, and, if annotated, the *why's*. However, the code book can be both intimidating and confusing, especially when there are amendments to the base code. A localized and visual guide like the "Field Guide: Residential New Construction Energy Efficient Construction Rhode Island Energy Code"<sup>34</sup> from National Grid's energy code technical support program, shown in [Figure 5](#), can help address these issues while sharing the rationale behind code requirements and providing examples of effective techniques for complying with code. This last point is crucial, as is offering materials in physical form, because trainees often share these with others.

---

<sup>31</sup> NMR Group, Inc. "Findings of Follow-Up Interviews with Massachusetts Code Compliance Support Initiative Residential Training Attendees (TXC 46)", *Submitted to Massachusetts Electric and Gas Program Administrators*, December 11, 2017 <http://ma-eeac.org/wordpress/wp-content/uploads/Code-Compliance-Support-Initiative-Interview-Follow-Ups.pdf>

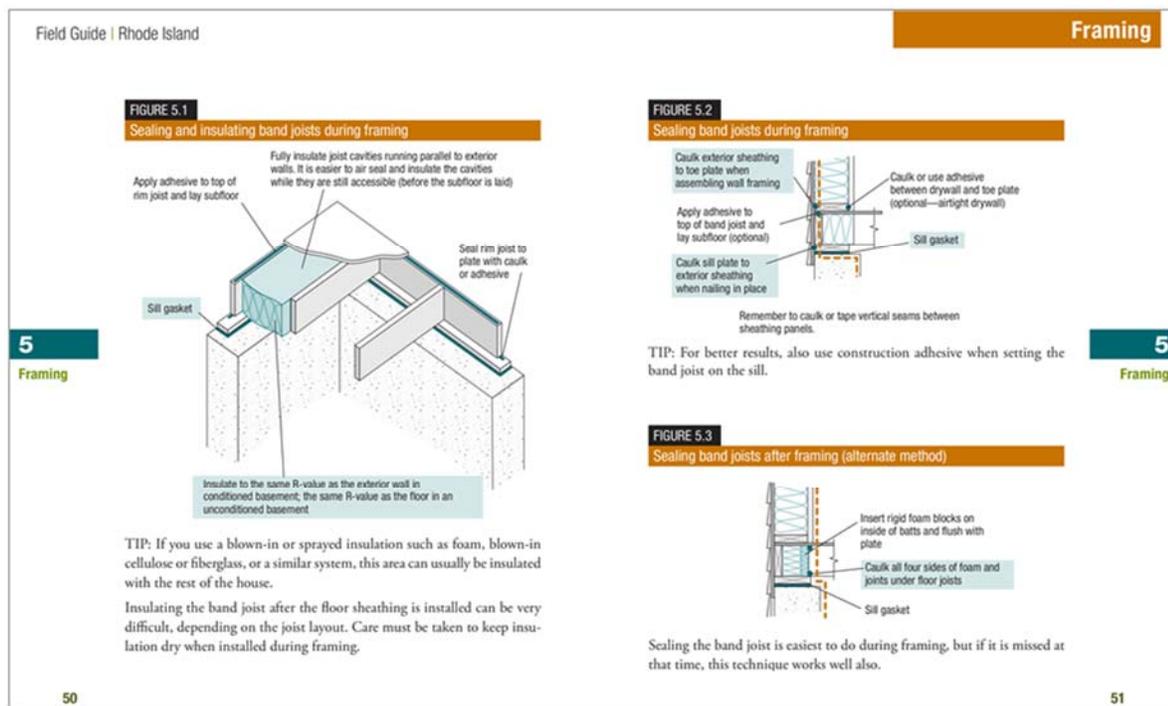
<https://www.nyserderda.ny.gov/All-Programs/Programs/Energy-Code-Training> (accessed March 26, 2018)  
<sup>32</sup> U.S. Department of Energy, "Building Energy Guides Resource Guide For Policy Makers", June 2011, [https://www.energycodes.gov/sites/default/files/documents/BECF\\_Policy\\_Maker\\_Resource%20Guide\\_June2011\\_v00\\_lores.pdf](https://www.energycodes.gov/sites/default/files/documents/BECF_Policy_Maker_Resource%20Guide_June2011_v00_lores.pdf) (accessed August 16, 2017).

