CADMUS

MEEA REPORT ON KENTUCKY CODES COMPLIANCE IMPROVEMENT STUDY

PHASE 1 – DATA COLLECTION REPORT

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Introduction

In February 2015, the Britt/Makela Group, now part of the Cadmus Group (Cadmus), was contracted by the Midwest Energy Efficiency Alliance (MEEA) to perform residential energy code compliance data collection in Kentucky. This data collection effort was funded as part of a three year U.S. Department of Energy (DOE) study of code compliance and energy use in newly constructed single family residential buildings (Award Number DE-EF0006755).

The goal of this study is to determine if a focused code compliance support effort will lead to increased compliance (and reduced energy use) in single family building across the state of Kentucky. The first step of this project is to establish a baseline from which to measure progress. Using a DOE prescribed data collection protocol[1], data was collected for a minimum of 63 instances for each of nine key energy code compliance categories:

Envelope Tightness (ACH50)

Window U-Factor

Ceiling Insulation

Foundation Insulation

HVAC Right Sizing

Window Solar Heat Gain Coefficient (SHGC)

Exterior Wall Insulation

High Efficacy Lighting

Duct Leakage

Under the DOE protocol, each home could be visited only once, necessitating that the key items remaining to complete the data set be collected from visits to other homes. It should be noted that HVAC Right Sizing was not part of DOE's original "key items" list but was included as a key item for Kentucky. Therefore Cadmus collected the necessary data on 63 installed heating and cooling systems in order to calculate the heating and cooling loads by performing a whole house (block load) Manual J load calculation as part of the original DOE contracted work. Since determining HVAC Right Sizing requires substantial calculation and interpretation, those results will be issued at a later date in a separate report. In addition to the 9 key item categories, Cadmus also collected data on other energy code compliance items "as available" for visual or physical inspection while on-site.

In addition to the original DOE contracted work, MEEA requested that Cadmus collect data on 42 installed duct systems (Manual D), which included collecting sufficient data to perform a room-by-room Manual J load calculation while also documenting the layout and dimensions of the installed duct system. As a final modification to the original scope of work, MEEA requested that air flow tests for each register be conducted on up to 35 buildings where the air handling system was operational. This provided additional data for MEEA to evaluate the effectiveness of the installed heating and cooling systems, and the potential energy savings involved in improved compliance.

While Kentucky energy code requirements (slightly modified 2009 IECC) are mandatory statewide, the code enforcement structure varies from county to county, as well as within a given county. There are

[1] https://www.energycodes.gov/sites/default/files/documents/drafts/111014_Residential%20FOA_Guidance_Document_DRAFT_rev2.pdf

three main categories of single family code enforcement, known as Expanded Jurisdiction Program, Level 1 and 1&2 Family Enforcement Programs and No Enforcement. In Expanded Jurisdictions all homes within given county or city are subject to plan review and site inspections. In Level 1 and 1&2 Family Enforcement Programs only homes within selected jurisdictions (either city or county) have required plan reviews and site inspections. While compliance with the Kentucky energy code is mandatory statewide, in areas of No Enforcement, there are no building code officials or other enforcement infrastructure in place to verify compliance with the code. Nevertheless, the contractor is still required to comply with the code. However, regardless of the category of enforcement, all home HVAC systems are permitted, reviewed, and inspected by either the Department of Housing, Buildings and Construction or the local Expanded HVAC Program.

The report that follows highlights the process that was used to collect the data, issues encountered in the field, patterns of non-compliance, and lessons learned.

Methodology

Sampling Plan

Kentucky has two centralized sources of statewide permits for single-family residential construction – plumbing permits and HVAC permits. The Kentucky code enforcement agency, the Department of Housing, Buildings and Construction (DHBC) provided the project team with the 2013 and 2014 permits for each county. This information was sent to the Pacific Northwest National Laboratory (PNNL) to use as a basis for creating a statistically valid data sampling plan. The plan identified how many data sets were required to be collected from each county (a data set includes at least one observation from each of the nine key items identified above). A copy of the sampling plan is attached as Appendix 4.

Builder Recruitment

In addition to providing permit information for the sampling plan, DHBC also provided the project team with the most recent 12 months of permits for each county. This information was provided on a rolling basis with the permit information being provided a few weeks ahead of Cadmus's planned data collection for that county. MEEA merged the plumbing and HVAC permit lists and filtered out duplicate addresses. MEEA then sent the list to the Kentucky-based Project Manager who would then contact each of the builders on the list. The Project Manager would explain the intent of the study and the logistics of the data collection process to the builder, and ask permission to include the selected address on the data collection list. In addition to ascertaining if the building was a viable candidate for data collection, the Project Manager also determined the relative size of the builder (large production builder, medium size builder, or small builder) and if the builder had other buildings under construction that might be available for data collection.

It should be noted that the Project Manager is a retired Deputy Commissioner from DHBC. This was of two-fold benefit – he had the local experience and knowledge necessary to effectively communicate the intent of the program, and was also a known and respected individual in the building community across the state. We feel that these two qualities are a significant part of the reason for the effectiveness of the builder recruitment effort – with fewer than 5% of builders contacted by the Project Manager saying "no" to the request for site access.

Once the Project Manager had made an effort to contact the builder for every address on the list, the list, along with builder responses for each address, was sent to MEEA. MEEA reviewed the list, highlighted "yes" and "no" builder responses, randomized the list, and sent it on to Cadmus. Cadmus would then contact the builders in the order shown on the randomized list to schedule site visits for the field team. Cadmus would then schedule field team travel to align with the most available builders.

Upon arriving in Kentucky, the field team would call the scheduled builders for a third time to confirm that their site visit was expected. If the field team could not contact the builder, they would proceed to the site and perform the data collection with the knowledge that they had received permission for the site visit. If the site was not at the stage needed for the data collection process, the field team would proceed with collecting as much data as possible.

Typically the builders that were on site at the time of data collection effort were very cooperative but did not take an active interest in the data collection effort. For data collection efforts that took place during the final stage of construction, the builders would have the homes accessible (e.g. unlocked) so that the team could access the homes and perform the testing required by the data collection protocol. Often they did not have a real interest in the study or the data that was collected. Custom builders typically asked more questions especially those that were trying to incorporate increased energy efficiency into their houses. They typically wanted to know how they did (e.g. what was the result of the blower door test) and what else they could do to increase efficiency in their houses. The field teams often encountered subcontractors on the job site. There was no real interest in the data collection process but occasionally those subcontractors who felt their workmanship was superior to others in their trade would describe their process for designing and installing systems. For example, an HVAC contractor provided information on how he followed the Manual J, D and S protocols for designing and installing residential mechanical systems. He pointed out that his competitors, including his father's mechanical company, used a "rule of thumb" approach that often resulted in call backs because of customer comfort complaints.

If the field team could not line up any site visits with the builders, the field team would either move on to another county or collect data on any house in the county that was encountered provided it was at the appropriate construction stage. If a sufficient number of builders could not be lined up for a given county (due to lack of builder cooperation or lack of construction activity), a new county would be substituted that matched the socio-economic and enforcement level of the original county. If a full data set could not be observed for a given county, as much information as possible was collected from the original county before moving on to the substitute county. Only the additional data necessary to complete the data set was collected from the substitute county. A map indicating the original sampling counties and their substitute counties is included as Appendix 4.

Field Team Training

Prior to the field team beginning on-site data collection, Cadmus trained each member of the field team when possible in Boise, ID. Training was provided in the field for those team members that were not available for training in Boise. The field teams consisted of one senior member, with extensive experience in the field and in the use of the DOE data collection protocol, and a more junior member. Each of the senior team members received their training in Boise. Those junior members that could not attend the training in Boise were trained in the field as part of the data collection process. The field team training was provided in stages as field team members prepared to begin on-site data collection.

Additional / supplemental training was also occasionally provided in the field as part of the data collection process. For example, training on collecting air flow information from each of the registers was conducted in the field by an experienced senior field team member. This training was provided as part of the data collection process.

The teams were trained on the proper completion of the data collection form for both the insulation stage of construction, and for buildings at final inspection. This training occurred in the Cadmus office and then at residential construction sites located in Boise, ID. The office training focused on completing the data collection forms and ensuring that the team members understood the type of information that was to be included in each of the data fields. Training was also provided to the Cadmus staff person responsible for scheduling and recruiting to ensure that they understood what type of information was to be collected. This allowed them to provide knowledgeable answers to builders who had questions about the study. Training was then conducted at construction sites.

The goal of the onsite training was to complete the data collection form and to answer any questions that the team might have on actual installations, and how they should assess compliance with those installations. For example, grading of insulation installation was covered as part of the training. Training was also provided on testing protocols for using a blower door and duct tightness tester. The training allowed each member of the field team to set up equipment and perform an envelope air leakage and duct leakage test. Additional training was provided on mapping duct systems for the Manual D analysis to ensure that the teams understood the protocol that was to be used to capture the information needed for analyzing duct design using Wrightsoft and SpecPro software. The final training was conducted on the use of the flow hood. Because of field team schedules, a train-the-trainer approach was taken for flow hood testing, where one person was trained in Boise and that person trained other members of the field team while in Kentucky.

Data Collection – General

The data collection effort was scheduled to focus on the parts of the state with greatest number of data sets first (generally the Bluegrass Region) and then move to the eastern and western portions of the state. The data collection effort was designed so that a sufficient number of homes were initially lined up to keep two field teams busy. This strategy dictated that the data collection efforts start in the Louisville / Lexington areas and the surrounding counties first. After the majority of the data collection was completed in these areas, houses were scheduled in the eastern and western parts of the state. This strategy provided better consistency and communication between the field teams. For example, since they were in close proximity during the initial part of the study, team members were able to meet at night and discuss their findings. This also allowed the field teams to be deployed to the same town if more homes became available for data collection than one team could complete in a day. Multiple teams were deployed in the field simultaneously approximately 50% of the time.

The Kentucky data collection process was unique in that Manual D information was collected on the heating and cooling systems that included mapping duct systems. Originally computer tablets were going to be used to sketch out the duct systems in the field so that they could be sent electronically to the Cadmus office for review and then to MEEA. The field teams were unsuccessful in this effort and modified the approach began to hand draw and label the duct systems, joints, etc. When collecting the data required for completing the field inspection checklists, field team members would typically split the effort with one person inspecting the efficiency features (e.g. window u-factor) and the other recording the findings (e.g. U=0.32).

As noted above, data collection was typically conducted either at the insulation stage or at final inspection. On site data collection was begun April 12, 2015 and finished on August 20, 2015. In total approximately 1,554 hours were spent on in-field data collection.

The collected data was uploaded to the PNNL online portal as data sheets were completed and sent back to the Cadmus Idaho office from the field. After performing a review of the data for quality assurance, Cadmus uploaded the data into the PNNL online portal. Conceptually this process was straight forward but there were issues with the online portal converting data that was uploaded to incorrect data inputs, and other changes to the online portal that required Cadmus to re-enter data. All of the issues were reported to PNNL in an effort to correct the problems with, and increase the stability and reliability of, the online portal. If functioning correctly, the data entry and upload took approximately 15 minutes to upload a data collection form and 138 forms were uploaded.

