IMPACT EVALUATION:

Nebraska's Residential Energy Code Training Program

June 2013

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Impact Evaluation of Nebraska Energy Code Training on Energy Code Compliance

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Abstract

This report presents the results of an impact evaluation of a building energy code training campaign on residential code compliance rates in the state of Nebraska. The authors conducted field inspections on a sample of 42 newly-constructed homes in Nebraska—normalizing, modeling, and comparing the results to a pre-training compliance evaluation.

On average the pre-training study buildings used 15.7 Million Metric British Thermal Units (MMBtu)/year (9.1 percent) more than a home that complied with the 2009 International Energy Conservation Code (IECC). The post-training study homes used 3.8 MMBtu/yr (2.2 percent) more than a minimally compliant home resulting in a decrease in annual energy use of 11.9 MMBtu/yr (6.9 percent).

While the change in compliance rates cannot be exclusively attributed to the code training program, these results suggest that building energy code trainings can be an effective tool in improving the efficiency gains from building energy codes. The authors recommend a subsequent study which measures compliance in multiple locales—using a fixed compliance assessment methodology both pre- and post-training, a defined and consistent training & education format, and greater sample size.

1. Introduction

Nebraska adopted the 2009 IECC for residential buildings effective August 27, 2011. Prior to adoption of the 2009 IECC, the state was enforcing the 2003 IECC for both residential and commercial construction. A state statute requires that the Nebraska Energy Office (NEO) provides training on adopted energy codes. Over the years energy code related training has been funded with U.S. Department of Energy (DOE) funding (e.g. the American Recovery and Reinvestment Act, competitive grants or formula grants). To better focus the training efforts, Nebraska conducted an energy code compliance baseline study in 2011. Subsequent training followed based on the findings of the study.

While the benefits of training and education in energy code implementation are widely recognized in Nebraska and other states, there has been little evidence gathered to quantify the value of training as it relates to energy saved. Recent compliance studies in Utah (Navigant, 2011) and Idaho (Cadmus Group, 2013) anecdotally demonstrate the value of training. Both states have deployed multi-year targeted training, with a balance of generalized stand-up training, site education, and follow-up technical assistance. The compliance rates were approximately 85 percent and 95 percent respectively. While these compliance studies may illustrate the value of comprehensive training programs, they do not illustrate the potential of energy code trainings to improve compliance rates over time.

The objective of this study was to evaluate the impact of Nebraska's energy code training campaign on residential new construction practices and energy consumption. Energy savings associated with training may be quantified in a three phase assessment: establish an energy code compliance baseline and baseline energy use; provide training on the efficiency features that were found to be deficient in the study; and deploy a post-training energy code compliance study. The compliance differences between the pre- and post-training compliance studies can be quantified to determine the impact of training on code compliance.

The authors leveraged data from a pre-training study conducted in 2011 and subsequent trainings conducted by the NEO and their training contractor, Jim Harper. In collaboration with these groups, Britt/Makela Group, Inc. (BMG) conducted post-training field inspections on a sample of 42 newly constructed homes throughout the state. Results of the initial study and BMG's follow-up study were both normalized for comparison. Each study was entered into a spreadsheet for analysis, and both were modeled in Rapid Electro Mechanical (REM)/Design to determine energy use. Energy use from every home in both studies was compared with a standardized code-compliant model, and the overall results from each study were compared with one another.

The discussion that follows provides a summary of findings and qualitative observations recorded as part of the data collection process (Section 2.0), followed by an overview of the methodology used in obtaining and analyzing the data (Section 3.0). Supporting documentation is included in the appendices.

2. Summary of Findings

2.1 Overall Energy Usage

Table 2.1 contains a comparison of the total energy use, heating energy use, and cooling energy use for the pre- and post-training houses that were studied. Water heating, lighting, and appliance use, although commonly part of energy analyses, did not vary as neither study was able to observe any aspects of construction that would impact their energy use. All models returned annual water heating use of 12.9 MMBtu/yr, and lights and appliance use of 33.1 MMBtu/yr.

On average the pre-training study buildings used 15.7 MMBtu/yr (9.1 percent) more than a home that complied with the 2009 IECC. The post-training study homes used 3.8 MMBtu/yr (2.2 percent) more than a minimally compliant home, resulting in a decrease in annual energy use of 11.9 MMBtu/yr (6.9 percent) per house.

The rows labeled 'Difference' show the difference between the average home and the compliant equivalent; the 'Difference' column shows the difference between the post- and pre- training studies. Negative values indicate energy savings and positive values indicate increased energy use (negative savings).

Table 2.1 Pre- and Post-Study Energy Usage Results

	Pre-Training Average	**Post-Training Average**	**Difference**
Total Annual Consumption (MMBtu/yr)	187.8	175.2	-12.6
Total Annual Compliant Equivalent	*172.1*	*171.4*	-0.7
Difference	15.7	3.8	-11.9
Annual Heating Consumption (MMBtu/yr)	133.8	121.1	-12.7
Annual Heating Compliant Equivalent	*117.9*	*117.2*	-0.7

Difference	15.9	3.9	-12.0
Annual Cooling Consumption (MMBtu/yr)	8.0	8.1	+0.1
Annual Cooling Compliant Equivalent	*8.1*	*8.1*	0.0
Difference	-0.1	0.0	-0.1

Note: The difference in compliant equivalent results is attributable to the small difference in the proportion of Lancaster County homes, which are modeled from different weather data. See Table 3.3.1 for more information on sample size and distribution.

2.2 Heating Energy Savings

The post-training study found increased compliance for selected efficiency measures over what was found in the pre-training study and a reduction in heating energy use. The increased compliance resulted in heating energy savings based on the analysis. Increased compliance was noted for duct systems, basement insulation R-value, insulation installation, and walk-out basement slab edge insulation. These were issues that were addressed in the training following the pre-training study.

2.2.1 Duct Systems

The initial study indicated that eight homes (10.6 percent of the sample size) did not have insulation on ducts outside conditioned space. During the post-training study the BMG data collection team did not observe any uninsulated ductwork located outside of conditioned space. Duct insulation requirements were covered in the training based on the initial deficiency, an effort that appears to have been successful.

2.2.2 Basement Wall Insulation

The post-training study showed an increase in compliance for basement wall insulation. The BMG data collection team observed one home without basement insulation, but based on information contained on the plans and insight from the inspector, it is likely that the insulation (draped fiberglass insulation) would have been installed late in construction to prevent damage. The initial study counted 14 (18.7 percent of all homes studied) as having no basement insulation. However, it is possible that some were in a similar phase of construction to the home in the second study, and it was not noted on the plans.

2.2.3 Slab Edge Insulation for Walk-out Basements

Insulating the exposed slab edge of a walkout basement is another topic covered in training where increased compliance was evident (21 or 28 percent non-compliant in the pre-training study, vs. 8 or 19 percent non-compliant in the post-training study). The analysis showed that missing slab-edge insulation increased the standard home's total energy use by 1.6 percent in Douglas and Sarpy

Counties, and 1.7 percent in Lancaster County. Heating energy use for all counties was increased by 2.4 percent, representing a significant loss of energy.

