

Massachusetts Electric and Gas Program Administrators

**Residential Single-Family Building
Department Document Review-Final
Report**

December 1, 2015

**Prepared by:
NMR Group, Inc.**



Massachusetts Electric and Gas Program Administrators

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Part of the Special and Cross-Cutting Evaluation Program Area

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1. EXECUTIVE SUMMARY

In conjunction with the ongoing single-family compliance/baseline study (from here on referred to as the “baseline study”), NMR recently visited 52 building departments throughout Massachusetts to determine what type of documentation is being filed to show compliance with the energy code for single-family homes.

The following code requirements should be associated with some form of documentation at the building department when a home goes through the permit process (Table 1). Our building department document review was focused on the following questions surrounding these requirements:

- How many homes had documentation filed for these various requirements?
- When present, what was the format of the filed documentation?
- How does documentation vary by energy code?
- How does documentation vary by municipality?

Table 1: Code Requirements Associated with Building Department Documentation

Code Requirements		
Stretch code	2009 IECC	2012 IECC
<ul style="list-style-type: none"> • HERS index requirement • Heating and cooling equipment loads calculated using Manual J • Duct leakage testing • Air leakage testing • ENERGY STAR thermal enclosure checklist 	<ul style="list-style-type: none"> • Insulation requirements • Heating and cooling equipment loads calculated using Manual J • Duct leakage testing 	<ul style="list-style-type: none"> • Insulation requirements • Heating and cooling equipment loads calculated using Manual J • Duct leakage testing • Air leakage testing



Figure 1 shows the percentage of homes in our sample that had filed documentation for the code requirements listed in Table 1. Striped bars in Figure 1 indicate that the documentation is required by the code version. Interestingly, manual J calculations, a mandatory requirement under all three codes considered in this study, were documented for only 10% of homes built under the 2012 IECC and 12% of homes built under the 2009 IECC or stretch code. The ENERGY STAR thermal enclosure checklist, a requirement under the stretch code, was documented for only 20% of stretch code homes. Perhaps the most significant finding relates to air and duct leakage testing. Duct leakage testing, a mandatory requirement under both the 2009 and 2012 IECC, was documented for only 20% and 27% of homes, respectively. Air leakage testing, a new mandatory requirement under the 2012 IECC, was documented for only 32% of homes.