Insulation Inspection

The following information was typically collected when the house was at the insulation stage:

- Exterior wall insulation R-value and quality
- Foundation wall insulation R-value and quality
- Raised floor insulation R-value and quality
- Air sealing. This included inspecting for appropriate air sealing on all penetrations in the building envelope including around windows, plumbing penetrations, utility penetrations, etc.
- Duct insulation R-value
- Window efficiency (U-factor)
- Window Solar Heat Gain Coefficient (SHGC)
- Air handler system information (e.g. furnace or heat pump)

Upon entering a house at the insulation stage, one field member would document the HVAC information (see Manual J and D discussion) and determine total square footage. The other field member would collect the other available information, including using the RESNET standards for grading insulation, documenting all of the air-sealing measures, and noting window U-factor. In addition, any other observable energy efficiency information that was included in the checklist was documented.

Final Inspection

The following information was typically collected when the house was at the final stage:

- Ceiling insulation R-value and quality
- High efficacy lighting
- Envelope tightness (ACH50)
- Duct Leakage
- Additional information on the air handler and cooling system sizes

- Other efficiency features that could not be viewed at insulation that were part of the energy code. For example, this would include, but is not limited to, thermostats, water heater type, basement wall insulation that was not installed at insulation, etc.

Upon entering a house at the final inspection stage, one member would determine house dimensions for the Manual J calculation (see Manual J discussion). The other field team member prepared the home for quantitative testing and conducted a single point house pressurization test at 50 Pa and a single point depressurization duct leakage test at 25 Pa. When both these tasks were completed, this team member would collect any additional efficiency information observable at the time of the site visit – for example, thermostat type, information on water heater types and ventilation systems, and verifying that high efficacy lighting was installed.

Manual D Inspection

To assist MEEA's efforts in assessing the effectiveness of the heating and cooling systems installed in homes throughout Kentucky, Cadmus collected sufficient data to perform a Manual J whole house load calculation on all homes visited during the final inspection. In a separate effort, sufficient information was also collected on 42 duct systems to perform Manual J room-by-room load calculations and assess the duct design compliance. The room-by-room data fed into the Manual J and D methodology and will be used to assess duct system effectiveness.

Data collected for Manual J will be used to determine if the heating and cooling equipment was sized properly for the house, without considering if the duct system was sized properly to deliver the necessary airflow to each room to satisfy the heating and cooling load. The goal of the Manual D data collection effort was to determine if HVAC contractors were designing and installing ducts correctly.

Manual D inspections were conducted during the insulation inspection when the entire duct system was typically observable. The field team measured the actual lengths and diameters of all of the ducts, documented the fitting reference numbers (per *Manual D*), and the dimensions and locations of the all of the registers in the house. By measuring the actual duct lengths the project team will be able to determine if the duct system used longer duct runs than needed to reach each of the registers. Information was also collected on duct sealing. In addition, Manual J room-by-room measurements were taken for the entire house. This information will be used to establish the room-by-room heating and cooling loads. All of this information was documented in diagram form and submitted to MEEA for further analyses. MEEA will use Wrightsoft and SpecPro software to determine compliance with ACCA Manual D requirements.

Collecting data to complete a Manual D analysis added an additional two to three hours per home onto the key item data collection process. Most of the additional time was spent collecting information on the air distribution system, including sketching the duct layout and identifying information on joints and registers. The actual time spent could vary significantly based on where the duct system was located (basement verses in the attic) and the number of systems in the house.

Manual J Inspection

Manual J block load inspections were performed in order to collect the data necessary to determine if the HVAC system was sized correctly. The field team documented the length and height of the house, along with duct R-values, duct leakage and building air leakage rates. This information was then submitted to MEEA for further Wrightsoft / SpecPro analysis. Manual J inspections were always conducted at the final inspection stage and a total of 78 Manual J inspections were performed.

Flow-Hood Testing

Beyond simply doing a Manual D analysis to determine whether a given duct was designed properly, flow-hood tests were conducted on 21 of the houses to determine the actual air flow to each room. All tests were conducted when the house was at the final inspection stage with the mechanical system fully operational. The goal of the testing was to determine if the required air flow (as determined by the Manual D and Manual J calculations) was coming out of the registers. The field team used an Alnor LoFlo Balometer to document the cubic feet per minute (cfm) of air coming out of each register in every room. The field team also conducted Manual J room-by-room measurements, consistent with the Manual D data collection, in order to determine room volumes, building envelope efficiency, and areas for each assembly.

Quality Assurance

All data was collected on the appropriate data collection forms (books). One book was completed for each home that was visited. After the data was collected, Cadmus reviewed the data books looking for irregularities and discrepancies. If any arose, they would reach out to the performing field team in order to clarify values. Cadmus also worked with MEEA to resolve any follow-up questions from the project team pertaining to the data. The data books were then scanned and submitted to MEEA which did its own review of the data. At the same time, Cadmus would input the information on to the DOE RCD site.

Items Difficult to Ascertain

During the study 3 key items were consistently difficult to observe:

- Slab-Edge Insulation
- Houses at Insulation Stage
- Basement Wall Insulation

Slab-Edge:

While slab-edge insulation is an important part of the thermal envelope, it was often very difficult to see directly. If the builder installed insulation underneath the slab or on the interior slab edge (e.g. on the inside of the stem wall as is typical for a walkout basement floor), the field team could only observe this prior to the slab being poured. The footing and stem wall are placed first on a non-monolithic slab allowing insulation to be installed on the inside of the stem wall. The slab floor is then poured and typically covers the insulation. The field teams typically entered the house at the insulation stage or final inspection stage, making it very difficult to view any slab edge insulation. There was no identifiable remedy for this issue. The data collection team was able to complete the 63 foundation insulation observations because there were enough houses that had either basement, crawlspace, or floor insulation to meet the observation requirements.

Houses at Insulation Stage:

Builders generally schedule the gypsum board installation as soon as possible following insulation installation and inspection (if the jurisdiction requires insulation inspection). Within that context, the amount of time that a house is at the insulation stage varies by the size of the builder. There was typically a very narrow window with production builders, often no more than one-day following insulation installation. For smaller builders, there was too much variance between builders to determine any consistent time frame.

Cadmus addressed this issue by visiting sites of builders who had not been contacted as part of the builder recruitment (see Builder Recruitment). The field team would typically try and find the builder on site and present him a letter showing the project's legitimacy and the data collection team's credentials. There was some success with the builders that were already recruited, but in order to avoid wasting field time the team would take advantage of as many walk-on inspections as possible.

Basement Wall Insulation:

Because of the humidity levels in Kentucky, many builders would not install basement wall insulation until just prior to receiving the certificate of occupancy. This meant that the field team could not depend on seeing basement wall insulation at either the insulation or final stage of construction. This issue came up enough to cause some concern, but in the end the issue did not impede the study or require a specific remedy.

Patterns of Non-Compliance

The field teams found 5 code requirements that consistently did not comply with Kentucky energy code requirements:

- Duct Leakage
- Duct Sealing
- Insulation Installation Quality
- High Efficacy Lights
- Air Leakage

Duct Leakage

All ducts were tested regardless of whether or not they were in conditioned space. The 2009 IECC allows a maximum of 12 cfm/100ft^2 @25Pa total leakage for ducts in unconditioned space when tested during the post construction phase. Approximately one quarter of the ducts located in unconditioned spaces (especially the attic) did not meet this requirement.

Duct Sealing

More than three quarters of houses with ducts located in conditioned space had leakage rates over 12 cfm/100ft^2@25Pa. At times, these ducts were too leaky for the equipment to transmit a reading. While there is no maximum leakage requirement for ducts in conditioned space, they are required to be sealed. Clearly these ducts are not meeting the sealing requirement (see Duct Sealing below). Following are some of the observed problems with respect to duct sealing:

- Unsealed framed return plenums
- Unsealed register boots
- Unsealed joints on the main trunks
- Unsealed filter boxes
- Penetrations in the framed return plenums

Unsealed framed cavities used as return ducts contributed heavily to the high duct leakage levels recorded. The most visible duct penetrations were in the framed return plenums.

Insulation Installation Quality

Approximately two thirds of the batt insulation installed in the walls was quality grade 2 or 3 (with grade 1 being the highest quality). Often the installer neglected to cut out around the electrical outlets and/or split the batts around the wires going through the framing members. The ceiling insulation was generally flat and consistent; at times there were valleys and mounds that diminished the overall R-Value.

High Efficacy Lights

More than half of the houses observed had no high efficacy lights installed, while over two thirds of the homes did not meet the code required minimum of 50% high efficacy lights. Where high efficacy lights had been installed, they would typically be a single light either in the garage or in the attic space.

Air Leakage

Approximately one-third of the homes tested with a blower door had leakage rates greater than the code maximum of 7ACH50. Since 7ACH50 is a relatively easy standard to achieve, some research should be done to determine the reasons for the high level of non-compliance. The high non-compliance rate is highlighted by the fact that roughly one-quarter of the homes met the very stringent air leakage standard (4ACH50) found in the 2012 IECC (including one home that met the Passive House standard).

Lessons Learned

Scheduling Builders

One of the biggest challenges in this project was non-responsive builders. Many times, after a builder had agreed to a data collection site visit with the Project Manager, the builder would not respond to scheduling calls from Cadmus. During the initial stages of the project, the Project Manager contacted the builder prior to Cadmus having data collection teams in the field. This sometimes resulted in the house being past the stage of construction needed for data collection (e.g. a house was at the insulation stage during the initial contact but sheetrock was installed when the field team was able to visit the site). This lack of responsiveness by the builder and site visit coordination issues resulted in the field team spending additional time on builder recruitment, which had a negative impact on the project budget. Better coordination between the Project Manager and Cadmus field teams will be necessary to resolve this issue. Initial contact with the builder should be made no more than one week in advance of the field team visiting the job site. Scheduling the builder should happen no later than the day following the initial contact with the builder. The field team should be deployed in the field no later than the week following initial builder contact.

Data Collection Team Deployment

Initially, Cadmus deployed two two-person data teams in the field simultaneously. The goal was to jump start the data collection process by scheduling as many onsite visits as possible in portions of the state with high sample sizes. To be cost effective, this strategy required that a sufficient number of onsite visits be scheduled for each team during the week. This varied based on the type of information needed for each visit (e.g. Manual D verses non-Manual D data collection) and also the drive time to the site. Also, it was difficult to accurately estimate the time needed to collect data for Manual D as this type of data collection was unique to this project. Because of issues with scheduling builders (see Scheduling

Builders) and the inherent vagaries of Manual D data collection, it was difficult to efficiently schedule onsite visits for both teams for the week, resulting in a reduction in team productivity. After the initial stages of the project, Cadmus found that it was more efficient to have one team deployed in the field at a time over a two week time span verses running two teams simultaneously.

Manual D

The data collection technique for Manual D evolved over the time in an effort to accurately collect the information necessary for an evaluation of the system in a reduced time period. Area take-offs for Manual J room-by-room calculation were originally performed using tape measures but the field teams converted to using laser measuring tools to increase the speed of performing the take-offs. For recording information on duct systems Cadmus initially proposed using computer tablets to draw the duct systems electronically so that the duct system information could be emailed to the Cadmus office and then to MEEA. During the diagram process the software would crash multiple times and all of the data would be lost. Based on these issues with the software and the tablet in the field, the field team chose to sketch out the duct system on paper and provide all of the information about duct fittings, duct sizes and duct length as notes on the drawing.