2.2.4 Insulation Installation

Insulation installation quality was another issue identified in the pre-training that was improved upon and that lead to heating savings based on the analysis. The quality of insulation installation can be graded (see appendix D for more information) with Grade I being the best installation quality and Grade III being worst. The analysis software was able to account for the differences in installation quality to determine heating and cooling use in the building and resulted in increased heating savings. The majority of homes in the pre-training study (48 or 64 percent) were given a Grade III for wall insulation. In conducting the post-training study, BMG did not observe any homes meeting the Grade III criteria as most insulation was very well installed. The BMG data collection team assumed that the unobserved insulation installation quality was at least a Grade II (basement, wall, and ceiling), based on the observed installation quality which was typically a Grade I or II. In the post-training study, no attic insulation was observed well enough to assign a grade; therefore Grade II was used for all homes. Using this conservative assumption resulted in underestimating the energy savings from quality attic insulation installation.

2.3 Cooling Energy Savings

Cooling energy savings were overall negative, meaning that homes that were less compliant used less energy for cooling than compliant homes. This can be attributed to a lack of slab edge insulation and missing basement insulation, which both help cool homes during the summer. There were more homes in the pre-training study with absent basement slab edge and/or basement wall insulation (41.3percent) than the post-training study (19.1 percent). However, this 'benefit' is offset by the much larger savings in heating (12 MMBtu/yr, versus 0.1 MMBtu/yr 'saved').

The BMG data collection team observed three homes with sections of ductwork in attics without proper insulation (R-4.2 for both supply and return, instead of R-8 and R-6), an additional two with only R-4.2 for attic returns, and one with a section of R-4.2 insulated ducting supplying a bonus room over a garage. These deficiencies were modeled as if the entire supply or return section were non-compliant. For the home with the bonus room, this relatively short section of ductwork was modeled as if 33 percent of the supply ducts were uninsulated. This likely shows a greater energy use than would have been evident had the entire duct system been studied and modeled with more precision.

2.4 Qualitative Findings

Several compliance issues were observed by the BMG data collection team during both the plan review and field portion of the study. Some of the issues impacted the energy use of the building and could be quantified and modeled as part of the analysis. Other issues were recoded as part of the data collection process but were more qualitative in nature and therefore could not be modeled.

Not all field observations of increased compliance could be modeled. BMG noted several major improvements that likely impact the overall energy use that were not included in the savings estimates, (e.g. more complete energy code compliance documentation and an increase in use of efficient recessed can lights). Some of the changes that were observed could be attributed to a change in energy code requirements between the 2003 and 2009 IECC. However, it is worth noting that savings due to increased compliance are underestimated since the 2009 IECC has been the required code for less time than the 2003 IECC had been at the time of the first study. Others were due to the training that was conducted following the pre-training study.

2.4.1 Documentation

Cooling energy savings were overall negative, meaning that homes that were less compliant used less energy for cooling than compliant homes. This can be attributed to a lack of slab edge insulation and missing basement insulation, which both help cool homes during the summer.

BMG observed several common issues with documentation that could not be modeled but would likely impact a home's energy use. Many RES*check* submittals listed ceiling insulation as some proportion cavity (usually R-14) and some continuous (usually R-24). This is likely an honest mistake, since the insulation would be filling the spaces inbetween the bottom chord as well as a continuous blanket above the chords of the trusses. However, the RES*check* software accounts for this, and loose-fill attic insulation should be entered all as cavity; continuous insulation is for insulation installed on the roof deck. BMG ran one RES*check* model of the standard home with the cavity + continuous attic insulation error (R-14 cavity, R-24 continuous) and one with R-38 cavity only, and found that there was a 1.7 percent advantage in compliance with the cavity + continuous error with the UA-tradeoff approach, and a 2.2 percent advantage with the performance-based approach.

The average compliance margin was 4.2 percent better than code, but there were 12 homes (28.6 percent) with a compliance margin of less than 2.2 percent, and nine homes (21.4 percent) had a compliance rate less than 1.7 percent. Of these, seven had both improper documentation and a low compliance margin. Had these homes been properly documented, further energy efficiency measures would have been taken, such as increased levels of insulation or more energy-efficient windows. One home with a 1.6 percent compliance margin listed the ceiling insulation as R-50 continuous; this home likely would not have passed had the documentation been completed properly.

Another common issue was missing assemblies in the RES*check* documentation. Most of these were in relation to the attached garage. There were four homes (9.5 percent) with a floor over a garage or unconditioned space, two with vaulted ceilings not documented (R-38 installed, taking credit for R-50 and R-49 throughout), and three homes with less insulation in the wall separating the garage from the house (R-15 instead of R-19 for one, and R-19 instead of R-24 for the other two). These documentation errors are likely causing more energy to be used in these homes than if they had been documented correctly and additional measures had been taken to bring the homes into compliance.

Similarly, several homes listed continuous insulation in the basement on their RES*check* documents, but had installed the specified insulation R-value in the cavity on-site. There were also several homes that listed a higher R-value for continuous exterior insulation than was actually used.

2.4.2 Lighting

Gasketed, recessed can lights rated for Insulation Contact (IC-Rated) and considered air tight cannot be modeled separately from overall air leakage rates in REM/Design (an energy modeling program widely used in the home energy industry), but can have a large impact on heating use in a home. All of the recessed can lights that were present in the homes that were visited met the code requirement.

The BMG data collection team saw very few compact fluorescent bulbs installed. Those that were observed were typically located in the garage. This observation combined with anecdotal evidence from speaking with inspectors and building officials, led BMG to believe that very few compact fluorescent lamps (CFLs) are installed, and that they are almost never inspected for. BMG modified its standard model to reflect no CFLs or pin-based fluorescents, which translates to a usage of 1.9 MMBtu/yr (or a 1.1 percent increase in total energy use).

2.4.3 Heating and Cooling Systems

Duct testing results were not examined in the post-training study, since three of the four jurisdictions do not require them, and they were no more available for the first study. Had they been available for either study, it would allow future comparison to determine the effectiveness of training. Training was conducted on duct sealing (and insulation, as noted earlier), but only close visual inspections of duct sealing in both studies could assess the effectiveness of this training topic. Equipment sizing was also not evaluated, since Manual J (heating/cooling load) calculations weren't examined in either study. Although it was not included on the previous study, the BMG data collection team noted that all of the thermostats observed were programmable. This could be attributed to a change in code from the 2003 to 2009 IECC.

2.4.4 Envelope Air Sealing

Air sealing methods cannot be quantitatively observed without a blower door test, and site visits did not allow for an accurate evaluation of air sealing compliance visually. However, 63 homes (84 percent) of the first study did not comply with air sealing requirements. Air sealing, an area with major differences in the 2009 IECC compared to the 2003 IECC, was a significant portion of the training. The BMG data collection team observed some chinking using improper materials, as well as a significant number of window openings and other cracks sealed well with foam or caulk.

2.4.5 Building Department Enforcement Practices

The follow-up training discussed plan review and inspection recordkeeping and processes, which would have a positive effect on energy code compliance that would translate into higher compliance rates of the building components that can be measured. However, it is also possible to attribute some increased compliance to building departments for other reasons. An increase in time spent on energy code compliance (such as new personnel or re-assigned personnel), new managerial emphasis on energy codes, or simply beginning to include energy efficiency measures in plan review and inspection (as was the case in one jurisdiction) would all be reasons for increased compliance not related to training. The BMG study did not acquire information on building department staff and operations and cannot assess any potential impact.