<sup>33</sup> Southeast Energy Efficiency Alliance, "Florida Circuit Rider Commercial Compliance Needs Assessment", July 2015, <http://seealliance.org/initiatives/built-environment/energy-codes/florida-rider/> (accessed January 30, 2018).

<sup>34</sup> Conservation Services Group, Inc. "Field Guide: Residential New Construction — Energy Efficient Construction Rhode Island Energy Code", 2014, <https://www1.nationalgridus.com/files/AddedPDF/Field%20Guide%20RI,%20Final.pdf> (accessed August 22, 2017).

Field guides are also featured in California's Energy Code Ace Program,<sup>35</sup> as well as NYSERDA's offerings.<sup>36</sup> The latter stands out due to the inclusion of a section on site orientation. Although this is not within the purview of current building code, building orientation has a significant impact on a home's energy use, especially through its influence over window orientation and consequently lighting plus space conditioning loads.<sup>37</sup>

**Figure 5: Best Practices Examples in Rhode Island Field Guide<sup>38</sup>**



Due to the unique environment Investor Owned Utilities (IOUs) operate under in California,<sup>39</sup> they may have more flexibility than their counterparts elsewhere in the country. Despite this, the most visible public-facing activities, besides those already discussed, are traditional offerings such as rebates for efficient equipment. However, CIAG, an industry working group, has proposed all of the enhancement activities listed at the beginning of this section in various

<sup>35</sup> Energy Code Ace, "Resources Ace" <http://energycodeace.com/resources> (accessed March 26, 2018).

<sup>36</sup> New York State Energy Research and Development Authority, "Build Better: A Guide to Energy Efficient Concepts for New Residential Construction" [https://nyserdacodetraining.com/resource\\_lib/build-better-guide.pdf](https://nyserdacodetraining.com/resource_lib/build-better-guide.pdf) (accessed March 26, 2018).

<sup>37</sup> U.S. Department of Energy "Building America Best Practices Series: Volume 3 – Builders and Buyers Handbook for Improving New Home Efficiency, Comfort, and Durability in the Cold and Very Cold Climates," August 2005, [https://www1.eere.energy.gov/buildings/publications/pdfs/building\\_america/38309.pdf](https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/38309.pdf) (accessed May 25, 2017).

<sup>38</sup> Conservation Services Group, Inc. *Field Guide: Residential New Construction Energy Efficient Construction Rhode Island Energy Code*. (2014).

<sup>39</sup> Title 24, the enabling legislation for state building codes and standards, was amended in 2005 with participation from the IOUs, as were state appliance efficiency standards. The IOUs' collaboration with regulators to tighten standards significantly reduced the achievable savings for traditional programs. Consequently, a system known as Codes and Standards Enhancement (CASE) reports was developed to permit the IOUs to recapture some of these efficiency gains.

whitepapers, as well as less orthodox schemes including a self-certification program for contractors. In exchange for reduced transaction costs (scheduling inspections for every project), participating contractors would undergo special training and carry extra liability insurance to be able to certify that certain aspects of their work comply with code.<sup>40</sup> A similar system exists for other aspects of construction in some parts of the state (e.g., roofing) and related licensed professions, such as architecture in New York. Such a system would still require some verification of compliance, but it could potentially reduce the load of overburdened building departments and permit them to redirect their attention to ensuring compliance among non-participants.

## 4.2 CONSIDERATIONS FOR A CONNECTICUT PROGRAM

There are several ways to influence the efficiency of the RNC market. Some of these approaches are detailed in the list below.

- Traditional RNC incentive programs
- Code compliance enhancement training and education programs (like those detailed above)
- Code development programs
- Market transformation initiatives intended to accelerate the adoption of zero energy buildings

The Companies are already engaged in most of these activities on some level. The RNC program in Connecticut offers incentives for builders to develop homes that are more efficient than the market baseline. The RNC program also conducts some code enhancement training and education, and promotes DOE Zero Energy Ready homes. Up to this point, the Companies have not attempted to identify the impacts associated with their code enhancement training efforts. If these efforts include outreach to builders and other market actors that do not participate in the program, the Companies might consider trying to quantify the impacts of those trainings. Neighboring states have shown that realizing the savings from code enhancement is challenging. However, if the Companies are already conducting training it seems reasonable to realize the savings from those efforts – no matter how small they may be.