Logistical Innovations

In order to cut down on shipping costs from Kentucky to Boise, Cadmus group rented a storage unit in Louisville which was centrally located for the field study. The cost of shipping the equipment ranged from $200-$800 each field visit. The cost of the storage unit was $25-$30 per month. The storage unit reduced the cost load heavily.

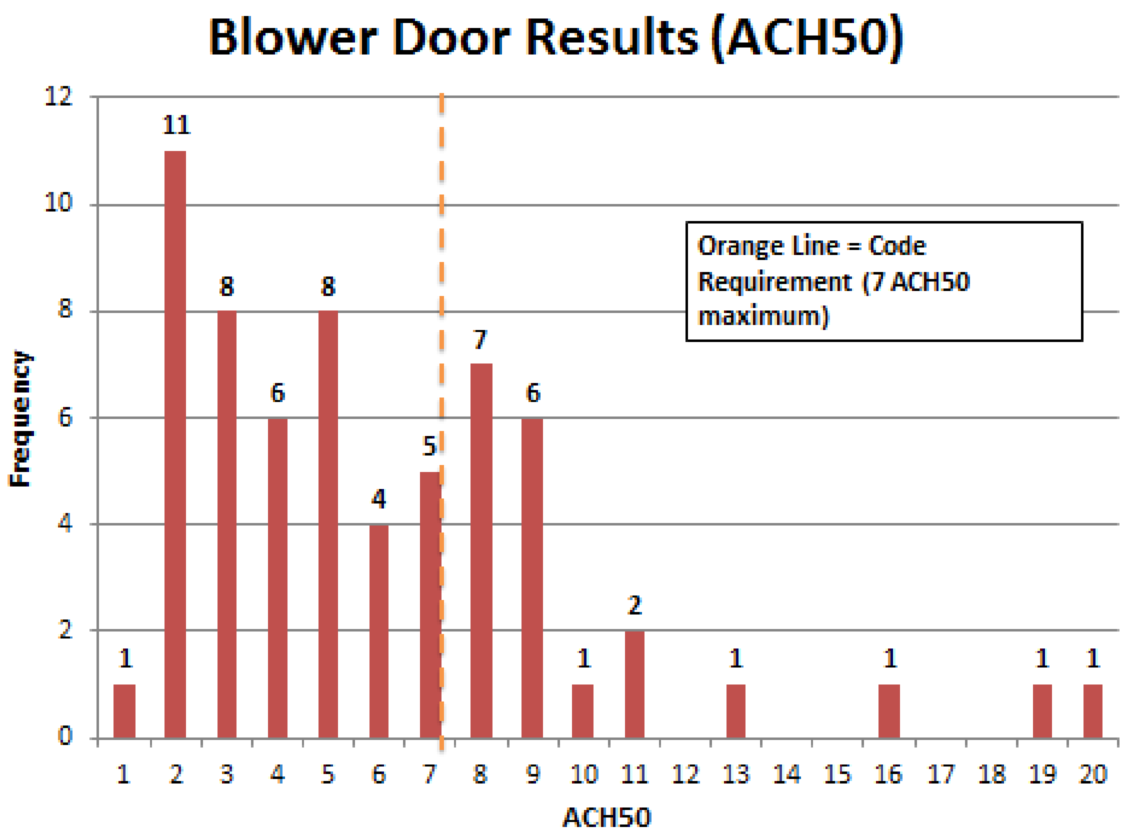
An apartment was rented in order to reduce hotel costs when Cadmus Group had multiple field teams employed simultaneously. Because the field schedule spanned partial months, there were additional costs for the apartment that reduced the cost-effectiveness. For example, because the apartment was rented until July 2nd, Cadmus group has to pay the rent for the entire month of July. This strategy could be effective in the future depending on the number of field teams employed and duration of the employment.

Total Money Spent Per Project

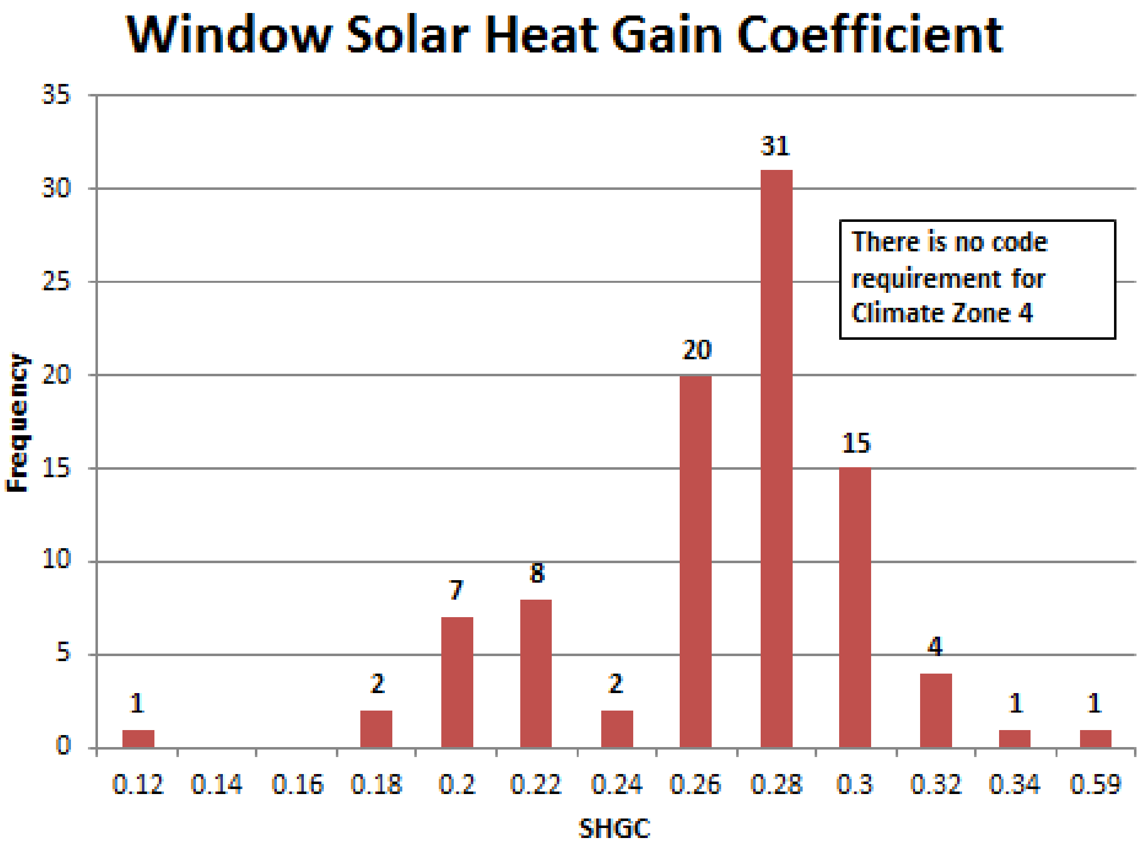
Project	Amount Spent[1]	Time Spent (hours)
Baseline Study	$118,149.51	1201
Manual D	$42,990.53	537
Flow Hood	$20,625.75	129

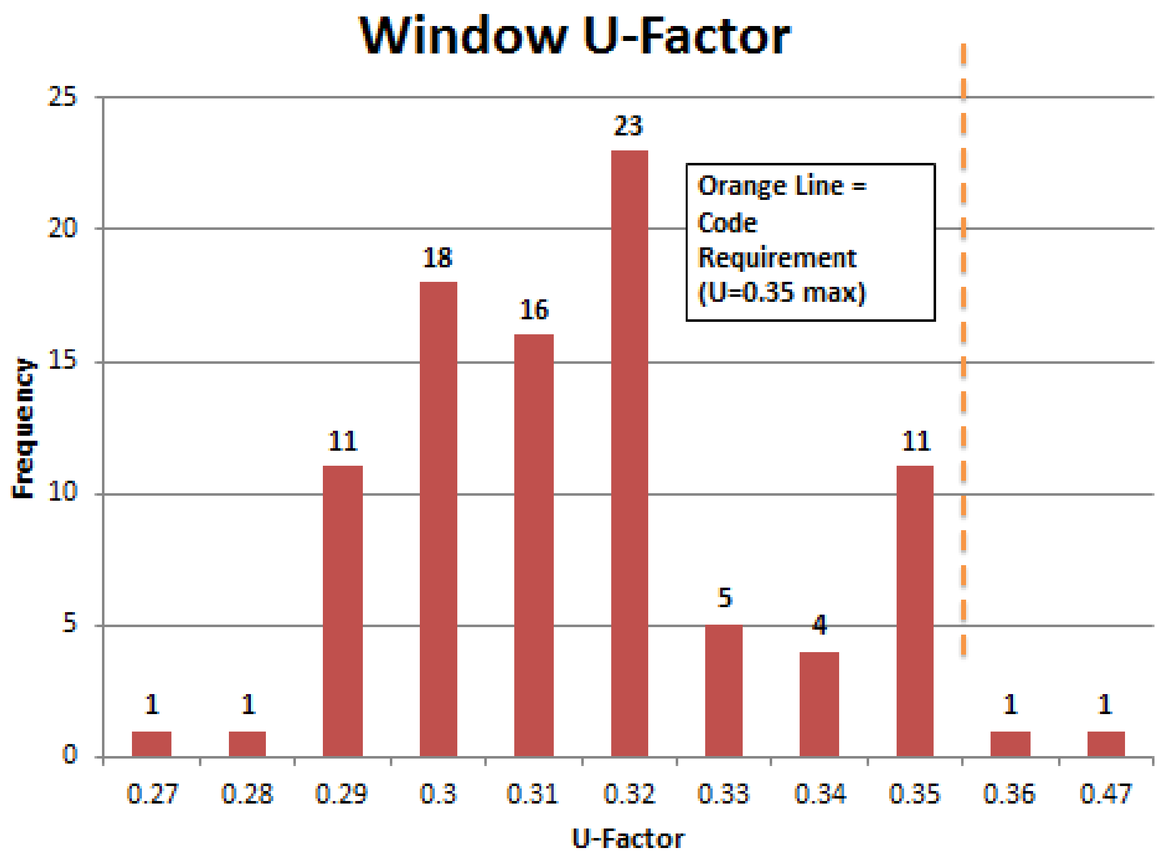
[1]The Amount Spent includes labor, travel and other non-labor administrative costs.