3. Methodology

3.1 Pre-Training Compliance Study Summary

The first study was conducted by a third party under contract to the NEO, as a compliance study and to identify energy code compliance issues. The average home from the initial study was 2,966 ft^2, and used an average of 187.8 MMBtu annually. See Table 2.1 for energy use by consumption category.

Data collected for the 75 residential buildings, as part of the pre-training study, was received from the NEO for review and used in establishing a baseline for residential construction practices and for determining if energy code training led to energy savings in the jurisdictions studied. The initial compliance study examined all counties in Nebraska, but BMG's study focused only on the three counties (four jurisdictions) with the most residential construction, based on the proportions in the initial compliance study. The NEO confirmed that these continued to be the jurisdictions with the most housing starts. Counties and sample sizes can be found in Table 3.3.1.

The data from the three counties was entered into a spreadsheet for analysis and to adjust values for energy use modeling of the homes. This data was used to model the energy use of each home in REM/Design. The compliance data (e.g. insulation R-Values, quality of insulation installation) was applied to a standard house model to normalize the energy use of each home studied. This data was compared with corresponding data from the second study to assess energy savings related to compliance training.

BMG's identified non-compliant components in the first study, which warranted a close inspection during the second study: slab-edge insulation, Insulation-Contact-Rated (IC-Rated) can lights, duct insulation, and insulation quality.

3.2 Review of Training Delivered to Jurisdictions

The most effective training provides audience-specific delivery targeted to its needs; technical assistance to key stakeholders; and circuit rider programs to ensure that the building, design, and enforcement industry has the required resources to design, build, and enforce energy codes. The industry norm of generalized stand-up training is thought to be less effective, but has not been formally measured by a pre- or post-training compliance assessment.

The pre-training study conducted by NEO was used to develop training material for jurisdictions throughout the state. Training addressed topics with less than a 90 percent compliance rate identified in the study. The State of Nebraska's budget for the training was approximately $23,000. The contract was to develop and deliver training to building officials and related personnel throughout jurisdictions that participated in the study. Training materials consisted of a PowerPoint presentation that lasted two hours, with informal follow-up discussions on codes and implementation. Sessions were small (10-20 individuals), and consisted of building officials, department heads, plan reviewers, and building inspectors. The 2009 IECC was adopted in August of 2011, and training took place in August-October 2012.

BMG reviewed the curricula that was developed for the training program and also discussed the training with the instructor—Jim Harper. Several key provisions in the IECC were covered in addition to sections of the training that provided valuable insight in the plan review and inspection process needed to ensure compliance with the IECC. The key elements of the training are discussed below in Table 3.2.

Table 3.2 Topics Covered in Training Session

Training Topic	Explanation
Plan Review and Inspection Record Keeping	Addressed importance of recording keeping for IECC compliance and included information that should be on the building plans and documentation to assess compliance with the IECC.
Plan Review and Inspection Process	A section that focused on the plan review and inspection process was included in the training that built off of the record keeping module in the training. This section provided recommendations for certifications for staff involved in both plan review and inspection and recommendations for who (mechanical, electrical, plumbing inspector, etc.) should be inspecting for what efficiency feature in the field. This section also included information that should be on the building plans to demonstrate compliance with the IECC.
Mechanical Systems	Covered the Manual J requirements that are included in the IECC and also the Manual D and S requirements that are included in the International Residential Code (IRC).
Duct Insulation and Sealing	Focused on the duct sealing requirements for duct systems. This included the air leakage testing requirement for ducts located outside of conditioned space. The duct insulation requirements were also covered for ducts both in and outside of conditioned space.
Ceiling Insulation Requirements.	The training provided an overview of the 2009 roof/ceiling insulation requirements. A comparison was provided to demonstrate the differences between the 2009 and 2012 R-value requirements for Nebraska. The importance of an insulation certificate for blown attic insulation was addressed to ensure that the installed insulation was installed to the correct R-values.

Slab Edge Insulation	Walk-out basements are common practice in Nebraska. This basement configuration includes one portion of the slab floor that is considered slab-on-grade and is therefore required to be insulated. The training program focused on insulating the slab edge to meet the requirements of the IECC for both unheated and heated basements.
Basement Insulation	Basements are the predominant foundation type in Nebraska and it is extremely difficult to comply with the IECC without insulating the basement walls. The training included a module specifically on basement wall insulation.
Air Sealing	Because the air sealing requirements have changed significantly from the older codes that were in place in Nebraska to the 2009 IECC a significant portion of time was allotted to cover the new air leakage requirements. This included compliance with Table 402.4.2 Air Barrier and Insulation Installation, the option for performing an air leakage test of the building envelope and the requirement for air tight-IC rated recessed can lights.
REScheck and IECC Compliance Options	An overview was provided for each of the available compliance options included in the 2009 IECC. An overview of REScheck was also provided as part of the discussion. The overview included a review of the inspection checklist provided by the software.

3.3 Post-Training Compliance Study

3.3.1 Sample Size and Jurisdictions Selected

The post-training study selected a sample size of 42 residential buildings, which represented 56 percent of the original 2011 study sample size. The total sample size for the same counties in the first study was 75 single family residences. Table 3.3.1 provides information on the number of residential buildings selected in each county for both the pre- and post-training studies.

Table 3.3.1 Sample Size of Pre- and Post-Training Study

County	Initial Sample Size/Proportion	Second Sample Size[1]/Proportion
Douglas	38/50.7%	20/47.6%
Sarpy	23/30.7%	15/35.7%
Lancaster	14/18.7%	7/16.7%

[1] The sample size correlates to the number of building plans and sites visited for each county

3.3.2 Checklist

The initial study used the U.S. DOE Score & Store checklist tool (Appendix E). At the time of the initial study, Nebraska was on the 2003 IECC. Since DOE did not have a checklist for the 2003 IECC, NEO adjusted one to the 2003 values.

BMG chose to use the DOE Building Energy Codes Program (BECP) Score and Store checklist as the data collection tool (see Appendix D), which increased consistency between the two studies. BMG used the 2009 IECC version of the checklist to coincide with Nebraska's adoption of the 2009 IECC. The comprehensive checklist has been the basis for several energy code compliance studies in other states and has been well vetted nationally.

3.3.3 Jurisdiction Visits and Data Collection

BMG contacted each jurisdiction to solicit its involvement in the study and to schedule a visit. Each jurisdiction was asked to provide a certain number of plans that represented typical construction practices in their jurisdiction. In addition, the jurisdictions were asked to provide a place for the BMG data collection team to review the plans in order to collect the data needed for the study. The final request was to arrange access to building sites in order to conduct the in-field data collection portion of the study. All of the jurisdictions were very cooperative in allowing access to building plans and arranging access to the building sites. BMG offered each jurisdiction informal training opportunities in the field on energy code compliance. A description of the training is covered in Section

3.3.3.1 Plan Review Data Collection

Each jurisdiction was requested to provide plans that were currently in the insulation stage of construction (see Table 3.3.1 for requested plan number). As a fall back, plans that were in at least rough-in (i.e. ready for framing, mechanical, electrical, and plumbing rough-in) inspection could be selected. Observing homes at the insulation stage is difficult because most builders schedule the installation of sheetrock to commence directly after the insulation inspection or, as in the case of Omaha, no insulation inspection is required. Given the time of year and construction activity, several of the homes that were currently under construction were either at the foundation stage, the final stage, or occupied. Each jurisdiction worked to the best of its ability to locate projects meeting the criteria of the study.