Figure 1. Summary of Energy-Related Documentation by Code

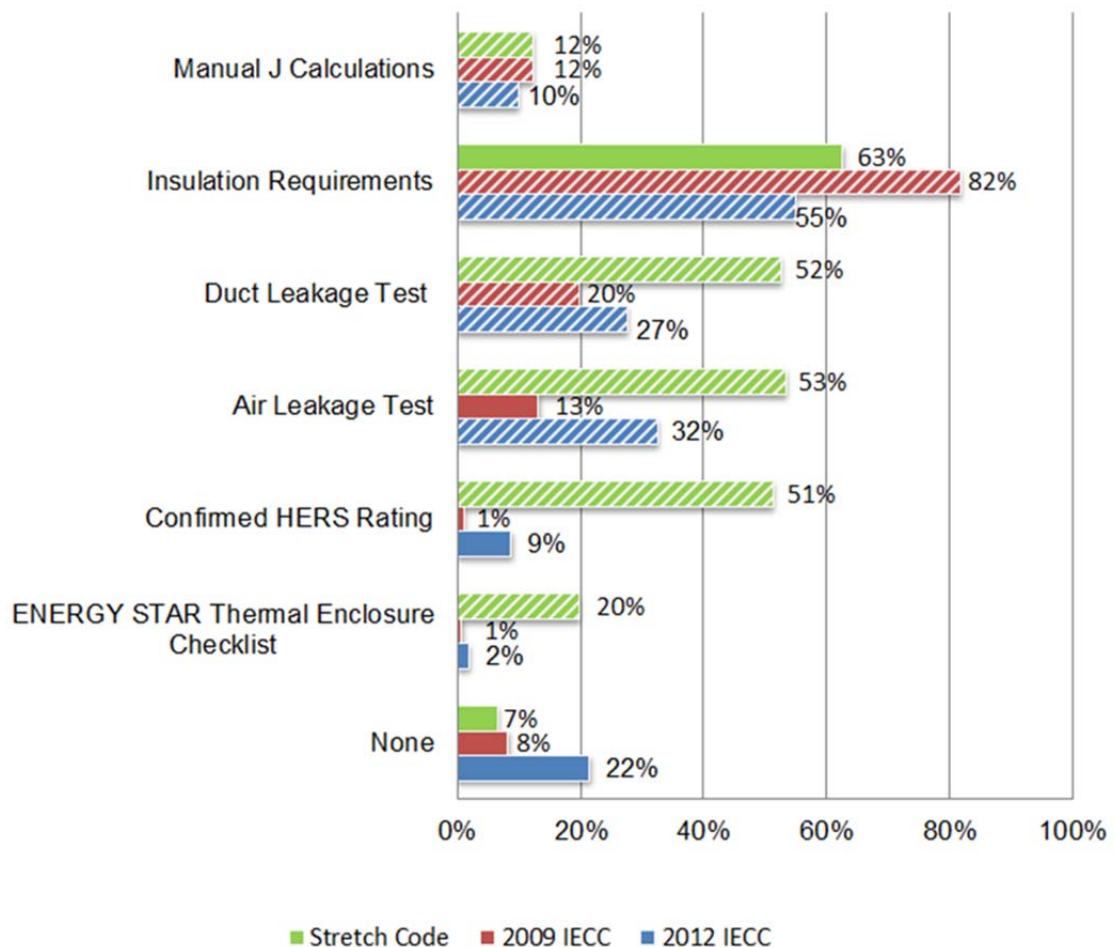
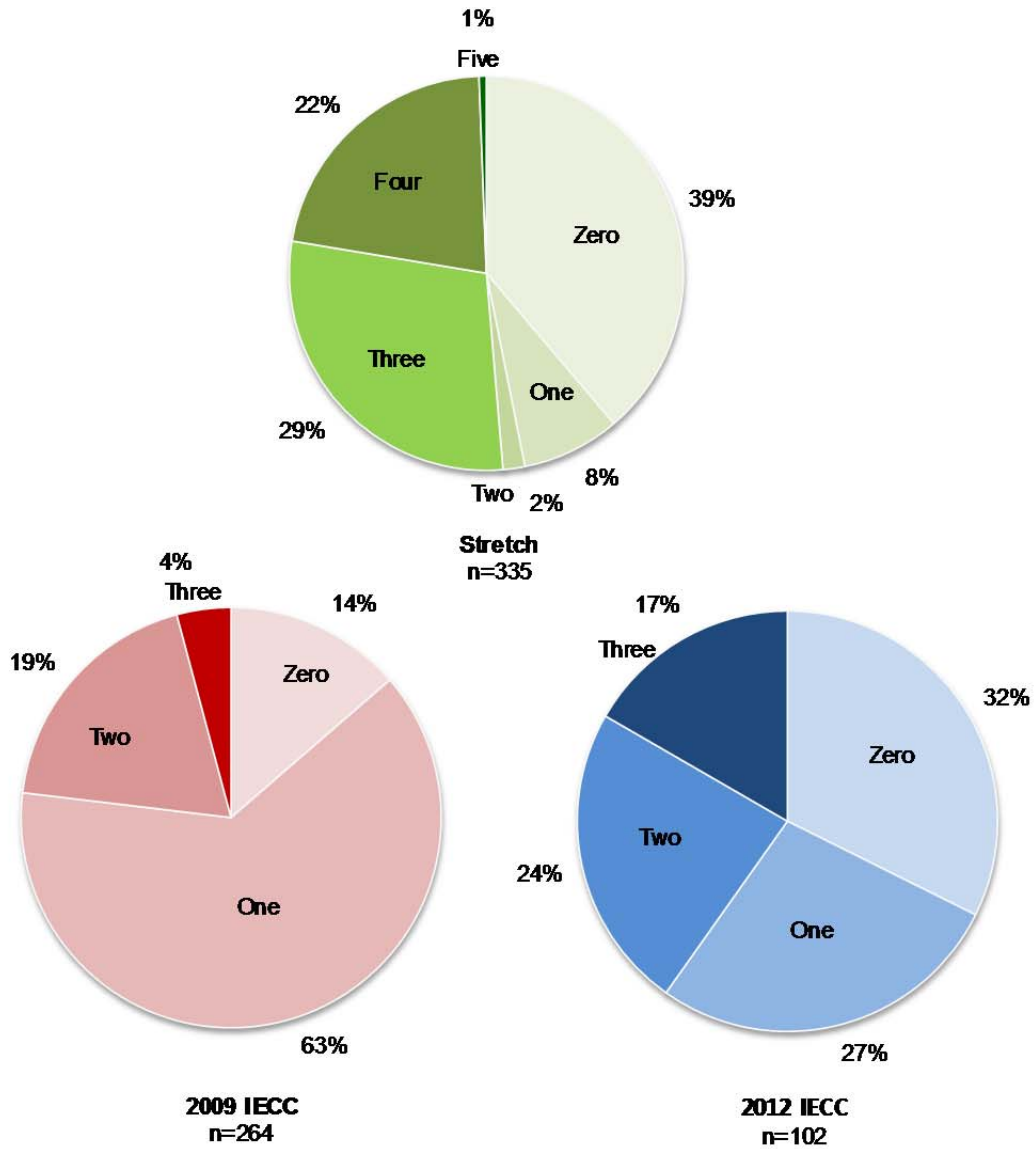