One thing that Connecticut has not engaged in is a code development program. This has been one of the primary focuses of the California codes and standards efforts. These programs focus on developing and supporting advanced building codes and accelerating their adoption in order to achieve energy savings. California has done this through the Title 24 codes and Massachusetts has done this through the stretch code. This is something the Companies may want to consider as it could result in additional savings from the RNC market.

---

<sup>40</sup> Compliance Improvement Advisory Group, “Statewide C&S Program Compliance Improvement: Should Building Departments Allow Contractors to Self-Certify Their Installations?,” January, 2015, <http://www.caciag.com/Documents/Contractor%20Self%20Certification%20Final.pdf> (accessed March 26, 2018).

Looking forward, it will be important for the Companies to document their efforts related to any of these market transformation efforts. Detailed documentation and evaluation results are necessary to determine the attributable savings to training, education, and/or code development efforts. In Massachusetts and Rhode Island, this has been done through ongoing surveys with training attendees and semi-regular baseline studies that measure the changes in building practices over time. The level of detail and effort dedicated to documentation varies by state, but claiming savings from these types of efforts is more defensible when the activities and their relative impacts have been consistently documented over time.



## Appendix A Additional Results

This appendix presents additional compliance results, including, but not limited to, details on measure-level compliance distributions, correlation between measure-level compliance scores, and a comparison of the MA-REC compliance scores to compliance scores generated in REM/Rate.

### A.1 MA-REC vs. REM/RATE COMPLIANCE

REM/Rate provides pass/fail compliance ratings, where passing means that a home would satisfy at least one code compliance method (i.e., Prescriptive, Performance, or UA Trade-off). The percent of modeled homes that comply with code using this REM/Rate compliance check are presented in [Table 11](#).

Note that unlike MA-REC, the REM/Rate method provides no partial credit and no measure-level detail. Accordingly, the compliance rates under MA-REC are far higher than under the REM/Rate method.

**Table 11: Alternative Compliance Calculations**

Compliance	Program		Non-Program		Statewide	
	2009 IECC	2012 IECC-CT	2009 IECC	2012 IECC-CT	2009 IECC	2012 IECC-CT
<i>n</i>	180		70		2,880	
REM/Rate	80%*	17%*	5%	2%	10%*	3%*
MA-REC	97%	96%	90%*	78%*	91%*	79%*

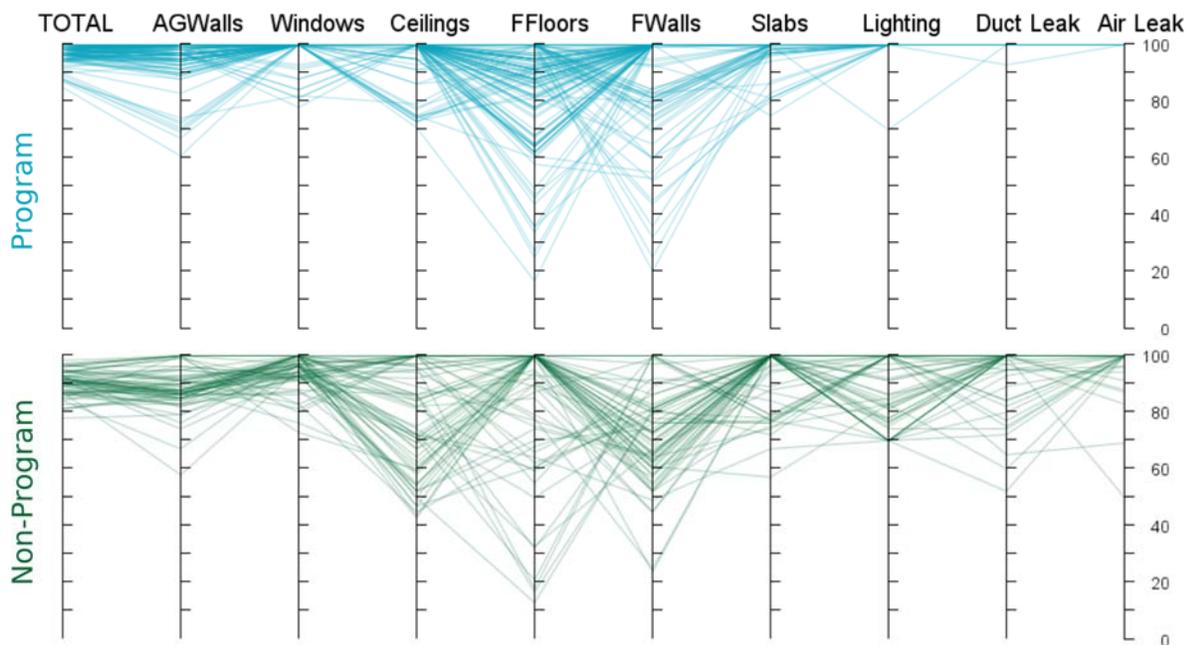
\* Significantly different at the 90% confidence level.