Data collection consisted of reviewing the energy code compliance documentation, if available, and reviewing the building plans to ensure that all the information necessary to determine compliance was included. The data collection form was completed using the available information, and comments were made for any issues found. For example, several of the RES*check* submittals incorrectly documented attic insulation. The documentation showed that a portion of the insulation was to be installed between the roof framing members (cavity) and a portion installed over the top of the framing (continuous). RES*check* requires that all attic insulation be installed as cavity. Several of the buildings documented that they complied with the prescriptive envelope requirements in Chapter 11 of the International Residential Code (IRC). In this case, the prescriptive values from Table N1102.1 were used to populate the checklist.

3.3.3.2 Data Collection in the Field

Each jurisdiction facilitated data collection in the field by either accompanying the BMG data collection team on site visits or by arranging with the builder to allow the team to access the construction sites. Gaining access to construction sites is typically the most difficult part of data collection because of the difficulty in contacting the builder and securing permission to visit the site. Working through the building departments to access the construction sites was critical to the success of this study.

A two-person team made one site visit per home. This data collection team verified the information that was collected during the plan review process. Discrepancies were documented on the form. Several non-envelope efficiency features that are required in the IECC were not verifiable on the building plans and needed to be inspected in the field. For example, IC-rated air-tight recessed can lights are required when installed in the building envelope. This is not typically shown on the building plans, so field inspection is necessary. Compliance for these features was documented on the form if the home was visited when the features were installed.

The data collection team attempted to visit every house selected during the plan review process. Not all houses were accessible for inspection because some were either still at the foundation stage or already occupied. Some of the homes were at the sheetrock stage or near the final inspection. Inspections were still conducted when possible in order to determine construction trends. For example, ductwork was typically accessible for inspection in the basement, so duct sealing techniques could be observed. As indicated earlier, IC-rated air-tight can lights were observable at this time. Regional trends were assessed and used to guide the analysis when data was not available. For example, mastic is typically used in the region to seal joints and penetrations in framing that forms return duct systems in homes. This observation was used to assess if duct sealing practices in the homes met the intent of the code.

If accompanied by a field inspector, the BMG data collection team pointed out examples of good construction practices that complied with the IECC. Deficiencies were also pointed out when observed, along with an explanation of why the installation didn't meet the code and how to fix it.

3.4 Post-Training Study Analysis

For the second study, BMG used the DOE's Score & Store checklist for the 2009 IECC as the data collection tool and the REM/Design software as the analysis tool. While not all of the items on the checklist could be modeled, the BMG data collection team completed the checklist as much as possible from a single site visit. For a list of assumptions of components not observable, see Appendix B. The post- survey examined approximately half the homes from the pre-survey, in roughly equal proportions per county. See Table 3.3.1 for information on the number of homes in each county. All homes in the second study were tract homes, distributed equally between active building companies.

3.4.1 Normalization of Data

The initial study was conducted for all of the houses compared to the 2003 IECC, the state code in effect at the time of the study. Since then, Nebraska has updated its code to the 2009 IECC. In order to compare data from the first and second studies, BMG normalized the initial study data to the 2009 IECC. This was accomplished by adjusting the values of components (such as R-Values and U-Factors) observed on plans and in the field to those of the 2009 IECC. In order to account for homes that complied with the code via the UA-tradeoff approach or the performance-based approach, values deemed to be in compliance with the guiding document (e.g. plans or RES*check* analysis) were also deemed to be in compliance with the prescriptive value of the code. Those that were not compliant were adjusted to be proportionally non-compliant with the 2009 IECC values. One jurisdiction allows compliance with the energy code through compliance with the IRC Chapter 11 provisions; compliance with these values was assumed to translate to compliance with IECC values. For components that were not observable, listed values taken from the plans or other compliance document were used, following the protocol of the initial compliance study. Sample calculations and further explanation can be found in Appendix C.

Based on DOE analysis, the 2003 IECC is approximately 15 percent less efficient than the 2009 IECC—so comparing the two versions of the study, without normalization, would result in exaggerated energy savings. The 2003 IECC allowed the use of heating and cooling equipment efficiency trade-offs to demonstrate compliance. This was removed from the code in the 2009 edition of the IECC. When equipment efficiency trade-offs were used, the efficiency levels of the envelope were less than the prescriptive table. The envelope R-values were adjusted accordingly to meet the minimum prescriptive envelope values for the 2009 IECC in order to normalize the results.

3.4.2 Data Analysis

The REM/Design software was used for the data analysis for both the pre- and post-study buildings. A standard building model, based on one developed by DOE for use in their cost effectiveness analysis, was used to compare energy savings related to compliance rates. Using a standard model rather than utility bills or modeling each home removes any potential for variations in occupant behavior; differences in weather from year-to-year; and trends in the average new home (such as size, number of windows, etc.). Adjusted values from each study document were applied to the standard model and then used to model annual energy consumption.

Many homes in the initial study had walk-out basements. Using a modified version of the standard home (as described in Appendix C), BMG calculated the percentage increase in energy use for homes with slab edge vs. no slab edge insulation where the basement floor was exposed to the exterior. This 'penalty' was applied to homes noted on the DOE Score & Store document as deficient in slab-edge insulation. An example calculation can be found in Appendix C.

Homes that did not have components present in the modeled building (such as ducts in unconditioned space) were modeled as fully compliant with the code requirements. If the home had a comparable component, it was modeled with the same compliance rates and proportions for the correlating component. For example, one home had a slab foundation instead of a basement, and was modeled as a basement with equivalent compliance rates for insulation level, insulation grade, and depth. A complete list of assumptions and other notes can be found in Appendix B.

4. Recommendations

Capturing the energy savings associated with training on the building energy code, and subsequently increasing compliance and enforcement capacity, is valuable to training funding sources (such as utilities, state energy offices, etc.). However, isolating the impact of energy code training can prove difficult when compliance rates may also be impacted by other code implementation efforts, voluntary new construction programs, or natural market adoption of construction practices.

While the change in compliance rates in Nebraska cannot be exclusively attributed to the code training program without further research, comparing the pre- and post-training compliance study results provides both quantitative and qualitative evidence of the impact of comprehensive energy code training efforts and suggests areas where future efforts may be needed. For example, NEO provided additional training on the 2009 IECC prior to passage of the code. Training was also offered on RES*check* and COM*check*. In addition, free copies of the IECC were offered to interested and affected stakeholders. Purchasing code books has been cited by national stakeholders as a barrier to compliance with codes. Each of these events happened after the pre-training study and probably had a positive impact on compliance rates. While the study focused on one training offering deployed in several jurisdictions, the results reflect the cumulative impact of training following the study. Further research should be conducted to determine the effects of free code books and a change to the 2009 IECC on compliance rates. The authors recommend a subsequent study which measures compliance in multiple locales using a fixed compliance assessment methodology both pre and post-training, a defined and consistent training and education format, and greater sample size.