DATA COLLECTION HISTOGRAMS

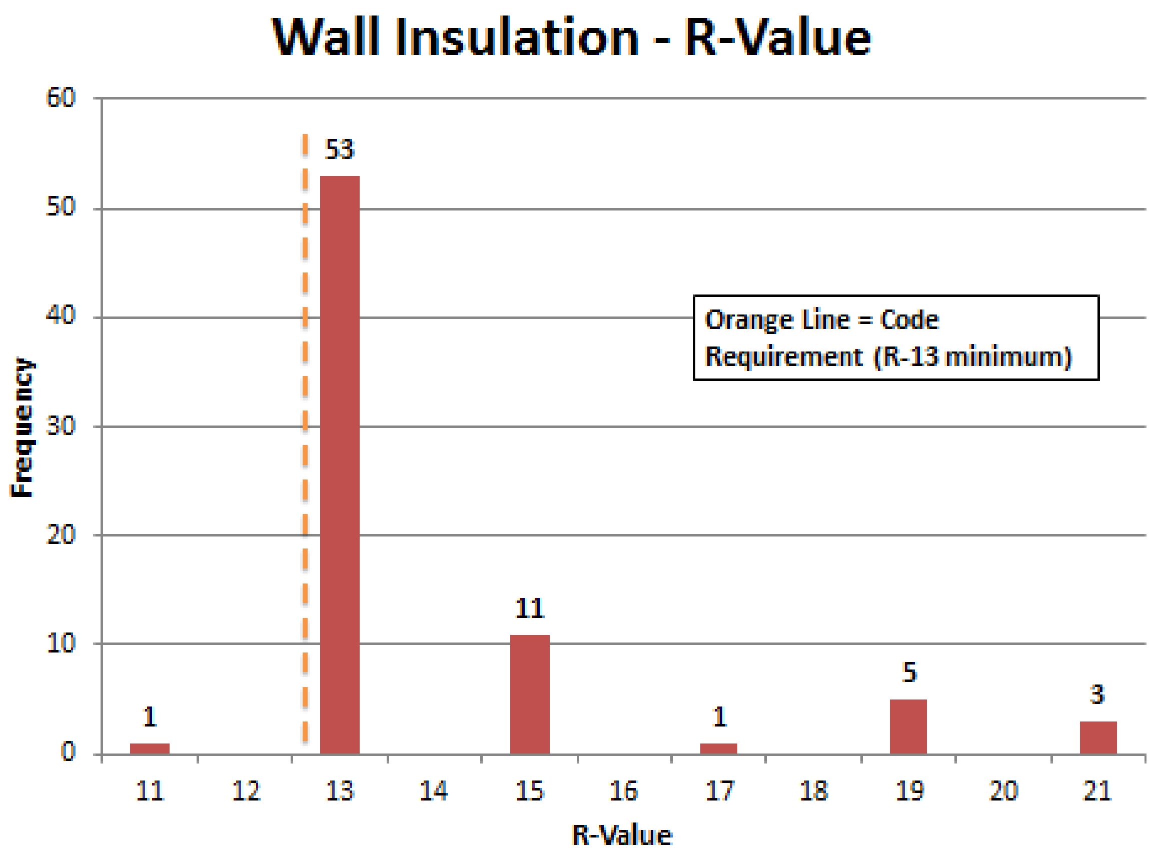


Blower Door Results (ACH50)
Frequency
ACH50
Orange Line = Code Requirement (7 ACH50 maximum)
0
2
4
6
8
10
12
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
1
11
8
6
8
4
5
7
6
1
2
1
1
1
1

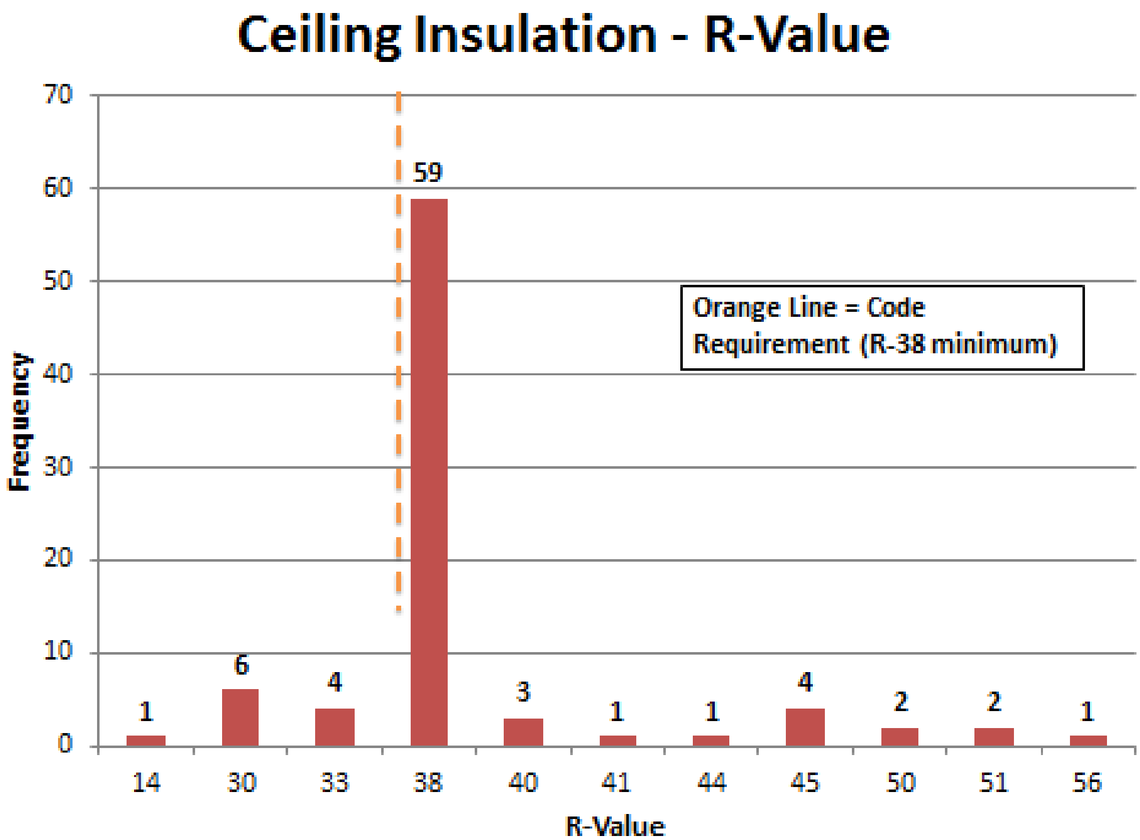

Window Solar Heat Gain Coefficient
Frequency
SHGC
35
30
25
20
15
10
5
0
0.12
0.14
0.16
0.18
0.2
0.22
0.24
0.26
0.28
0.3
0.32
0.34
0.59
1
2
7
8
2
20
31
15
4
1
1
There is no code requirement for Climate Zone 4



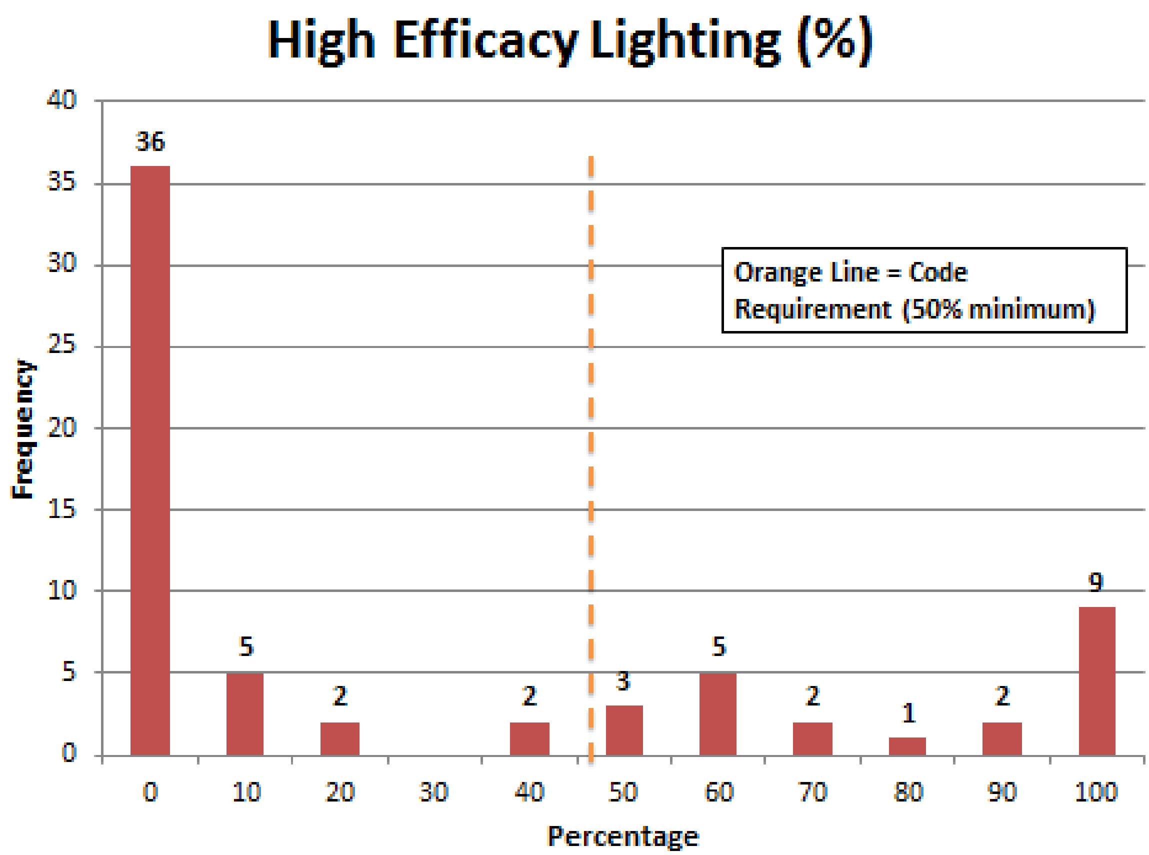
Window U-Factor
Orange Line = Code Requirement (U=0.35 max)
Frequency
U-Factor
25
20
15
10
5
0
0.27
0.28
0.29
0.3
0.31
0.32
0.33
0.34
0.35
0.36
0.47
1
1
11
18
16
23
5
4
11
1
1