### A.2 COMPLIANCE DISTRIBUTIONS AND CORRELATIONS

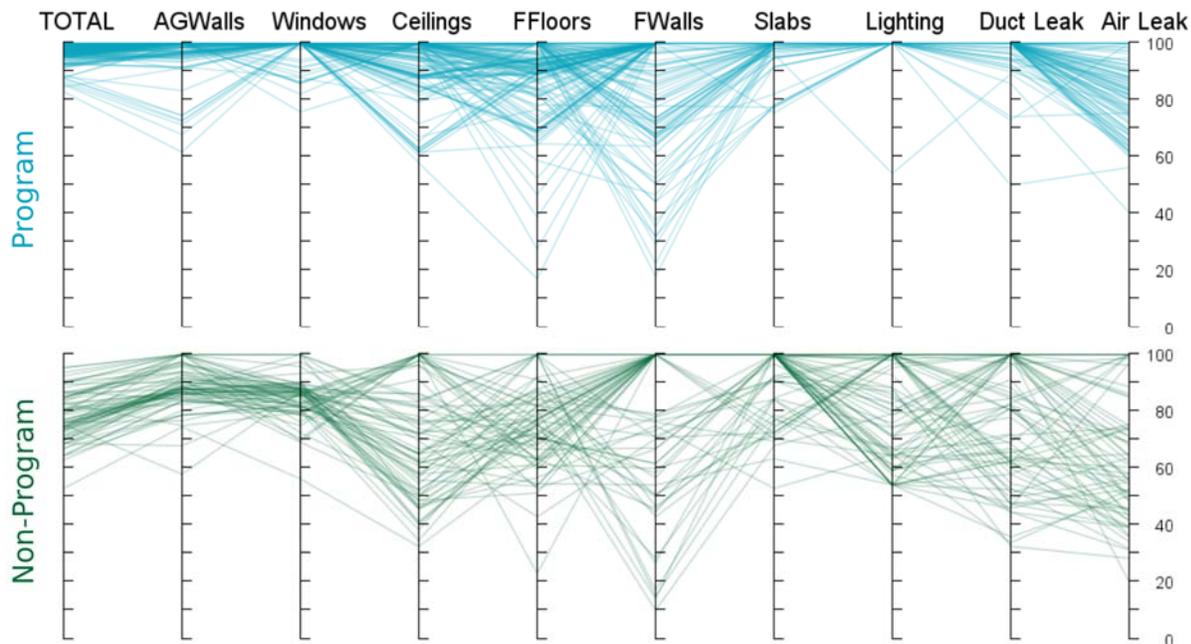
[Figure 6](#) and [Figure 7](#) show the distribution of overall compliance and compliance for each measure in parallel coordinate charts. **Note, these values show the 2012 IECC-CT results assuming a business-as-usual scenario (no changes in building practices in the face of a new code) and represent compliance floors.** The compliance rates for each measure in a home are connected by translucent lines, thereby highlighting relationships between some measures (e.g., walls, windows, and overall compliance), as well as clusters of similarly behaving homes.