Appendix A. Standard Model Parameters

The following table lists features of the standard model home. The first section lists the DOE model, on which the standard model was based. The second section is based on the data required by REM/Design input pages and their order. If a value is not listed for an input found on the REM/Design page, the default REM/Design input or no input was used.

Table A. Standard Model Home		
DOE Reference Building Information		
	Conditioned Floor Area	2,400 (plus 1,200 of conditioned space for basement)
	Footprint and Height	30x40; 8.5 ceilings
	Area Above Conditioned Space	1,200 (over vented crawlspace or basement)
	Area Below Roof/Ceilings	1,200
	Perimeter Length	140
	Gross Exterior Wall Area	2,380
	Window Area	15% (357ft2) equally distributed between the four cardinal directions
	Door Area	42
	Heating System	natural gas furnace
	Cooling System	central electric air conditioning
	Water Heating	natural gas
REM/Design Input Pages		
Site Information		
	Climate Location	Omaha, NE, for Douglas and Sarpy Counties Lincoln, NE, for Lancaster County
	Electricity Utility	Default Electric Provider
	Gas Utility	Default Gas Provider
Building Information		
	Area of Conditioned Space	3,600
	Volume of Conditioned Space	30,600
	Year Built	2009
	Housing Type	Single-family detached
	Floors on or Above Grade	2
	Walkout Model - Floors on or Above Grade	3
	Number of Bedrooms	3
	Foundation Type	Conditioned Basement
Foundation Walls		
	Type	According to studied home

	Length	140
	Height	8.5
	Height Above Grade	1.5
	Depth Below Grade	7
	Location	Between conditioned space and ambient/ground
	Walkout Model - Length	110
Slab Floors		
	Type	According to studied home
	Area	1,200
	Depth Below Grade	7
	Full Perimeter	140
	Total Exposed Perimeter	140
	On-Grade Exposed Perimeter	0
	Walkout Mode - Slab Floor Area	1,140
	Walkout Model - Slab Floor Full Perimeter	136
	Walkout Model - Slab Floor Total Exposed Perimeter	136
	Walkout Model - Additional Slab Floor Area	60
	Walkout Model - Additional Slab Floor Full Perimeter	64
	Walkout Model - Additional Slab Floor Total Exposed Perimeter	34
	Walkout Model - Additional Slab Floor On-Grade Exposed Perimeter	34
Frame Floors		No frame floor inputs
Rim/Band Joists		
	Rim Insulation Value and Grade - Joist Cavity and Continuous	According to studied home
	Area	140
	Joist Spacing	16
	Location	Between conditioned space and ambient
	Band Insulation Value and Grade - Joist Cavity and Continuous	According to studied home
	Other Values Same as Rim	
	Walkout Model - Rim Area	110
	Walkout Model - Other Inputs the Same as Above	
Above-Grade Walls		
	Wall Construction	Standard wood frame
	Type Insulation and Grade	According to studied home
	Type Inputs Stud Spacing/Stud Width/Stud Depth	16/1.5/3.5 for R-Values≤15, 5.5 for R-Values>15
	Gross Area	2,380

	Walkout Model - Gross Area	2,365
Windows and Glass Doors		
	Four Orientations	N, E, S, W
	Wall Assignment	Same for all
	Area	89.3 each orientation
	Type	Double pane, Lo-E, Argon, Vinyl
	U-Value	0.35
	SHGC	0.4
	Overhang	None
	Interior Shading - Winter	0.85
	Interior Shading - Summer	0.7
	Adjacent Shading - Winter	None
	Adjacent Shading - Summer	None
Doors		
	Type	Steel-polystyrene Rval Opaque = 2.00
	Opaque Area	42
	Wall Assignment	Main above-grade wall
Ceilings		
	Type Insulation Value and Grade	According to studied home
	Ceiling Area	1,200
	Attic Exterior	1,296
Skylights		No skylight inputs
Mechanical Equipment		
	Space Heating	80AFUE Gas Furn. 110k, conditioned area
	Water Heating	50 gal. 0.91EF Elec Water heater
	Space Cooling	13SEER A/C 4 ton
	Setpoint Temperature Heating	72
	Setpoint Temperature Cooling	75
	Programmable Thermostat	Heating and cooling
	Capacity Weight % of Load Served	100% for each unit
GSHP Well		No GSHP well inputs
Duct Systems		
	Square Feet Served	3,600
	Number of Return Grills	2
	Equipment Served	See above
	Use Measured Leakage	CFM @ 25 Pascals
	Leakage to Outside	Total 288 CFM @25 Pascals
	Duct Test Conditions	Post-Construction Test
	Total Duct Leakage	288 CFM @25 Pascals
	Duct Surface Area - Supply	729
	Duct Surface Area - Return	270
	Duct Location - Conditioned	33/0

Basement Supply % Area/R-Value	
Duct Location - Conditioned Basement Return % Area/R-Value	50/0
Duct Location - Conditioned Space Supply % Area/R-Value	34/0
Duct Location - Conditioned Space Return % Area/R-Value	0/0
Duct Location - Attic, Under Insulation Supply % Area/R-Value	33/8.0
Duct Location - Attic, Under Insulation Return % Area/R-Value	50/6.0
Infiltration/Ventilation	
Measurement Type	Code default
Heating Season Infiltration Value (ACH @50 Pascals)	7
Cooling Season Infiltration Value (ACH @50 Pascals)	7
Shelter Class	4
2009 IECC Verification	Tested
Mechanical Ventilation System for IAQ	None
Ventilation Strategy for Cooling	Natural ventilation
Lights and Appliances	
RESNET Defaults	All, except CFL%
CFL%	50
Pin-Based CFL%	0
Mandatory Requirements	
IECC Mandatory Requirements	2009 IECC
Interior Mass	None
Active Solar	None
Photovoltaics	None
Sunspace	None

Appendix B. Modeling Assumptions

Following is a list of assumptions used in modeling each home for both studies.

Table B. Modeling Assumptions		
Assumptions, by REM/Design Input Pages/Assembly Type		Notes/Explanation
Site Information		
	Climate Location	Omaha, NE, for Douglas and Sarpy Counties Lincoln, NE, for Lancaster County
	Electricity Utility	Default Electric Provider
	Gas Utility	Default Gas Provider
Building Information		
	DOE model is close to common building practice in Nebraska	Verified with Jim Harper
	Three bedrooms	National average, according to energy database*
	Four occupants	National average, according to energy database*
	Shelter class 4	Typical for suburban homes, assume all homes suburban
	Walkout basement model - Number of floors above grade changed to 3+	*Per REM/Design guidelines for walkout basements*
Foundation Walls		
	Assume Grade II insulation if not observable	
Slab Floors		N/A
Frame Floors		
	No floors over unconditioned space modeled	
Rim/Band Joists		
	Rim modeled same as basement insulation (value and grade), except where exterior wall insulation was used	No specific checklist item for rim joist insulation

	exterior insulation value was added to the rim joists as continuous insulation	
	Continuous basement insulation modeled as cavity insulation in rim joists	
	Band joist modeled same as wall insulation (value and grade)	No specific checklist item for band joist insulation
	16" on-center construction	
Above-Grade Walls		
	"Installed per manufacturer's instructions" "(Y)" means Grade I insulation	From compliance study; Y, Y*, N are checkbox options
	"Installed per manufacturer's instructions" "(Y*)" means Grade II insulation	
	"Installed per manufacturer's instructions" "(N)" means Grade II insulation	
	Insulation over R-15 in 2 x 6 cavity	
	All insulation fills cavity completely	3.5" or 5.5"
	Homes with continuous + cavity insulation on plans/compliance documentation compared to model with compliant continuous + cavity insulation	