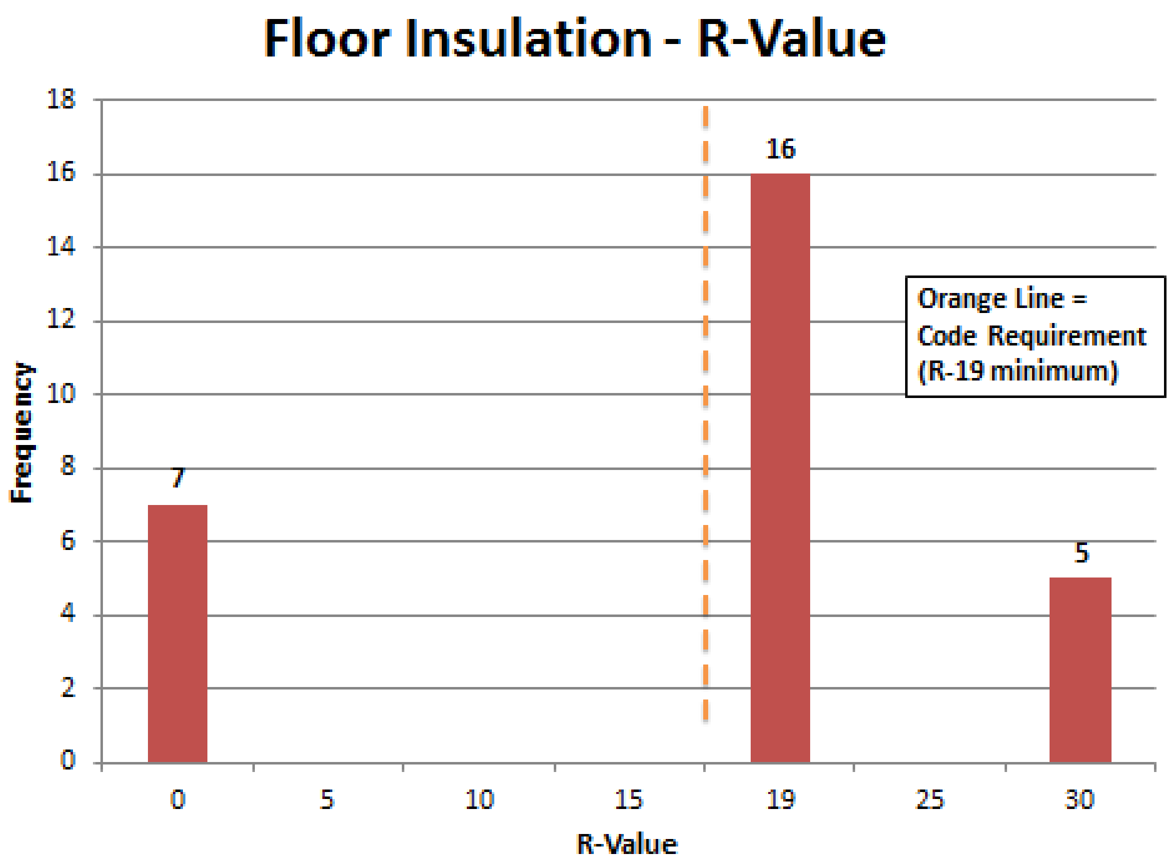


Wall Insulation - R-Value
Frequency
R-Value
60
50
40
30
20
10
0
11
12
13
14
15
16
17
18
19
20
21
53
11
1
1
5
3
Orange Line = Code Requirement (R-13 minimum)

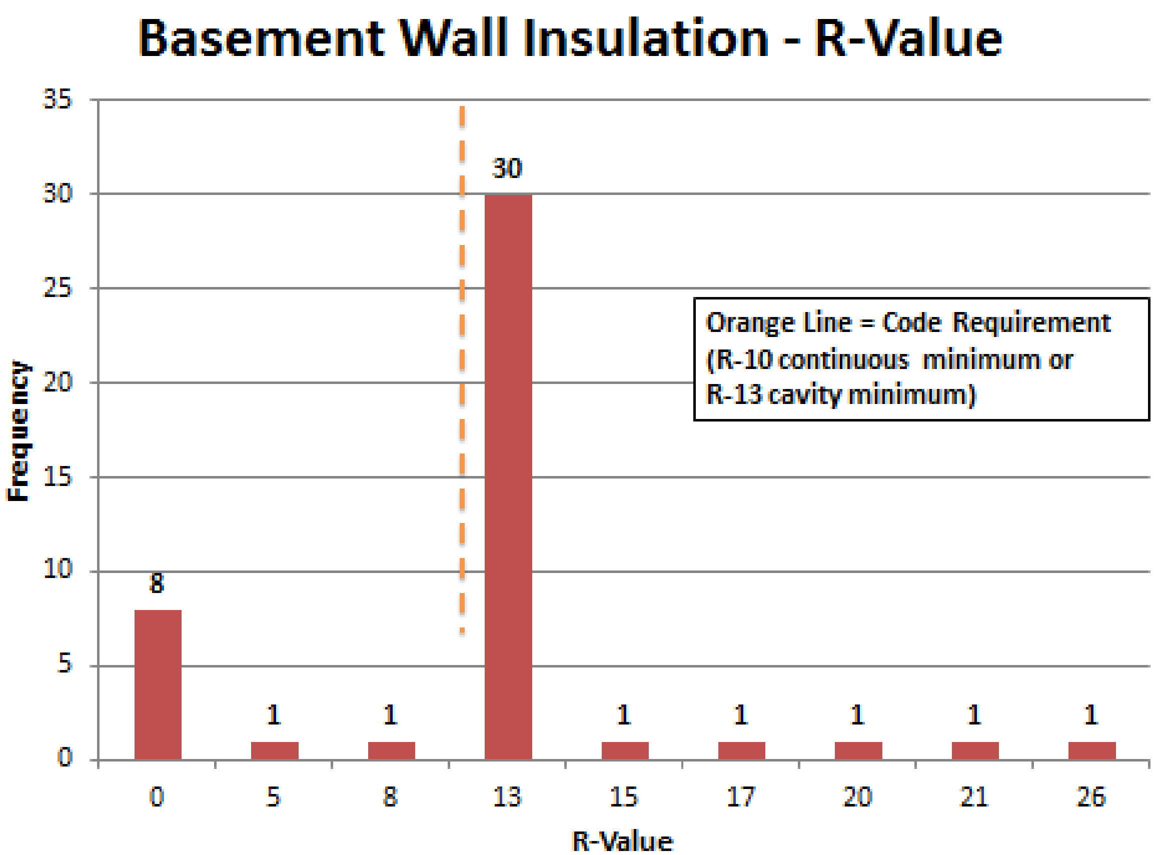


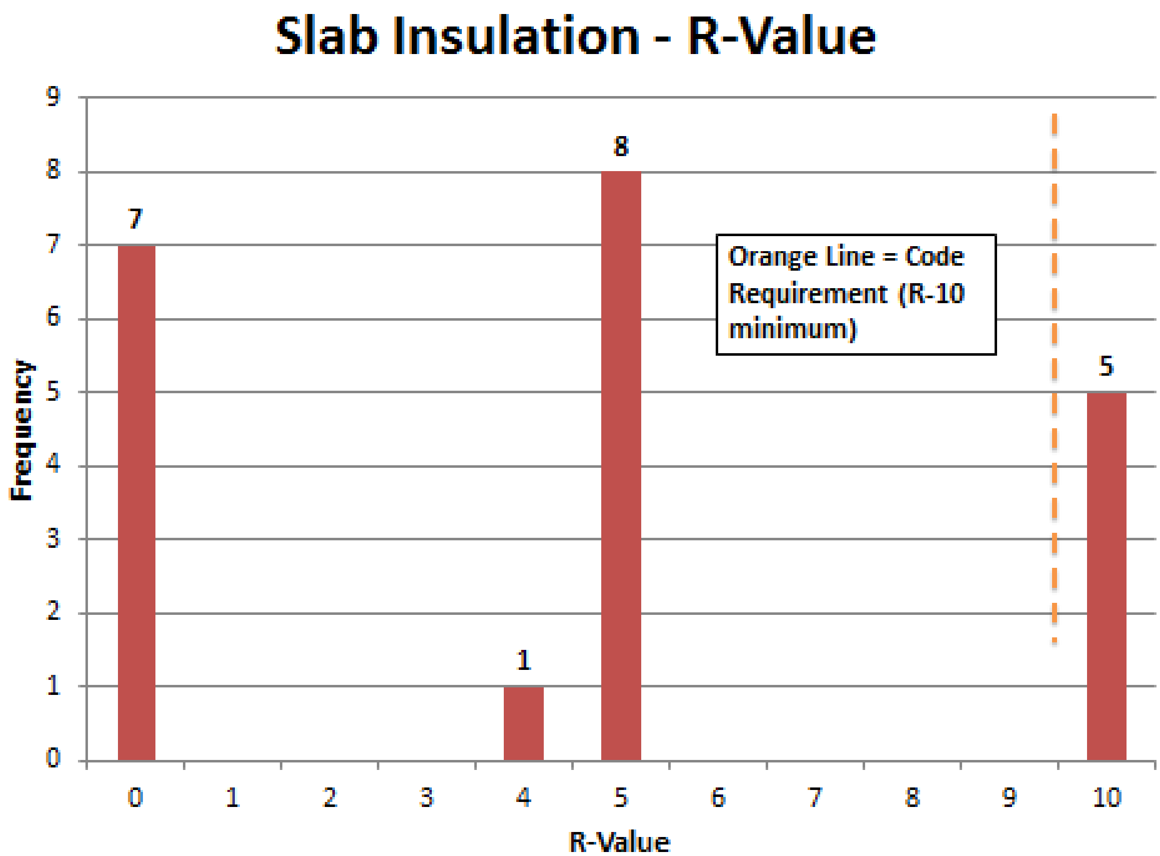
Ceiling Insulation - R-Value
70
60
50
40
30
20
10
0
Frequency
59
Orange Line = Code Requirement (R-38 minimum)
1
6
4
3
1
1
4
2
2
1
14
30
33
38
40
41
44
45
50
51
56
R-Value


High Efficacy Lighting (%)
Frequency
Percentage
Orange Line = Code Requirement (50% minimum)
40
35
30
25
20
15
10
5
0
36
5
2
2
3
5
2
1
2
9
0
10
20
30
40
50
60
70
80
90
100