Comparing [Figure 6](#) to [Figure 7](#) highlights the wider distribution of 2012 IECC-CT compliance values for duct leakage and air leakage in both program and non-program homes, as well as lighting in non-program homes. These figures also show how the non-program homes are estimated to have lower average overall compliance under the newer code, as well as lower average compliance for above grade walls, foundation walls, and windows.

**Figure 6: Distribution of 2009 IECC Program & Non-Program Compliance**



**Figure 7: Distribution of 2012 IECC-CT Program & Non-Program Compliance**



An alternative view of the relationships between compliance of different measures is given in [Table 12](#) and [Table 13](#). Note that the top-right, unshaded portion of the tables show the 2009 IECC compliance correlations, and the shaded bottom-left portion of the tables show the 2012 IECC-CT. All program homes comply with IECC 2009 air leakage requirements, precluding correlation.

**Table 12: Cross-Measure Compliance Correlations in Program Homes**

	Total	AGW	Wdw	Ceil.	FF	FW	Slab	Light	Duct	Air
Total		<b>.83*</b>	<b>.26*</b>	<b>.47*</b>	<b>.55*</b>	<b>.49*</b>	<b>.35*</b>	.06	.03	N/A
AG Walls	<b>.74*</b>		.06	<b>.40*</b>	<b>.17*</b>	<b>.38*</b>	<b>.43*</b>	-0.01	-0.04	N/A
Windows	.11	-0.08		.00	-0.08	.02	-0.07	-0.02	-0.02	N/A
Ceilings	<b>.60*</b>	<b>.43*</b>	-0.08		.06	.04	.10	.07	-0.03	N/A
Frame Floors	<b>.48*</b>	<b>.27*</b>	-0.04	<b>.22*</b>		.04	-0.06	-0.05	-0.05	N/A
Found. Walls	<b>.32*</b>	<b>.39*</b>	-0.01	-0.02	<b>-.15*</b>		<b>.43*</b>	-0.01	<b>.29*</b>	N/A
Slabs	<b>.45*</b>	<b>.59*</b>	-0.08	<b>.15*</b>	-0.00	<b>.45*</b>		-0.02	<b>.23*</b>	N/A
Lighting	<b>.19*</b>	-0.02	-0.02	.08	-0.06	.04	.05		-0.01	N/A
Duct Leakage	<b>.28*</b>	-0.05	-0.06	-0.07	-0.08	.10	.08	.15		N/A
Air Leakage	<b>.45*</b>	-0.04	-0.08	<b>.19*</b>	<b>.18*</b>	<b>-.27*</b>	-0.06	<b>.15*</b>	<b>.32*</b>	

\* Significant correlation at the 90% confidence level.