Figure 2 shows the number of requirements that were documented for the homes in our sample. These charts consider only the mandatory requirements presented in Table 1. As shown, none of the 2012 IECC homes had documentation for all four code requirements, 4% of 2009 IECC homes had documentation for all three requirements, and 1% of stretch code homes had documentation for all five requirements. Surprisingly, 32% of 2012 IECC homes, 14% of 2009 IECC homes, and 39% of stretch code homes did not have documentation for any of the requirements listed in Table 1.

Figure 2. Number of Code Requirements Documented by Code





1.1 CONCLUSIONS AND CONSIDERATIONS

NMR has identified the following conclusions and considerations based on our document review.

Conclusions

- None of the items considered in our review were documented for all homes
- Very few homes had documentation filed for all applicable requirements
- The documentation filed for homes varies widely by measure and by municipality
- Duct leakage testing, a mandatory requirement under both the 2009 and 2012 IECC, was documented for only 20% of homes built under the 2009 IECC and 27% of homes built under the 2012 IECC
- Air leakage testing, a mandatory requirement under the 2012 IECC, was documented for only 32% of homes built under the 2012 IECC
- REScheck checklists, intended to be populated by code officials, were found to be blank for all but one out of 237 homes where the checklist was present in the filed documentation
- Only 10% of homes built under the 2012 IECC, 12% of homes built under the 2009 IECC, and 12% of homes built under the stretch code had documentation showing that manual J calculations were used to calculate heating and cooling design loads
- Only 20% of stretch code homes had documentation showing that the ENERGY STAR thermal enclosure checklist was completed during construction.

Considerations

The results of this study could be used in conjunction with the results of the ongoing baseline study to inform future CCSI trainings. Specifically, the future CCSI trainings might focus on the measures listed below if the baseline study finds non-compliance to be commonplace.

- Duct leakage—a mandatory requirement under both the 2009 and 2012 IECC
- Air leakage—a mandatory requirement under the 2012 IECC
- Manual J calculations—a mandatory requirement under the 2009 IECC, 2012 IECC, and the stretch code.

These measures were all documented infrequently and as a result, it is possible that these tests and calculations are not being conducted for all homes. The information presented in this study could be used to help inform code officials of the importance of requiring documentation that verifies that these tests and calculations were conducted. It is reasonable to assume that compliance with these measures would increase if code officials began to require documented compliance on a more consistent basis.

2. INTRODUCTION

As part of the single-family compliance/baseline study, NMR is visiting building departments across the state of Massachusetts to document the energy code, compliance path, and contact information associated with new single-family homes built in various municipalities. This information is being used to develop a representative sample for the baseline on-site inspections.