	Homes in first study with continuous + cavity insulation on documentation but with R-only cavity installed, R-Values were added and treated as cavity insulation only	2003 IECC allowed adding of R-Values, so compliant
	16" on-center construction for 2 x 4 and 2 x 6	Per common practice
	Different R-Values for garage walls were not modeled	
	Assume Grade II insulation if not observable	
Windows and Glass Doors		
	No basement windows	Would not affect differences in model comparisons
Doors		N/A
Ceilings		
	More than one depth marker does not ensure quality installation	
	Assume Grade II insulation if not observable	All homes of second study
	Homes with documentation showing continuous + cavity insulation were modeled as the sum of the R-Values cavity only	
	Homes with documentation showing continuous attic insulation only modeled as same R-Value cavity only	
Skylights		N/A

Mechanical Equipment		
	HVAC equipment installed is lowest efficiency commonly available (80 AFUE, 13 SEER)	
	HVAC equipment is sized correctly	
	50 gallon water heater	
	Thermostat setpoint temperatures of 72 heating, 75 cooling	Per 2009 IECC values
GSHP Well		None
Duct Systems		
	Attic supply and return ducting under insulation	According to field observations in follow-up study
	Walkout basement model - ducts remain the same	50% of supply remains in basement, remain uninsulated
Infiltration/Ventilation		N/A
Lights and Appliances		
	No exterior lights	
	RESNET defaults for appliance size, type, and energy use	
Mandatory Requirements		
	IECC Mandatory Requirements	2009 IECC
Interior Mass		N/A
Active Solar		N/A
Photovoltaics		N/A
Sunspace		N/A

Appendix C. Sample Calculations

2003 IECC to 2009 IECC Normalization

Prescriptive values for the 2003 IECC were generally less stringent than those in the 2009 IECC. In order to compare both studies, BMG adjusted prescriptive values from the 2003 IECC to the 2009 IECC by changing compliant values to the more stringent values. For example, R-8 supply and R-2 return duct insulation values became R-8 and R-6, respectively. Non-compliant values for each home in the first study were adjusted proportionally to the compliant values. For example, an R-15 above grade wall that should have been an R-18 in the 2003 IECC would become an R-16.7.

$$\left(\frac{2009\ Value}{2003\ Value}\right) \times 2003\ noncompliant\ value = adjusted\ value$$[1]

$$\left(\frac{20}{18}\right) \times 15 = 16.7$$

Slab-edge/Walkout Basement Model

The standard comparison model homes for each set of weather data (Omaha and Lincoln) were modified to include a slab-edge. Each of these models was in turn modeled without proper slab-edge insulation. The percentage difference for each energy category (total, heating, and cooling) was applied to the corresponding values for each home lacking slab-edge insulation.

For example:

Omaha model with slab-edge insulation total annual energy use =182.6

Omaha model without slab-edge insulation total annual energy use =185.6

$$\left(\left(\frac{185.6}{182.6}\right) \times 100\right) - 100 = 1.6\%\ difference$$

$$unadjusted\ total\ energy\ use \times 1.016 = adjusted\ energy\ use$$

$176.4 \times 1.016 = 179.2$ MMBtu/yr

[1] All values rounded to one decimal place per REM/Design parameters

Appendix D. REM/Design Insulation grade criteria[2]

Cavity insulation shall be rated according to the quality of the installation. This grade is applied when it is possible to inspect the insulation as installed. The insulation rating grades are I, II, or III.

Grade I: Grade I shall be used to describe insulation that is generally installed according to the manufacturer's instructions and/or industry standards. A "Grade I" installation requires that the insulation material uniformly fills each cavity side-to-side and top-to-bottom, without substantial gaps or voids around obstructions (such as blocking or bridging), and is split, installed, and/or fitted tightly around wiring and other services in the cavity.

To obtain a "Grade I", wall insulation shall be enclosed on all six sides, and shall be in substantial contact with the sheathing material on at least one side (interior or exterior) of the cavity. For exterior applications of rigid insulation, insulation shall be in firm contact with the structural sheathing materials and tightly fitted at joints.

For faced batt insulation, Grade I can be designated for side-stapled tabs, provided the tabs are stapled neatly (no buckling), and provided the batt is only compressed at the edges of each cavity, to the depth of the tab itself. For sprayed and blown-in insulation, density shall be sufficient that the fill material springs back when compressed slightly with a hand or finger.

Grade II: Grade II shall be used to describe an installation with moderate to frequent installation defects: gaps around wiring, electrical outlets, plumbing and other intrusions; rounded edges or "shoulders"; or incomplete fill amounting to 10% or more of the area with less than 70% of the intended thickness (i.e., 30% compressed); or gaps and spaces running clear through the insulation amounting to *no more than 2%* of the total surface area covered by the insulation.

Grade III: Grade III shall be used to describe an installation with substantial gaps and voids, with missing insulation amounting to greater than 2% of the area but less than 5% of the surface area it is intended to occupy. More than 5% missing insulation shall be measured and modeled as separate, uninsulated surfaces.
The insulation grade is applied to foundation wall, frame floor, above grade wall, and ceiling cavity insulation only. All new library entries will default to Grade III.

[2] Text Directly from REM/Design Cavity Insulation Grade Help Topic Page

Appendix E. Checklist

Score + Store

Residential Data Collection Ch
2009 International Energy Conservation Code Climat

Building ID: ____________________ **Date:**__________ **Name of Evaluator(s):**____________________

Building Contact (optional): Name:__________________ **Phone:**______________________ **Email:**__________

Building Name: ________________________ **Address:**____________________________ **Conditioned Floor Area:**__________

Subdivision: ______________________________________ **Lot #:**____________________

State: __________ **County:**________________________ **Jurisdiction:**____________________

Compliance Approach (check all that apply): ☐ Prescriptive ☐ Trade-Off ☐ Performance

Compliance Software Used: ____________________________ **Above-Code Program:**____________________

Building Type: 1-and 2-Family, Detached: ☐ 1-and 2-Family Dwellings ☐ Modular ☐ Townhouse
Multifamily: ☐ Apartment ☐ Condominium

Foundation Type: ☐ Basement ☐ Slab ☐ Conditioned Crawl Space ☐ Floor Over Unconditioned Spac

Project Type: ☐ New Building ☐ Existing Building Addition ☐ Existing Building Renovation