**Table 13: Cross-Measure Compliance Correlations in Non-Program Homes**

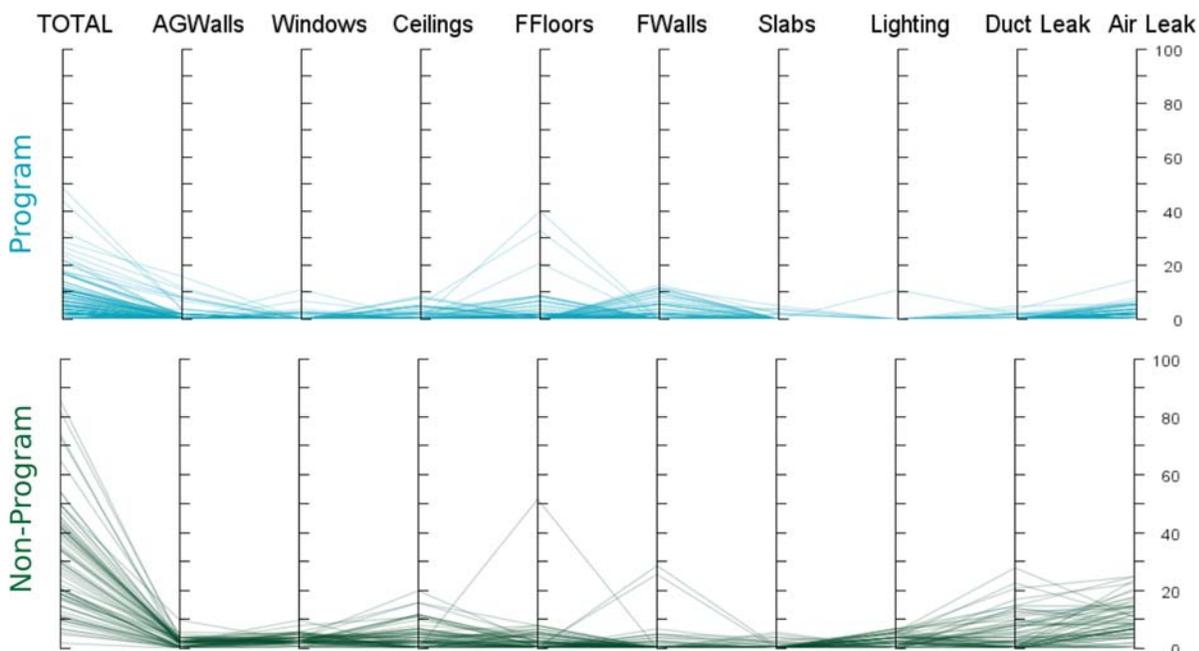
	Total	AGW	Wdw	Ceil.	FF	FW	Slab	Light	Duct	Air
Total		<b>.51*</b>	.22	<b>.68*</b>	.19	-0.02	.15	<b>.43*</b>	<b>.53*</b>	<b>.50*</b>
AG Walls	<b>.61*</b>		-0.15	<b>.26*</b>	-0.06	.09	.16	.01	<b>.25*</b>	.15
Windows	<b>.37*</b>	.20		-0.03	-0.20	-0.14	-0.03	.20	.10	-0.01
Ceilings	<b>.60*</b>	<b>.29*</b>	-0.05		-0.14	.05	.16	<b>.26*</b>	<b>.28*</b>	.09
Frame Floors	<b>.26*</b>	.08	-0.01	-0.04		<b>-.28*</b>	-0.13	.03	-0.09	<b>.30*</b>
Found. Walls	-0.16	.12	-0.13	.06	-0.19		<b>.37*</b>	<b>-.24*</b>	-0.17	-0.08
Slabs	.12	<b>.29*</b>	.00	.19	-0.10	<b>.45*</b>		.00	-0.04	-0.15
Lighting	<b>.40*</b>	-0.04	.12	<b>.26*</b>	.15	-0.23	-0.07		.23	-0.05
Duct Leakage	<b>.72*</b>	<b>.44*</b>	<b>.27*</b>	<b>.40*</b>	-0.12	-0.16	.03	.21		.07
Air Leakage	<b>.83*</b>	<b>.43*</b>	.18	<b>.34*</b>	<b>.32*</b>	<b>-.33*</b>	-0.08	.17	<b>.47*</b>	

\* Significant correlation at the 90% confidence level.

### A.3 GROSS POTENTIAL SAVINGS DISTRIBUTIONS

The distributions of overall and measure level gross potential savings are shown in Figure 8. One third of sampled non-program homes (34%) have greater than average (36%) potential savings, and account for 60% of the sample potential savings. Ceilings, frame floors, air leakage, and duct leakage alone account for 51% of potential savings in these lower performing homes. The disparity in duct leakage is particularly noticeable in this sample, with an average energy savings potential of 38%, compared to 11% in the remaining homes.

**Figure 8: Distribution of Projected Gross Potential Savings under 2012 IECC-CT**  
(% Savings over Baseline MMBtu Consumption)



### A.4 ADDITIONAL COMPLIANCE COMPARISONS

Below we detail comparisons between Connecticut and Massachusetts compliance results for program homes and non-program homes separately. In addition, we present a comparison between Connecticut compliance results and recent Idaho compliance study.