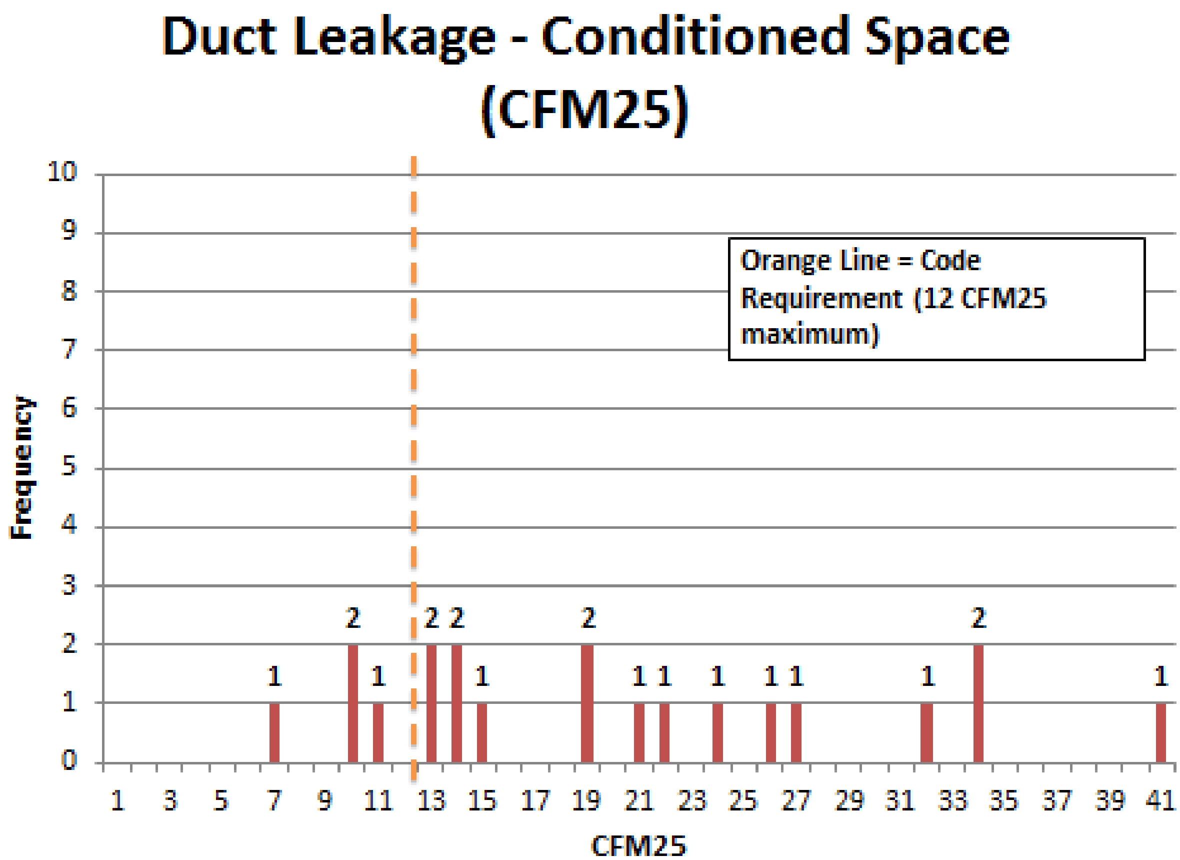


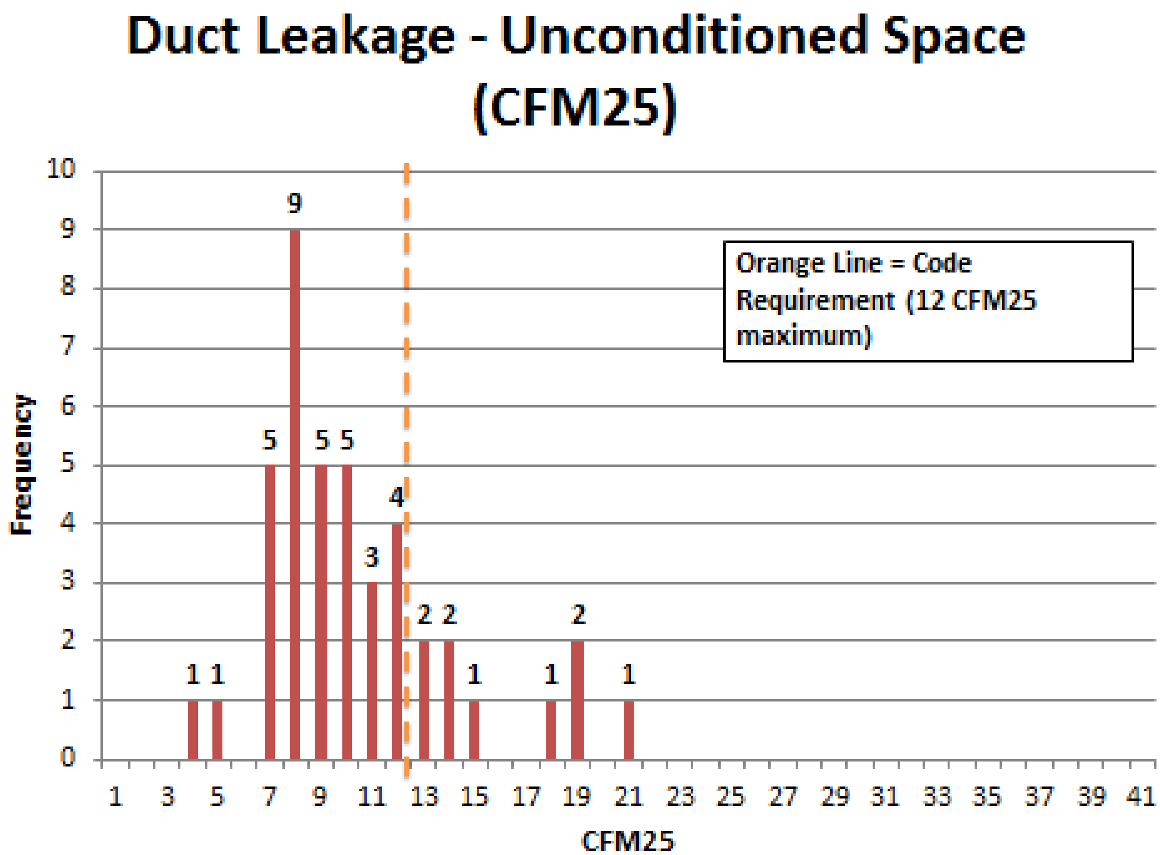
Floor Insulation - R-Value
Frequency
R-Value
18
16
14
12
10
8
6
4
2
0
0
5
10
15
19
25
30
7
16
5
Orange Line =
Code Requirement
(R-19 minimum)


Basement Wall Insulation - R-Value
Frequency
R-Value
0
5
10
15
20
25
30
35
8
1
1
30
1
1
1
1
1
0
5
8
13
15
17
20
21
26
Orange Line = Code Requirement
(R-10 continuous minimum or
R-13 cavity minimum)



Slab Insulation - R-Value
9
8
7
6
5
4
3
2
1
0
Frequency
7
8
1
5
Orange Line = Code Requirement (R-10 minimum)
0
1
2
3
4
5
6
7
8
9
10
R-Value


Duct Leakage - Conditioned Space (CFM25)
Orange Line = Code Requirement (12 CFM25 maximum)
Frequency
CFM25
0
1
2
3
4
5
6
7
8
9
10
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41
1 2 1 2 2 1 2 1 1 1 1 1 1 2 1



Duct Leakage - Unconditioned Space (CFM25)
Orange Line = Code Requirement (12 CFM25 maximum)
Frequency
CFM25
10
9
8
7
6
5
4
3
2
1
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41
1 1 5 9 5 5 3 4 2 2 1 1 2 1

APPENDIX 1

Kentucky Codes Compliance Improvement Study

Project Team Members – Phase 1

Midwest Energy Efficiency Alliance (MEEA) – Lead Agency

- Isaac Elnecave
- Chris Burgess
- Kelsey Horton
- George Mann, Project Manager – Independent Contractor

Kentucky Department of Housing, Buildings, and Construction (DHBC) – Partnering Organization

- Roger Banks
- Karen Jones
- Ric McNees
- Carey Graham

Kentucky Department of Energy Development and Independence (DEDI) – Partnering Organization

- Greg Guess
- Lee Colten
- Bill Lunsford

Britt/Makela Group (now part of Cadmus) – Data Collecting Contractor

- Eric Makela
- Michelle Britt
- Nigel Makela
- Jolyn Green
- David Freelove
- Talon Freelove
- Peter Arathoon
- Sara Stewart

- Chuck Johnson

APPENDIX 2

Kentucky Codes Compliance Improvement Study

Count of Key Item Observations

Topic	Number of Data Points
Key Item: Manual J	78
Key Item: Blower Door Test Results	64
Key Item: Window Solar Heat Gain Coefficient	92
Key Item: Window U-Factor	92
Key Item: Exterior Wall Insulation	77
Key Item: Ceiling Insulation	85
Key Item: Fraction of High-Efficacy Lighting	68
Foundation Insulation - floor	28
Foundation Insulation - basement	37
Foundation Insulation - slab	21
Key Item: Total Foundation Insulation	86
Key Item: Duct Leakage Test Results	63

APPENDIX 3

Kentucky Codes Compliance Improvement Study

Count of Non-Key Item Observations

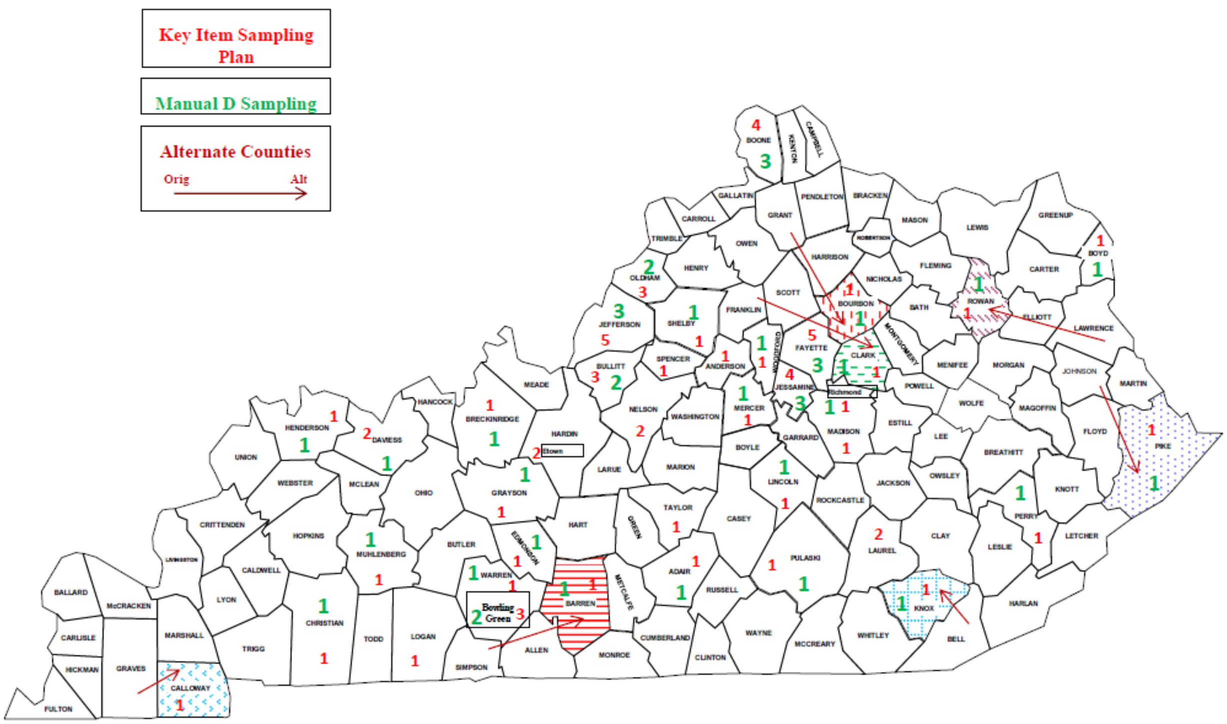
Topic	Number of Data Points
Total Conditioned Floor Area (Sq Feet)	135
Number of Stories Above Grade	136
Predominant Heating Source	125
Heating System Type	114
Heating System Capacity	94
Cooling System Type	87
Cooling System Capacity	77
Predominant Water Heating Source	88
Water Heating System Type	81
Water Heater Tank Gallon Capacity	65
Heating System Efficiency	94
Cooling System Efficiency	59
HVAC Equipment Sized per ACCA Manual S	10
Predominant Foundation Type	140
Protective covering installed to protect exposed exterior insulation + extends minimum 6 in below grade	7
Slab insulation depth or length	8
Is the slab heated?	16
Is the basement conditioned?	56
Conditioned basement wall insulation depth of burial or distance from top of wall	39
Is crawl space vented or unvented?	33
Unvented crawl space wall insulation R-value (continuous)	5
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 wall	4
Unvented crawl space wall insulation depth of burial or distance from top of wall	4
All joints, seams, & penetrations in building thermal envelope sealed	81
Site-built windows, doors, & skylights sealed	25
Openings between window & door assemblies & their respective jambs and framing sealed	75
Utility penetrations sealed	95