2009 IECC Section #	Pre-Inspection/Plan Review	Prescriptive Code Value	Plans Verified Value	Field Verified Value	Complies?	Comments/Assur
103.2 [PR1][1]	Construction drawings and documentation sufficiently demonstrates energy code compliance for the building envelope.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
103.2, 403.7 [PR3][1]	Construction drawings and documentation sufficiently demonstrates energy code compliance for lighting and mechanical systems. Systems serving multiple dwelling units must demonstrate compliance with the commercial code.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
403.6 [PR2][2]	Heating and cooling equipment is sized per ACCA Manual S based on loads per ACCA Manual J or other approved methods.		Heating: Btu/hr_____ Cooling: Btu/hr_____	Heating: Btu/hr_____ Cooling: Btu/hr_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	

Additional Comments/Assumptions:

General building information only required if different than above

Building ID:____________________

Date: __________ **Name of Evaluator(s):**____________________

Building Contact (optional): Name:____________ **Phone:**____________ **Email:**____________

Building Name: ____________ **Address:**____________ **Conditioned Floor Area:**__________ ft^2

Compliance Approach (check all that apply): ☐ Prescriptive ☐ Trade-Off ☐ Performance

Compliance Software Used: ____________ **Above-Code Program:**____________

2009 IECC Section #	Foundation Inspection	Prescriptive Code Value	Plans Verified Value	Field Verified Value	Complies?	Comments/Assumptions
402.1.1 [FO1][1]	Slab edge insulation R-value.	Unheated: R-10 Heated: R-15	R-____ ☐ Unheated ☐ Heated	R-____ ☐ Unheated ☐ Heated	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
303.2, 402.2.8 [FO2][1]	Slab edge insulation installed per manufacturer's instructions.			If complies: ☐ Good ☐ Fair ☐ Poor	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.1.1 [FO3][1]	Slab edge insulation depth/length.	2 ft	____ ft	____ ft	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.1.1 [FO4][1]	Conditioned basement wall insulation R-value. Where internal insulation is used, verification may need to occur during Insulation Inspection. Not required in warm-humid locations in Climate Zone 3.	Continuous: R-10	R-____	R-____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
303.2 [FO5][1]	Conditioned basement wall insulation installed per manufacturer's instructions.			If complies: ☐ Good ☐ Fair ☐ Poor	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.2.7 [FO6][1]	Conditioned basement wall insulation depth from top of wall.	10 ft or to basement floor	____ ft	____ ft	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.2.9 [FO7][1]	Unvented crawl space wall insulation R-value.	Continuous: R-10 Cavity: R-13	R-____ R-____	R-____ R-____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
303.2 [FO8][1]	Unvented crawl space wall insulation installed per manufacturer's instructions.			If complies: ☐ Good ☐ Fair ☐ Poor	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.2.9 [FO9][1]	Unvented crawl space continuous vapor retarder installed over exposed earth, joints overlapped by 6 in. and sealed, extending at least 6 in. up and attached to the wall.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.2.9 [FO10][1]	Unvented crawl space wall insulation depth from top of wall.	To finished grade + 24 in. vertical and/or horizontal	____ in.	____ in.	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
303.2.1 [FO11][2]	Exposed foundation insulation protection.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
403.8 [FO12][2]	Snow melt controls.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	

Additional Comments/Assumptions:

1	High Impact (Tier 1)	2	Medium Impact (Tier 2)	3	Low Impact (Tier 3)

General building information only required if different than above

Building ID:____________________

Date: ____________ **Name of Evaluator(s):**____

Building Contact (optional): Name:______________________ **Phone:**___________________________ **Email:**_____________________

Building Name: ______________________________ **Address:**____________________________________ **Conditioned Floor Area:**___________

Compliance Approach (check all that apply): ☐ Prescriptive ☐ Trade-Off ☐ Performance

Compliance Software Used: ___________________________________ **Above-Code Program:**________________________

2009 IECC Section #	Framing/Rough-In Inspection	Prescriptive Code Value	Plans Verified Value	Field Verified Value	Complies?	Comments/Assum
402.1.1, 402.3.4 [FR1][1]	Door U-factor.	U-0.35	U-_____	U-_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.1.1, 402.3.1, 402.3.3, 402.5 [FR2][1]	Glazing U-factor (area-weighted average).	U-0.35 (0.48 max)	U-_____	U-_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.1.1, 402.3.2, 402.3.3, 402.5 [FR3][1]	Glazing SHGC value (area-weighted average).	N/A	SHGC:_____	SHGC:_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
303.1.3 [FR4][1]	U-factors of fenestration products are determined in accordance with the NFRC test procedure or taken from the default table.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.1.1, 402.3.3, 402.5 [FR5][1]	Skylight U-factor.	U-0.6 (0.75 max)	U-_____	U-_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.1.1, 402.3.3, 402.5 [FR6][1]	Skylight SHGC value.	N/A	SHGC:_____	SHGC:_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
303.1.3 [FR7][1]	SHGC values are determined in accordance with the NFRC test procedure or taken from the default table.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.1.1 [FR10][1]	Mass wall exterior insulation R-value. If more than 1/2 of the insulation is on the wall interior, the interior insulation requirement applies and verification may need to occur during Insulation Inspection.	R-13	R-_____	R-_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
303.2 [FR11][1]	Mass wall exterior insulation installed per manufacturer's instructions.			If complies: ☐ Good ☐ Fair ☐ Poor	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.3.5 [FR8][1]	Sunrooms enclosing conditioned space have a maximum fenestration U-factor of 0.50 in Climate Zones 4-8. New glazing separating the sunroom from conditioned space must meet code requirements.	U-0.5	U-_____	U-_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.3.5 [FR9][1]	Sunrooms enclosing conditioned space have a maximum skylight U-factor of 0.75 in Climate Zones 4-8.	U-0.75	U-_____	U-_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	

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1	High Impact (Tier 1)	2	Medium Impact (Tier 2)	3	Low Impact (Tier 3)

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2009 IECC Section #	Framing/Rough-In Inspection	Prescriptive Code Value	Plans Verified Value	Field Verified Value	Complies?	Comments/Assumptions
402.4.4 [FR20][1]	Fenestration that is not site built is listed and labeled as meeting AAMA/WDMA/CSA 101/I.S. 2/A440 or has infiltration rates per NFRC 400 that do not exceed code limits.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.4.5 [FR16][2]	IC-rated recessed lighting fixtures sealed at housing/interior finish and labeled to indicate <= 2.0 cfm leakage at 75 Pa.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
403.2.1 [FR12][1]	Supply ducts in attics are insulated to R-8. All other ducts in unconditioned spaces or outside the building envelope are insulated to R-6. Not applicable if all systems are ductless.	Attic Supply: R-8 Other: R-6	R-_____ R-_____	R-_____ R-_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
403.2.2 [FR13][1]	All joints and seams of air ducts, air handlers, filter boxes, and building cavities used as return ducts are sealed.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
403.2.3 [FR15][3]	Building cavities are not used as ducts or plenums.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
403.3 [FR17][2]	HVAC piping conveying fluids above 105 °F or chilled fluids below 55 °F are insulated to R-3.	R-3	R-_____	R-_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
403.4 [FR18][2]	Circulating service hot water pipes are insulated to R-2.	R-2	R-_____	R-_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
403.5 [FR19][2]	Automatic or gravity dampers are installed on all outdoor air intakes and exhausts.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	