#### A.4.1 Comparison to Compliance in Massachusetts - Program Homes

**2009 IECC.** As shown in Table 14, program homes in Connecticut built under the 2009 IECC have identical compliance rates to Massachusetts homes built under the same code (97% for both).

**2012 IECC.** On average, the estimated compliance for program homes early in the 2012 IECC-CT code cycle (96%) is comparable to the 2012 IECC compliance seen in the Massachusetts program homes (94%). In this comparison, duct leakage compliance is much higher in Connecticut than Massachusetts, but little can be inferred from this because the

2012 IECC-CT has much more lenient total duct leakage requirements than the 2012 IECC in force in Massachusetts (8 CFM25/100 ft<sup>2</sup> vs. only 4 CFM25/100 ft<sup>2</sup>, respectively). The only other measure more than five percentage points apart between these groups is air leakage, a six-point higher compliance rate in Massachusetts (96% vs. 90% estimated for the early 2012 IECC-CT).

**Table 14: Program MA-REC Compliance by Measure Across States<sup>¶</sup>**

Building System	Connecticut					Massachusetts		
	Late 2009 IECC	Early 2012 IECC-CT				Late 2009 IECC	Early 2012 IECC	Δ
		BAU	Δ	MA Ratio	Δ			
Windows	99%	99%	0%	99%	0%	100%	100%	0%
Air Leakage	100%	90%	-10%	96%	-4%	100%	96%	-4%
<i>Above Grade Walls</i>	96%	98%	2%	95%	-1%	95%	94%	-1%
Ducts <sup>‡</sup>	100%	99%	-1%	80%	-20%	100%	80%	-20%
Ceilings	98%	94%	-4%	93%	-5%	97%	92%	-5%
Lighting	100%	100%	0%	100%	0%	100%	100%	0%
<i>Frame Floors</i>	86%	89%	3%	88%	2%	87%	89%	2%
Foundation Walls	92%	89%	-3%	90%	-2%	94%	92%	-2%
<i>Slabs</i>	98%	99%	1%	97%	-1%	96%	94%	-2%
<b>OVERALL</b>	<b>97%</b>	<b>96%</b>	<b>-1%</b>	<b>95%</b>	<b>-2%</b>	<b>97%</b>	<b>94%</b>	<b>-3%</b>

<sup>¶</sup> Italics denote measures with unchanged prescriptive requirements between codes.

<sup>‡</sup> Non-amended 2012 IECC duct leakage requirements are stricter in Massachusetts.

#### A.4.2 Comparison to Compliance in Massachusetts - Non-Program Homes

**2009 IECC.** In Table 15, compliance rates for non-program homes in Connecticut and Massachusetts built under 2009 IECC are similar, except for a higher lighting compliance rate in Connecticut. The higher compliance rate for lighting in Connecticut could be due to the Connecticut homes having been built more recently than the Massachusetts homes, which were built at the end of the 2009 IECC cycle.<sup>41</sup>

**2012 IECC.** The projected compliance rates for existing, non-program homes under the 2012 IECC-CT are lower for windows, ceiling insulation, and, especially, air leakage than were observed in homes built early in the 2012 IECC code cycle in Massachusetts.

<sup>41</sup> The Connecticut sample included homes built between 2014 and 2016, while the Massachusetts sample included homes built between 2013 and 2015.

Table 15: Non-Program MA-REC Compliance by Measure Across States<sup>!!</sup>

Building System	Connecticut					Massachusetts		
	Late 2009 IECC	Early 2012 IECC-CT				Late 2009 IECC	Early 2012 IECC	Δ
		BAU	Δ	MA Ratio	Δ			
Windows	94%	85%	-9%	81%	-13%	97%	96%	-1%
Air Leakage	98%	64%	-34%	87%	-11%	98%	81%	-17%
<i>Above Grade Walls</i>	88%	89%	1%	78%	-10%	90%	89%	-1%
Ducts <sup>‡</sup>	95%	76%	-19%	87%	-8%	89%	73%	-16%
Ceilings	78%	70%	-8%	75%	-3%	79%	88%	9%
Lighting	<b>90%*</b>	79%	-11%	73%	-17%	<b>77%*</b>	64%	-7%
<i>Frame Floors</i>	72%	75%	3%	79%	7%	80%	81%	1%
Foundation Walls	85%	80%	-5%	92%	7%	90%	84%	-6%
<i>Slabs</i>	94%	92%	-2%	84%	-10%	94%	92%	-2%
OVERALL	90%	78%	-12%	86%	-4%	89%	83%	-6%

\* Significantly different between Connecticut and Mass. at the 90% confidence level.