Topic	Number of Data Points
Thermal envelope behind tubs & showers on exterior walls sealed	66
Common walls between dwelling units sealed	15
Shower & tub on exterior walls per Table 402.4.2	67
Common wall per table 402.4.2	25
Fenestration that is factory built has infiltration rates per NFRC 400 that don't exceed code limits	44
IC-rated recessed lighting fixtures sealed at housing/interior finish and labeled to indicate less than 2 cfm leakage at 75 PA	66
Attic framing material	138
Knee wall framing material	42
Predominant knee wall framing depth	41
Door NFRC-rated U factor	9
Window NFRC-rated U factor	92
Glazed fenestration NFRC-rated SHGC value	92
Floor Framing Material	103
Frame or Mass Walls?	138
Wall Framing Material	137
Predominant wall framing depth	136
Mass wall insulation R-value (cavity)	3
Mass wall insulation R-value (continuous)	1
All joints and seams of air ducts sealed	91
All joints & seams of air handlers sealed	111
All joints & seams of filter boxes are sealed	99
Building cavities are not used as supply ducts or plenums	96
Automatic or gravity dampers are installed on all outdoor air intakes and exhausts	93
Supply duct in unconditioned space or outside insulation R-value	47
Return duct in unconditioned space or outside insulation R-value	44
Supply duct in attic R-value	61
Return ducts in attic R-value	65
% of supply duct in unconditioned crawl space	128
% of supply duct in conditioned space	130
% of supply duct in unconditoned attic	128
% of supply duct in unconditioned basement	128
% of return duct in unconditioned crawl space	128
% of return duct in conditioned space	129
% of return duct in unconditioned attic	128
% of return duct in unconditioned basement	128
Insulation minimum R-value for HVAC piping conveying fluids above 105° or below 55°	102
Pipe insulation R-value for DHW pipes	17
Dropped ceilings or chases adjacent to thermal envelope sealed	21

Topic	Number of Data Points
Knee walls sealed	26
Rim joist junctions sealed	72
Other sources of infiltration sealed	84
Air barrier and thermal barrier per Table 402.4.2	73
Walls per Table 402.4.2	73
Windows and doors per Table 402.4.2	74
Rim joists per Table 402.4.2	70
Floors per Table 402.4.2	45
Crawl space walls per Table 402.4.2	16
Shafts and penetrations per Table 402.4.2	61
Narrow cavities per Table 402.4.2	75
Plumbing and wiring per Table 402.4.2	74
Electrical & phone boxes on exterior walls per Table 402.4.2	80
HVAC register boots per table 402.4.2	95
Knee wall insulation R-value (cavity)	36
Knee wall insulation R-value (continuous)	8
Knee wall insulation quality	36
Location of basement wall insulation	37
Basement cavity insulation quality	35
Floor insulation installed in substantial contact with underside of subfloor	22
Floor cavity insulation quality	20
All installed insulation is labeled or installed R-values provided	86
Frame wall insulation quality (cavity)	72
Mass wall cavity insulation quality	2
Where is mass wall insulation located?	2
Blower door test from previous test by other parties	1
Walls & ceilings separating a garage from conditioned spaces sealed	55
Attic access openings sealed	58
Ceiling & attic per Table 402.4.2	67
Garage separation per Table 402.4.2	56
Recessed lighting per Table 402.4.2	52
Wood-burning fireplaces have tight-fitting flue dampers & outdoor air for combustion	31
Is insulation located in ceiling or rafters?	91
Roof cavity insulation quality	78
Attic hatch and door insulation ≥ R-value of adjacent assembly	54
Manufacturer manuals for mechanical & water heating systems have been provided	72
Duct tightness test result from previous tests	1
Type of ventilation system	117
If AHU-integrated, does it have heat/energy recovery?	10
If exhaust-based, does it have dedicated exhaust fans or rely on bathroom exhaust fans?	102

APPENDIX 4

Key Item Sampling Plan with Alternate County Transitions



APPENDIX 5

Kentucky Codes Compliance Improvement Study

Sample Data Collection Form

ID #	Home Address	Stage of Completion	Builder & Builder Contact info

ID	Code Section	Description	Meets Requirement	Does Not Meet Requirement	Not Applicable	Not Observable	Observation	Format	Units	Comments
Home Documentation General										
LOC1	NA	State where home is located						Text		
LOC2	NA	Climate zone where home is located						Text		
LOC3	NA	Does the home fall in the Warm-Humid Zone (question applicable only to zone 3)						Yes or No		
LOC4	NA	County where home is located						Text		
LOC5	*NA*	*Town or place where home is located*						*Text*		
LOC6	*NA*	*Number of homes builder builds per year*						*Number*		
LOC7	*NA*	*Identification Code for home*						*Text*		
Home Documentation Compliance Method										
Comp1	NA	Energy code to which the home is permitted						Text		

Comp2	NA	Compliance path within the energy code that was used *or will be used.*						Text		
Comp3	NA	Did this *or will this* home use REScheck for compliance?						Yes or No		
Comp4a	NA	Did this *or will this* home use HERS for compliance?						Yes or No		
Comp4b	NA	Will HERS index be used for compliance purposes?						Yes or No		
Comp5	NA	What is the HERS Index?						Number		
ID	**Code Section**	**Description**	**Meets Requirement**	**Does Not Meet Requirement**	**Not Applicable**	**Not Observable**	**Observation**	**Format**	**Units**	**Comments**
Comp6	NA	Compliance documentation with energy code details (e.g., plans, REScheck report, etc.) was available and reviewed for this home. *(If yes, please fill out "REScheck, HERS, or Other Compliance Documentation" columns on Envelope, Mechanical, and Lighting tabs, if time is available.)*						Yes or No		
Comp7	NA	Is the home in an "above-code" program?						Yes or No		
Comp8	NA	If "yes" to previous question, what is the above-code program *and what is level of performance of achieved in that above code program?*						Text		
Mechanical Equipment										
EQ1	NA	Predominant heating Source - gas, oil, electricity, wood.						Text		
EQ2	NA	Heating system type - furnace, boiler, heat pump, *electric resistance strip heat.*						Text		

EQ4	NA	Heating system capacity in Btu/h						Number	Btu/h	
EQ5	NA	Cooling system type - central ac, room ac, heat pump						Text		
EQ7	NA	Cooling system capacity in Btu/h						Number	Btu/h	
EQ8	NA	Predominant hot water heating source - gas, oil, electricity, wood, solar						Text		
EQ9	NA	Water heating system type - storage, tank-less, solar						Text		

ID	Code Section	Description	Meets Requirement	Does Not Meet Requirement	Not Applicable	Not Observable	Observation	Format	Units	Comments
EQ11	*NA*	*Water heater tank capacity in gallons*						*Number*	*Gallons*	
Geo1	NA	Total Conditioned Floor Area for the building *(intended or actual)*						Number	Square feet	
Geo2	NA	Number of stories above grade *(intended or actual)*						Number	Stories	
PR2	302.1, 403.6	Heating and cooling equipment is sized per ACCA Manual S based on loads calculated per ACCA Manual J or other methods approved by the code official						Check Box		

2009 Residential Data Collection Form - General Comments

The cell below is intended for use by the Project Team to provide any additional general information that may be of use when the data is analyzed. Please do not provide any personally identifiable information such as homeowner or

ID	Code Section	Description	Meets Requirement	Does Not Meet Requirement	Not Applicable	Not Observable	Field Observation	REScheck or HERS Value*	Format	Units	Comments
Envelope Foundation All Foundations											
BG17	NA	Predominant (most common) foundation type - Crawlspace, basement, slab-on-grade							Text		
FO11	303.2.1	A protective covering is installed to protect exposed exterior insulation and extends a minimum of 6 in. below grade									
Envelope Foundation Slab											
FO1	***402.1.1***	***Slab edge insulation R-value***							***Number***	***R-value***	

FO3	402.1.1	Slab edge insulation depth or length							Number	Feet	
Slab1	NA	Is the slab heated?							Yes or No		
Envelope Foundation Basement											
BG19	NA	Is the basement conditioned?							Text		
FO4a	***402.1.1***	***Conditioned basement wall insulation R-value (cavity insulation)***							***Number***	***R-value***	
FO4b	***402.1.1***	***Conditioned basement wall insulation R-value (continuous insulation)***							***Number***	***R-value***	
FO6	402.2.7	Conditioned basement wall insulation depth of burial or distance from top of wall							Number	Feet	
Envelope Foundation Crawlspace											
BG18	NA	Is the crawlspace vented or unvented?							Text		
FO7a	***402.2.9***	***Unvented crawl space wall insulation R-value (cavity insulation)***							***Number***	***R-value***	
FO7b	***402.2.9***	***Unvented crawl space wall insulation R-value (continuous insulation)***							***Number***	***R-value***	
CSIQ1	NA	What is the crawl space wall cavity insulation quality? (I,II,III) - see INFO - Insulation Grading tab							Text		
FO9	402.2.9	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							Check Box		
ID	**Code Section**	**Description**	**Meets Requirement**	**Does Not Meet Requirement**	**Not Applicable**	**Not Observable**	**Field Observation**	**REScheck or HERS Value***	**Format**	**Units**	**Comments**
CSIQ1	NA	What is the crawl space wall cavity insulation quality? (I,II,III) - see INFO - Insulation Grading tab							Text		
FO9	402.2.9	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							Check Box		

FO10	402.2.9	Unvented crawl space wall insulation depth of burial or distance from top of wall.							Number	Feet	
Envelope Air Leakage											
FR23a	402.4.1	All joints, seams, and penetrations in building thermal envelope sealed							Check Box		
FR23b	402.4.1	Site-built windows, doors, and skylights sealed							Check Box		
FR23c	402.4.1	Openings between window and door assemblies and their respective jambs and framing sealed							Check Box		
FR23d	402.4.1	Utility penetrations sealed							Check Box		
FR23h	402.4.1	Thermal envelope behind tubs and showers on exterior walls sealed							Check Box		
FR23i	402.4.1	Common walls between dwelling units sealed							Check Box		
AB&I13	402.4.2.2	Shower and tub on exterior walls per Table 402.4.2							Check Box		
AB&I15	402.4.2.2	Common wall per Table 402.4.2							Check Box		
AB&I17	402.4.2.2	Fireplace per Table 402.4.2							Check Box		
FR20	402.4.4	Fenestration that is factory built has infiltration rates per NFRC 400 that do not exceed code limits							Check Box		
FR16	402.4.5	IC-rated recessed lighting fixtures sealed at housing/interior finish and labeled to indicate ≤2.0 cfm leakage at 75 Pa							Check Box		
ID	**Code Section**	**Description**	**Meets Requirement**	**Does Not Meet Requirement**	**Not Applicable**	**Not Observable**	**Field Observation**	**REScheck or HERS Value***	**Format**	**Units**	**Comments**
Envelope Ceiling and Attic											
M1	NA	What is the attic framing material - wood or steel?							Text		
Envelope Ceiling and Attic Knee-walls											
KW3	NA	What is the knee wall framing material - wood or steel?							Text		