Additional Comments/Assumptions:

General building information only required if different than above

Building ID:

Date: ____________ **Name of Evaluator(s):**

Building Contact (optional): Name: ______________________ **Phone:** ___________________________ **Email:**

Building Name: ____________________________ **Address:** ___________________________________ **Conditioned Floor Area:**

Compliance Approach (check all that apply): ☐ Prescriptive ☐ Trade-Off ☐ Performance

Compliance Software Used: __________________________________ **Above-Code Program:**

2009 IECC Section #	Insulation Inspection	Prescriptive Code Value	Plans Verified Value	Field Verified Value	Complies?	Comments/Assu
303.1 [IN13][2]	All installed insulation labeled or installed R-values provided.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.1.1, 402.2.5, 402.2.6 [IN1][1]	Floor insulation R-value.	Wood: R-30 (or sufficient to fill cavity, R-19 minimum) Steel: R-19+R-6 in 2x6 or R-19+R-12 in 2x8 or 2x10	R-_____ ☐ Wood ☐ Steel	R-_____ ☐ Wood ☐ Steel	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
303.2, 402.2.6 [IN2][1]	Floor insulation installed per manufacturer's instructions, and in substantial contact with the underside of the subfloor.			If complies: ☐ Good ☐ Fair ☐ Poor	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.1.1, 402.2.5, 402.2.4 [IN3][1]	Wall insulation R-value. If this is a mass wall with at least 1/2 of the wall insulation on the wall exterior, use FR10 and mark this N/A.	Wood: R-20 or R-13+R-5 Mass: R-17 Steel: R-13+R-10; R-19+R-9; R-25+R-8	R-_____ ☐ Wood ☐ Mass ☐ Steel	R-_____ ☐ Wood ☐ Mass ☐ Steel	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
303.2 [IN4][1]	Wall insulation installed per manufacturer's instructions.			If complies: ☐ Good ☐ Fair ☐ Poor	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.2.11 [IN8][1]	Sunroom wall insulation has a minimum R-value of R-13. New walls separating the sunroom from conditioned space must meet code requirements.	R-13	R-_____	R-_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
303.2 [IN9][1]	Sunroom wall insulation installed per manufacturer's instructions.			If complies: ☐ Good ☐ Fair ☐ Poor	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
303.2 [IN11][1]	Sunroom ceiling insulation installed per manufacturer's instructions.			If complies: ☐ Good ☐ Fair ☐ Poor	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.2.11 [IN10][1]	Sunroom ceiling minimum insulation R-value of R-19 in Climate Zones 1-4, and R-24 in Climate Zones 5-8.	R-24	R-_____	R-_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	

Additional Comments/Assumptions:

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1	High Impact (Tier 1)	2	Medium Impact (Tier 2)	3	Low Impact (Tier 3)

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General building information only required if different than above

Building ID:______

Date: ______ **Name of Evaluator(s):**______

Building Contact (optional): Name:______ **Phone:**______ **Email:**______

Building Name: ______ **Address:**______ **Conditioned Floor Area:**______ ft²

Compliance Approach (check all that apply): ☐ Prescriptive ☐ Trade-Off ☐ Performance

Compliance Software Used: ______ **Above-Code Program:**______

2009 IECC Section #	Final Inspection Provisions	Prescriptive Code Value	Plans Verified Value	Field Verified Value	Complies?	Comments/Assumptions
402.1.1, 402.2.1, 402.2.2 [FI1][1]	Ceiling insulation R-value.	Wood: R-38 Steel Truss: R-49; R-38+R-3 Steel Joist: R-49	R-_____ ☐ Wood ☐ Steel	R-_____ ☐ Wood ☐ Steel	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
303.1.1.1, 303.2 [FI2][1]	Ceiling insulation installed per manufacturer's instructions. Blown insulation marked every 300 ft².			If complies: ☐ Good ☐ Fair ☐ Poor	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.2.3 [FI3][1]	Attic access hatch and door insulation >=R-value of the adjacent assembly.		R-_____	R-_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.4.2, 402.4.2.1 [FI17][1]	Building envelope tightness verified by blower door test result of <7 ACH at 50 Pa. This requirement may instead be met via visual inspection, in which case verification may need to occur during Insulation Inspection.	ACH 50 < 7	ACH 50 =_____	ACH 50 =_____	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
402.4.3 [FI8][2]	Wood-burning fireplaces have gasketed doors and outdoor combustion air.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
403.2.2 [FI4][1]	Duct tightness via post-construction with maximum leakage of 8 cfm to outdoors, or 12 cfm across systems. For rough-in tests, verification may need to occur during Framing Inspection, with maximum leakage of 6 cfm across systems and 4 cfm without air handler.	Post-Construction To Outdoors: 8 cfm Across System: 12 cfm Rough-In To Outdoors: 4 cfm Across System: 6 cfm	_____ cfm	_____ cfm	☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
403.6 [FI5][1]	Heating and cooling equipment type and capacity as per plans.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
403.1.1 [FI9][2]	Programmable thermostats installed on forced air furnaces.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
403.1.2 [FI10][2]	Heat pump thermostat installed on heat pumps.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
403.4 [FI11][2]	Circulating service hot water systems have automatic or accessible manual controls.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
403.9.1 [FI12][3]	Readily accessible switch on heaters for swimming pools.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	

2009 IECC Section #	Final Inspection Provisions	Prescriptive Code Value	Plans Verified Value	Field Verified Value	Complies?	Comments/Assu
403.9.2 [FI19][3]	Timer switches on pool heaters and pumps are present.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
403.9.3 [FI20][3]	Heated swimming pools have a cover. Covers on pools heated over 90 °F are insulated to R-12.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
404.1 [FI6][1]	50% of lamps in permanent fixtures are high efficacy lamps.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
401.3 [FI7][2]	Compliance certificate posted.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	
303.3 [FI18][3]	Manufacturer manuals for mechanical and water heating equipment have been provided.				☐ Complies ☐ Does Not Comply ☐ Not Observable ☐ Not Applicable	

Additional Comments/Assumptions:

10/15/2012
Version 3.0

1	High Impact (Tier 1)	2	Medium Impact (Tier 2)	3	Low Impact (Tier 3)

About the Institute for Market Transformation (IMT)

The Institute for Market Transformation (IMT) is a Washington, DC-based nonprofit organization promoting energy efficiency, green building, and environmental protection in the United States and abroad. IMT's work addresses market failures that inhibit investment in energy efficiency and sustainability in the building sector. For more information, visit imt.org.

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About Britt-Makela Group

Britt/Makela Group, Inc. was formed in 2001 by Eric Makela and Michelle Britt to meet the growing need for independent code development, training, and analysis resources. Their complementary backgrounds encompass building energy, land use and transportation planning, and regulatory issues. BMG brings a combination of national and local experience, research and practice on best practices, new ideas, and lessons learned. BMG provides states and jurisdictions with expertise to develop the plans and programs best suited to the needs of their community. BMG is committed to fostering the changes needed so that one day energy efficiency and sustainability will be the norm.

Disclaimer

The views and opinions expressed in this report are the responsibility of IMT and the Britt/Makela Group and do not necessarily represent the views and opinions of any individual, government agency, or organization mentioned in this report.