<sup>!!</sup> Italics denote measures with unchanged prescriptive requirements between codes.

<sup>‡</sup> Non-amended 2012 IECC duct leakage requirements are stricter in Massachusetts.

#### A.4.3 Comparison to Compliance in Idaho

A 2013 study conducted on behalf of the Northwest Energy Efficiency Association (NEEA)<sup>42</sup> assessed residential compliance with 2009 IECC in 66 homes; predominantly in IECC Climate Zone 5 (83%), with the remainder in Zone 6.<sup>43</sup> The study explored multiple compliance determination methods, including the Northwest Power and Conservation Council Regional Technology Forum/Ecotope's SEEM software, which produces results for several shell measures that are comparable to the MA-REC algorithm. Unfortunately, insufficient data was available for air leakage and duct leakage compliance, precluding the calculation of an overall compliance score. Also note that the Idaho figures in [Table 16](#) were computed with data reported for an average sampled home, rather than an average of compliance rates across individual sample homes. Consequently, it is possible that high-performing homes could be masking lower compliance in others for some measures, although the distribution of space-conditioning energy model results in the NEEA report suggest that any such effect is minor. There is a more significant methodological issue when comparing the results of these reports however, the Idaho analysis uses nominal R-values without installation grade adjustments. Fortunately, one of the other compliance methods used in the report (the PNNL checklist) includes Grade I installation as a compliance data point, and this has been included in [Table 16](#) for context.

<sup>42</sup> Cadmus Group, Inc. "Idaho Residential Energy Code Compliance" February 21, 2013 <https://neea.org/docs/default-source/reports/idaho-residential-code-compliance.pdf> (accessed Sept. 1, 2017).

<sup>43</sup> The most significant difference between Climate Zones 5 and 6 for 200 IECC is a prescriptive code requirement of R-49 ceilings for the latter in lieu of R-38.

**Table 16: Statewide 2009 IECC Compliance by Measure**

Building System	Connecticut MA-REC	Idaho	
		SEEM	PNNL Grade I
<i>n</i>	250	66	–
Windows	95%	100%	–
Air Leakage	98%	N/A	–
Above Grade Walls	89%	100%	91% (11)
Ducts	96%	N/A	–
Ceilings	80%	100%	76% (16)
Lighting	91%	74% <sup>‡</sup>	–
Frame Floors	73%	100%	100% (21)
Foundation Walls	85%	86%	100% (8)
Slabs	94%		N/A
<b>OVERALL</b>	<b>91%</b>	<b>N/A</b>	<b>–</b>

<sup>‡</sup> Recalculated from third-party values provided in the original report to match MA-REC partial-credit.

## A.5 HISTORICAL CODE TRAININGS OFFERED BY THE COMPANIES

Below is a summary of the code trainings that have been offered by the Companies from 2011 to 2017. Training attendees included a wide array of market actors, including code officials, builders, design professionals, and others. Some covered residential codes and others covered commercial code. In addition, some trainings focused on specific areas of the energy codes while others covered the code requirements more broadly. This training schedule was included in the Delphi panel materials developed for the R1707 RNC NTG evaluation.

- 2011
  - Seven trainings covering the 2009 IECC
- 2012
  - 16 trainings and/or conference sessions covering the 2009 IECC
- 2013
  - Four trainings covering either commercial compliance documentation, 2009 IECC requirements, or 2012 IECC requirements
- 2014
  - Eight trainings covering either compliance documentation, 2009 IECC requirements, or 2012 IECC requirements
- 2015
  - Five trainings covering either the 2009 IECC or 2012 IECC requirements
- 2016
  - Five trainings and/or conference sessions covering the 2012 IECC requirements
- 2017
  - Seven trainings covering the 2012 IECC requirements