In addition to the information collected for the baseline study, NMR took photos of all energy-related documentation available in the building departments for each of the homes investigated during our building department visits. For the purposes of this evaluation, NMR assembled documentation for homes in 52 different municipalities. We then carefully reviewed this information for insights that could be valuable to the CCSI and help inform future training efforts. NMR attempted to answer the following questions:

- Was REScheck documentation present?
 - If present, what compliance method was used?
 - If present, was a checklist filed along with the report? If yes, was the checklist populated?
- Was documentation filed that verified a blower door test was conducted?
- Was documentation filed that verified a duct blaster test was conducted?
- Was there any documented proof that code officials verified the insulation values listed in the REScheck documents?
- Was a HERS score documented? If so, what documentation was filed to show the HERS score?
- Was an ENERGY STAR thermal enclosure checklist document present?
- Was a prescriptive code compliance checklist filed?
- Was there any documentation that suggests a Manual J assessment was conducted?

2.1 SAMPLE OF TOWNS

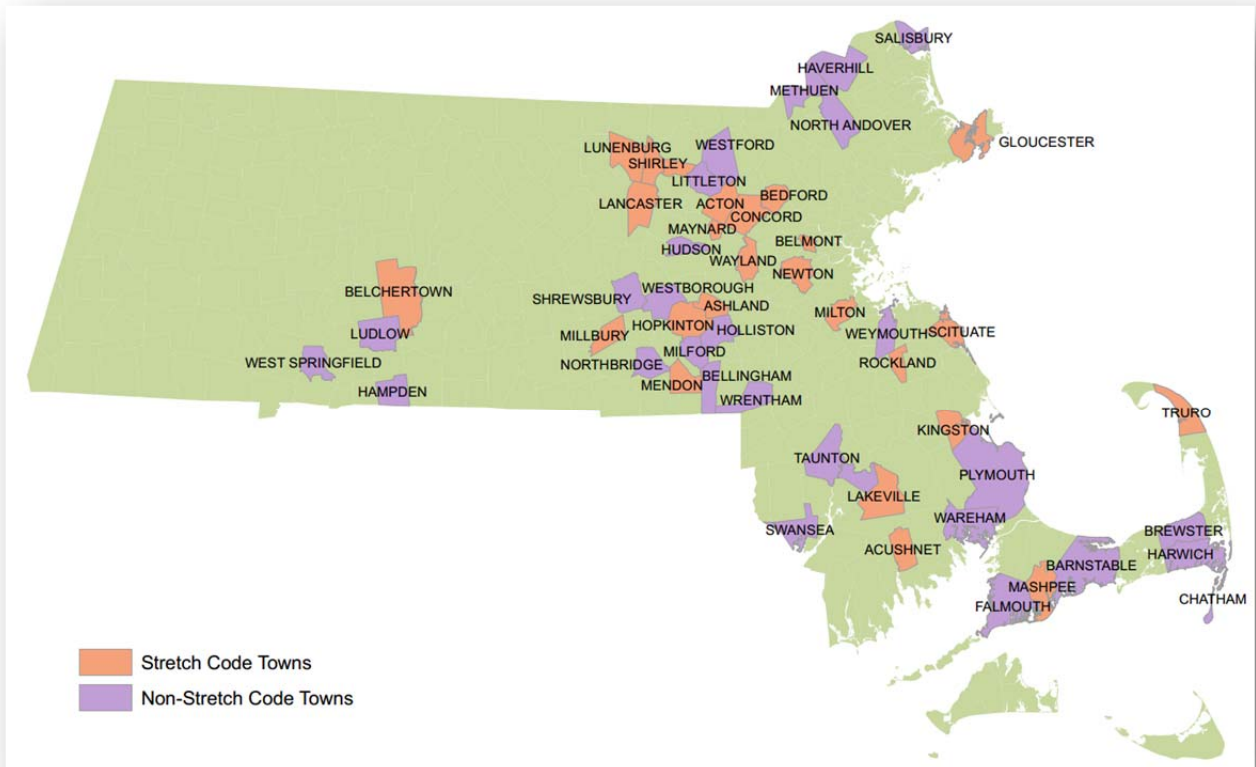
As part of the baseline study the Team, in conjunction with the study's working group, decided to use a cluster sampling approach. Cluster sampling is a sampling technique where the entire population is divided into groups, or clusters, and a random sample of these clusters is selected. For the Single-family Compliance/Baseline study the clusters are towns. In the second stage of sampling, a sample of homes is randomly selected from each cluster/town.