KW4	NA	What is the predominant knee wall framing depth? (2 inch, 4 inch, 6 inch, 8 inch, etc.)							Number	inches of framing depth	
Envelope Fenestration											
FR1	402.1.1, 402.3.4	Door NFRC-rated U-factor (area-weighted average)							Number	U-factor	
FR2	***402.1.1, 402.3.1, 402.3.3, 402.5***	***Window NFRC-rated U-factor (area-weighted average)***							***Number***	***U-factor***	
FR3	***402.1.1, 402.3.2, 402.3.3, 402.5***	***Glazed fenestration (including windows, glazed doors, and skylights) NFRC-rated SHGC value (area-weighted average)***							***Number***	***SHGC***	
FR5	402.1.1, 402.3.3, 402.5	Skylight NFRC-rated U-factor (area-weighted average)							Number	U-factor	
Envelope Foundation Floor											
M2	NA	What is the floor framing material - wood or steel?							Text		
Envelope Wall All Walls (Does not include knee walls)											
Wall1	NA	Are the walls predominantly frame walls or mass walls?							Text		
Envelope Wall Frame (Does not include knee walls)											
M3	NA	What is the wall framing material - wood or steel?							Text		
Wall2	NA	What is the predominant wall framing depth? (2 inch, 4 inch, 6 inch, 8 inch, etc.)							Number	inches of framing depth	
ID	**Code Section**	**Description**	**Meets Requirement**	**Does Not Meet Requirement**	**Not Applicable**	**Not Observable**	**Field Observation**	**REScheck or HERS Value***	**Format**	**Units**	**Comments**
Envelope Wall Mass (Does not include knee walls)											
FR10a	***402.1.1***	***Mass wall insulation R-value (cavity insulation)***							***Number***	***R-value***	
FR10b	***402.1.1***	***Mass wall insulation R-value (continuous insulation)***							***Number***	***R-value***	

Mechanical Ducts											
FR13a	403.2.2	All joints and seams of air ducts are sealed							Check Box		
FR13b	403.2.2	All joints and seams of air handlers are sealed							Check Box		
FR13c	403.2.2	All joints and seams of filter boxes are sealed							Check Box		
FR15	403.2.3	Building cavities are not used as supply ducts or plenums							Check Box		
FR19	403.5	Automatic or gravity dampers are installed on all outdoor air intakes and exhausts							Check Box		
FR12a	403.2.1	Supply duct in unconditioned space or outside insulation R-value							Number	R-value	
FR12b	403.2.1	Return duct in unconditioned space or outside insulation R-value							Number	R-value	
FR12c	403.2.1	Supply duct in attic R-Value							Number	R-value	
FR12d	403.2.1	Return duct in attic R-value							Number	R-value	
DP4	NA	Rough percentage of supply duct in unconditioned crawlspace							Number	Percent	
DP5	NA	Rough percentage of supply duct in conditioned space							Number	Percent	
DP6	NA	Rough percentage of supply duct in unconditioned attic							Number	Percent	
DP7	NA	Rough percentage of supply duct in unconditioned basement							Number	Percent	
ID	**Code Section**	**Description**	**Meets Requirement**	**Does Not Meet Requirement**	**Not Applicable**	**Not Observable**	**Field Observation**	**REScheck or HERS Value***	**Format**	**Units**	**Comments**
DP8	NA	Rough percentage of return duct in unconditioned crawlspace							Number	Percent	
DP9	NA	Rough percentage of return duct in conditioned space							Number	Percent	

DP10	NA	Rough percentage of return duct in unconditioned attic							Number	Percent	
DP11	NA	Rough percentage of return duct in unconditioned basement							Number	Percent	
DP12	*NA*	*Sum of rough percentages of supply ducts in observations DP4 through DP7 (should be 100%)*							Number	Percent	
DP13	*NA*	*Sum of rough percentages of return ducts in observations DP8 through DP11 (should be 100%)*							Number	Percent	
Mechanical Piping											
FR17	403.3	Insulation minimum R-value for HVAC piping conveying fluids above 105°F or chilled fluids below 55°F							Number	R-value	
FR18	403.4	Pipe insulation R-value for DHW pipes							Number	R-value	
Envelope Air Leakage											
FR23e	402.4.1	Dropped ceilings or chases adjacent to the thermal envelope sealed							Check Box		
FR23f	402.4.1	Knee walls sealed							Check Box		
FR23k	402.4.1	Rim joist junctions sealed							Check Box		
FR23l	402.4.1	Other sources of infiltration sealed							Check Box		
AB&I1	402.4.2.2	Air barrier and thermal barrier per Table 402.4.2							Check Box		
AB&I3	402.4.2.2	Walls per Table 402.4.2							Check Box		
AB&I4	402.4.2.2	Windows and doors per Table 402.4.2							Check Box		
AB&I5	402.4.2.2	Rim joists per Table 402.4.2							Check Box		
AB&I6	402.4.2.2	Floors (including above-garage and cantilevered floors) per Table 402.4.2							Check Box		
AB&I7	402.4.2.2	Crawl space walls per Table 402.4.2							Check Box		
ID	**Code Section**	**Description**	**Meets Requirement**	**Does Not Meet Requirement**	**Not Applicable**	**Not Observable**	**Field Observation**	**REScheck or HERS Value***	**Format**	**Units**	**Comments**
AB&I8	402.4.2.2	Shafts and penetrations per Table 402.4.2							Check Box		

ID	Code Section	Description	Meets Requirement	Does Not Meet Requirement	Not Applicable	Not Observable	Field Observation	REScheck or HERS Value*	Format	Units	Comments
AB&I9	402.4.2.2	Narrow cavities per Table 402.4.2							Check Box		
AB&I12	402.4.2.2	Plumbing and wiring per Table 402.4.2							Check Box		
AB&I14	402.4.2.2	Electrical and phone boxes on exterior walls per Table 402.4.2							Check Box		
AB&I16	402.4.2.2	HVAC register boots per Table 402.4.2							Check Box		
Envelope Ceiling and Attic Knee-walls											
KW1	NA	Knee Wall insulation R-value (cavity insulation)							Number	R-value	
KW2	NA	Knee Wall insulation R-value (continuous insulation)							Number	R-value	
KW5	NA	What is the knee wall insulation quality? (I,II,III) - see INFO - Insulation Grading tab							Text		
Envelope Foundation Basement											
WIP2	NA	Where is the basement wall insulation (inside, outside)?							Text		
IQ4	NA	What is the basement cavity insulation quality? (I,II,III) - see INFO - Insulation Grading tab							Text		
Envelope Foundation Floor											
IN1a	***402.1.1, 402.2.5, 402.2.6***	***Floor insulation R-value (cavity insulation)***							***Number***	***R-value***	
IN1b	***402.1.1, 402.2.5, 402.2.6***	***Floor insulation R-value (continuous insulation)***							***Number***	***R-value***	
IN2	402.2.6	Floor insulation installed in substantial contact with the underside of the subfloor							Check Box		
IQ2	NA	What is the floor cavity insulation quality? (I,II,III) - see INFO - Insulation Grading tab							Text	NA	

Envelope Insulation											
IN13	303.1.1, 303.1.2	All installed insulation is labeled or the installed R-values provided							Check Box		
Envelope Wall Frame (Does not include knee walls)											
IN3a	***402.1.1, 402.2.5***	***Frame Wall insulation R-value (cavity insulation)***							***Number***	***R-value***	
IN3b	***402.1.1, 402.2.5***	***Frame Wall insulation R-value (continuous insulation)***							***Number***	***R-value***	
IQ3	NA	What is the frame wall insulation quality? (I,II,III) - see INFO - Insulation Grading tab							Text		
Envelope Wall Mass (Does not include knee walls)											
MIQ1	NA	What is the mass wall cavity insulation quality? (I,II,III) - see INFO - Insulation Grading tab *(Not applicable to ICF walls - applicable only to mass walls with framed insulation)*							Text		
WIP1	NA	Where is the mass wall insulation located (inside, outside)?							Text		
Compliance Documentation Certificate											
FI7	401.3	Compliance certificate posted							Check Box		
Envelope Air Leakage											
FI17	***402.4.2.1***	***Blower door test results from Project Team test using RESNET Protocol (ACH @ 50 PA)***						***Number***	***ACH50***		
BD1	NA	Blower door test results from previous test by other parties (ACH @ 50 PA) (for comparison only)						Number	ACH50		
FR23g	402.4.1	Walls and ceilings separating a garage from conditioned spaces sealed							Check Box		
FR23j	402.4.1	Attic access openings sealed							Check Box		

ID	Code Section	Description	Meets Requirement	Does Not Meet Requirement	Not Applicable	Not Observable	Field Observation	REScheck or HERS Value*	Format	Units	Comments
AB&I2	402.4.2.2	Ceiling and attic per Table 402.4.2							Check Box		
AB&I10	402.4.2.2	Garage separation per Table 402.4.2							Check Box		
AB&I11	402.4.2.2	Recessed lighting per Table 402.4.2							Check Box		
FI8	402.4.3	Wood-burning fireplaces have tight fitting flue dampers and outdoor air for combustion							Check Box		
Envelope Ceiling and Attic											
BG15	NA	Is the insulation located in the ceiling or the rafters?							Text		
FI1	***402.1.1, 402.2.1, 402.2.2, 402.2.5***	***Predominant ceiling insulation Total R-value (cavity and continuous insulation)***						***Number***	***R-value***		
IQ1	NA	What is the roof cavity insulation quality? (I,II,III) - see INFO - Insulation Grading tab							Text		
FI3	402.2.3	Attic access hatch and door insulation ≥R-value of the adjacent assembly							Check Box		
Mechanical Documentation											
FI18	303.3	Manufacturer manuals for mechanical and water heating systems have been provided						Check Box			
Mechanical Controls											
FO12	403.8	Snow- and ice-melting system controls installed						Check Box			
FI11	403.4	Circulating service hot water systems have automatic or accessible manual controls						Check Box			
Mechanical Ducts											

Room Name											House Orientation			N	NE	E	SE	S	SW	W	NW

ID	Code Section	Description	Meets Requirement	Does Not Meet Requirement	Not Applicable	Not Observable	Field Observation	REScheck or HERS Value*	Format	Units	Comments
FI4	***403.2.2***	***Duct tightness test result (post-construction total leakage) by Project Team using RESNET Protocol (CFM/100 ft ^{2} floor area @ 25 Pa)***						***Number***	***CFM/100 ft ^{2}***		
DT1	NA	Duct tightness test result from previous tests (CFM/100 ft^2 floor area @ 25 Pa) (describe previous duct tightness test in comments – post-construction or rough-in, to outdoors or total, air handler installed or not)						Number	CFM/100 ft^2		
Mechanical Equipment											
EQ3	NA	Heating system efficiency in HSPF or AFUE						Number	HSPF or AFUE		
EQ6	NA	Cooling system efficiency in SEER						Number	SEER		
EQ10	NA	Water heater efficiency in EF						Number	EF		
Mechanical Ventilation											
V1	NA	What type of ventilation system does the home have? (AHU-integrated, exhaust fans only, standalone ERV/HRV)						Text			
V2	NA	If AHU-integrated, does it have heat/energy recovery?						Yes or No			
V3	NA	If exhaust-based, does it have dedicated exhaust fan(s) for ventilation or does it rely on bathroom exhaust fan(s)?						Text			
Lighting Documentation											
FI6	***404.1***	***Percentage of permanently installed fixtures that have high-efficacy lamps***						***Number***	***Percent***		

	Volume	Average Ceiling Height	Thermal Envelope Floor Area	Floor Area	Roof Area	Exterior Walls				Garage Walls				Window				Doors				Basement Walls				Register CFM
						Front	Back	Left	Right	Front	Back	Left	Right	Front	Back	Left	Right	Front	Back	Left	Right	Front	Back	Left	Right	
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