We developed two individual cluster samples of 25 towns each—one sample of non-stretch code towns and one sample of stretch code towns. Each cluster sample was provided with ten supplemental towns that the Team could draw sample from if necessary. Accounting for the supplemental towns, our overall sample for the baseline will include a minimum of 50

towns and a maximum of 70; both the stretch code and non-stretch code clusters will include between 25 and 35 towns. The non-stretch code cluster sample covers homes built at the end of the 2009 IECC cycle and homes built at the beginning of the 2012 IECC cycle. Our sample of documents is heavily weighted towards stretch code homes due to the fact that our sample of towns is evenly split between stretch code and non-stretch code and the non-stretch code towns represent both the 2009 and 2012 IECC samples while stretch code towns only represent stretch code homes.

Figure 3 displays the distribution of municipalities that were included in our document review.

Figure 3: Distribution of Building Departments Visited



Of the 52 towns included in the document review, 26 included at least one stretch code home, 25 included at least one 2009 IECC home, and 23 included at least one 2012 IECC home. Stretch code was adopted and implemented by individual towns at various points in time, and as a result, several sampled towns have a mix of homes permitted under stretch code and 2009 or 2012 IECC. For example, of the 21 sampled homes from Acushnet (a stretch code town in our baseline study cluster sample approach), two were permitted under 2009 IECC. Meanwhile, one of the 51 Holliston homes and one of the four Westford homes (non-stretch code towns in our baseline study cluster sample approach) was permitted under stretch code.



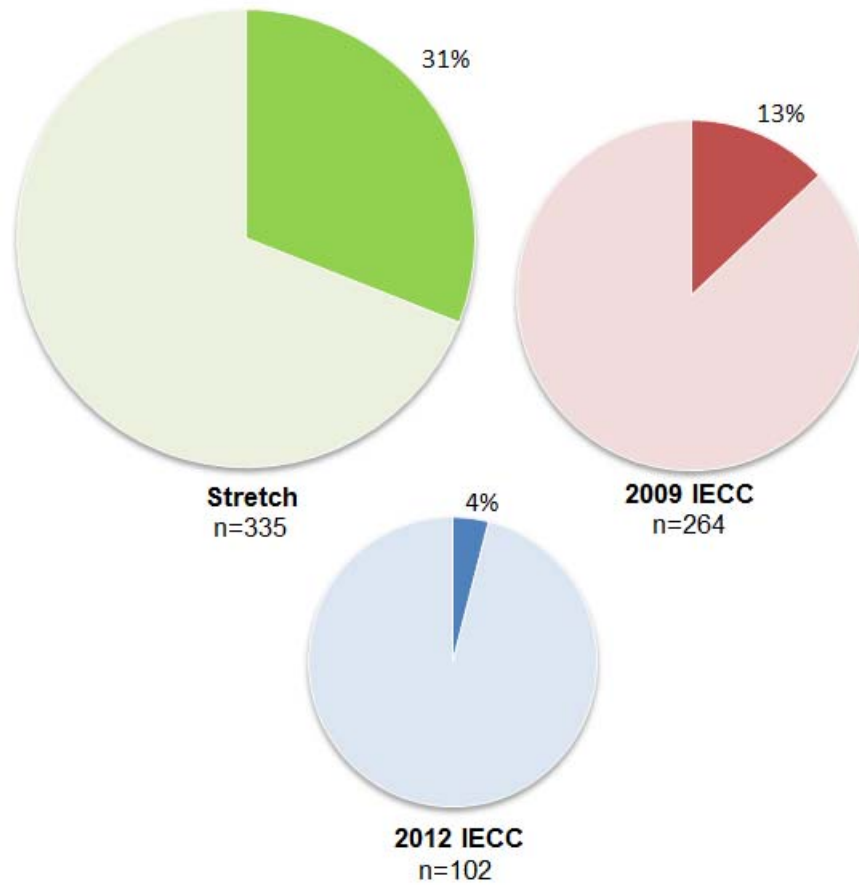
In total, we reviewed documentation for 389 homes. Two of the 52 building departments we visited were unable to provide us with the documentation for any of the homes we requested, while another town in our sample only included homes built under the 2007 IECC code with Massachusetts amendments. Twelve of the homes we sampled did not appear to have been completed yet, and were thus excluded from the final sample. We only reviewed the documentation for one home per development in order to keep our data requests manageable for the building department staff that assisted in our research. For developments, we assumed that all of the homes have the same documentation and were permitted under the same code as the one home that was reviewed. Using this assumption, our overall sample size increases to 701 homes as displayed in Table 2. A table breaking this information out by town is provided in [Appendix A](#). The remainder of this report presents results using the extrapolated sample size of 701 homes as we believe this is more representative of the overall market. The number of homes sampled by town ranged from 1 to 86, with an average of 14 homes per town.

Table 2: Energy Code under Which Homes Were Permitted

Homes Reviewed			
Code	Count of Homes	Percent of Homes	Count of Towns
Stretch	172	44%	26
IECC 2009	127	33%	25
IECC 2012	74	19%	23
IECC 2007	4	<1%	1
Home not complete	12	<1%	10
Total	389	100%	52
Final Sample Including Extrapolation to Homes in Developments			
Code	Count of Homes	Percent of Homes	Count of Towns
Stretch	335	48%	26
IECC 2009	264	38%	24
IECC 2012	102	15%	21
Total	701	100%	49

We cross referenced the 701 homes in our sample with homes that went through the Massachusetts Residential New Construction (RNC) program. As shown in Figure 4, just under one-third (31%) of the homes permitted under stretch code went through the RNC program, while 13% of homes permitted under 2009 IECC and 4% of homes permitted under 2012 IECC went through the program. Please note that the darker shaded areas of the pie charts in Figure 4 represent the percentages of homes that went through the program, while the sample sizes below the figures represent the number of homes in our sample that were permitted under the different codes. Similar figures, presented throughout the remainder of the report, use a similar format where darker shaded pie areas indicate the highlighted results in the text. The higher rate of RNC program participation among stretch code homes is not surprising given the overlap between stretch code and program requirements.

Figure 4. Percent of RNC Program Homes



3. SUMMARY OF CODE REQUIREMENTS

During the planning for this study, the Team strategically identified energy-related requirements that would, in theory, require documentation at building departments to prove compliance with the energy code. This section details the document-related code requirements associated with each of the codes assessed as part of this study.

3.1 STRETCH CODE REQUIREMENTS

The stretch code requires that homes undergo third party verification and meet a certain HERS index requirement based on the size of the home. Specifically, the stretch code requires the following HERS index for new single-family homes:

- HERS index of 65 or less for homes that are 3,000 ft² or larger
- HERS index of 70 or less for homes that are less than 3,000 ft²

As such, it is reasonable to expect documentation of the HERS index to be filed at the building department for stretch code homes. Similarly, the stretch code requires that homes meet the mandatory requirements of the base energy code (2009 IECC). The 2009 IECC includes the following requirements that we would expect to be associated with documentation at the building department.

- Heating and cooling equipment sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J
- Duct tightness verified via post-construction or rough-in duct leakage testing

The 2009 IECC does not require that homes undergo air leakage testing (though it is an option), but this is a standard requirement of a HERS rating. Given this, the Team expects building departments to require some form of air leakage testing documentation for stretch code homes.

Lastly, the stretch code requires that builders and HERS raters complete the ENERGY STAR homes thermal enclosure checklist and the Team anticipates that building departments should require verification that this checklist was completed.

3.2 2009 IECC CODE REQUIREMENTS

The 2009 IECC requires that homes meet a series of insulation requirements using either a prescriptive path, a UA trade-off approach, or a performance path. If a prescriptive compliance path is used, then it may be associated with a prescriptive checklist of the insulation values installed in the home that is filed at the building department. If the UA trade-off approach or a performance approach is used, then some form of energy model documentation (typically a REScheck file or a REM/Rate file) should be filed at the building department to show: 1) the insulation values that were installed at the site, and 2) whether or not these values comply with the code.

As detailed in the stretch code section above, the 2009 IECC includes the following requirements that we would expect would be associated with documentation at the building department.



- Heating and cooling equipment sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J
- Duct tightness verified via post-construction or rough-in duct leakage testing

The 2009 IECC does not require air leakage testing, but it is an option. If a builder selected the testing option for the air leakage requirement, then it should be associated with documentation at the building department.

3.3 2012 IECC CODE REQUIREMENTS

The 2012 IECC requirements are very similar to the 2009 IECC requirements that are detailed above. The only major difference in terms of documentation requirements is that air leakage testing is required at all homes under the 2012 IECC. Given that, we expect to see documentation of air leakage testing for all homes that were permitted under the 2012 IECC. Otherwise, the following requirements that have been mentioned previously should also be associated with some form of documentation:

- Insulation requirements
 - Documentation may vary depending on the compliance path (prescriptive, UA trade-off, or performance)
- Manual J documentation
- Duct leakage testing

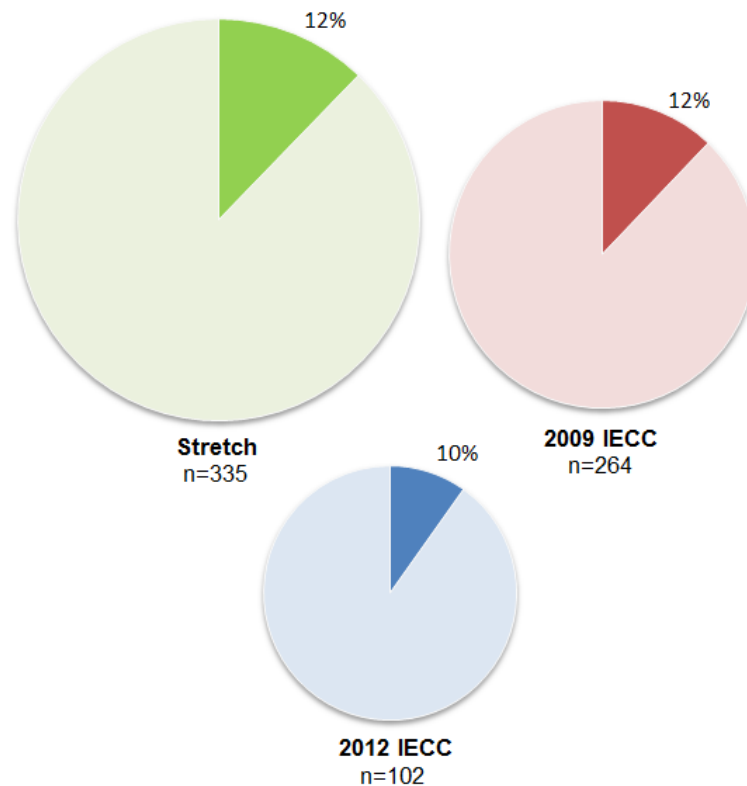
4. FINDINGS

In this section, we present findings from our review of the documents filed at building departments. We begin by looking at each individual energy-related requirement, and end with combinations of requirements for each code.

4.1 MANUAL J

As noted earlier in the summary of code requirements, 2009 IECC, 2012 IECC, and the stretch code require heating and cooling equipment to be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J. Where we found documentation that this requirement had been met, it usually took the form of Manual J calculations created using Wrightsoft or Elite software packages. Despite being required by all three codes, the Manual J requirement was documented infrequently. Only 12% of the stretch code homes, 12% of the 2009 IECC homes, and 10% of the 2012 IECC homes we reviewed had documentation on file that heating and cooling equipment had been sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J.

Figure 5. Documentation of Manual J Calculations by Code

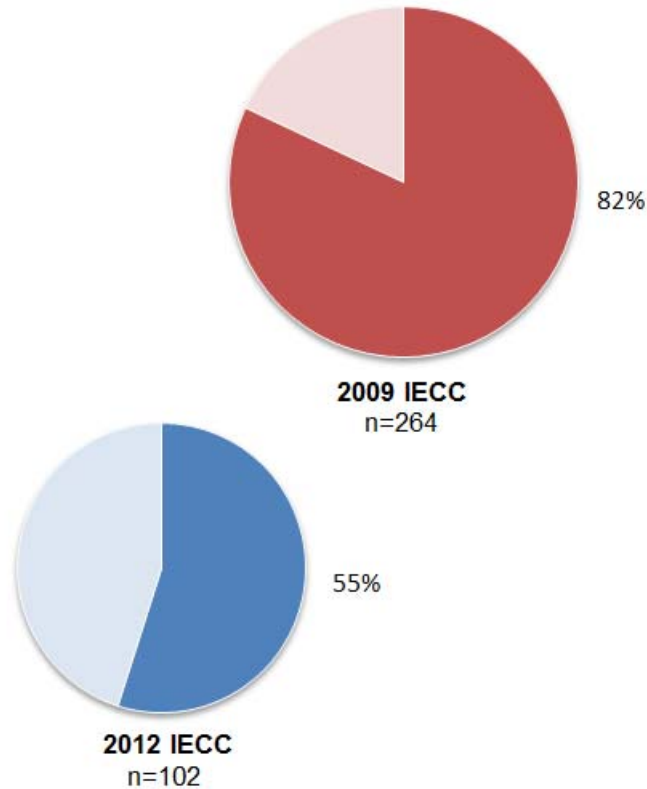


4.2 INSULATION REQUIREMENTS

The 2009 and 2012 IECC require that homes meet a series of insulation requirements using either a prescriptive path, a UA trade-off approach, or a performance path. Depending on the

compliance path used, documentation that this requirement had been satisfied took the form of a prescriptive checklist, a REScheck file, or a home energy rating certificate (from REM/Rate). Over four-fifths (82%) of homes permitted under 2009 IECC had documentation on file showing the insulation values installed, while over one-half (55%) of homes permitted under 2012 IECC had this documentation on file (Figure 6).

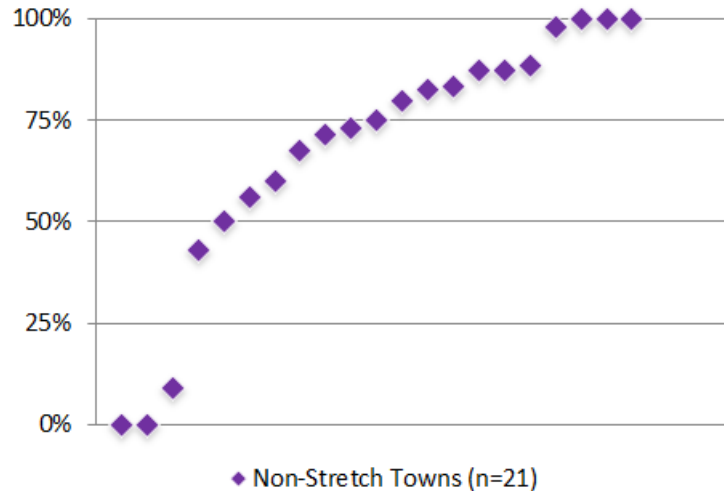
Figure 6. Documentation of Insulation Requirements by Code



REScheck files were the most common type of documentation for the insulation requirements. When printing a REScheck compliance certificate, it is accompanied by a checklist that is meant to be populated by code officials when they verify the insulation values shown in the builder-submitted REScheck certificate. Over three-quarters (78%) of the REScheck certifications we reviewed were accompanied by REScheck Checklists. Of the 237 REScheck checklists we reviewed, only one had actually been filled in.

Figure 7 displays the percentage of homes permitted under 2009 and 2012 IECC per town with documentation on file showing the insulation values installed. Only towns with at least five homes permitted under 2009 and 2012 IECC were included in Figure 7. The percentage of homes with documentation on file showing the insulation values installed ranged from 0% (two towns) to 100% (three towns). For most towns, documentation of insulation values was present for at least 50% of homes permitted under 2009 and 2012 IECC.

Figure 7. Percent of Homes with Insulation Documentation by Town



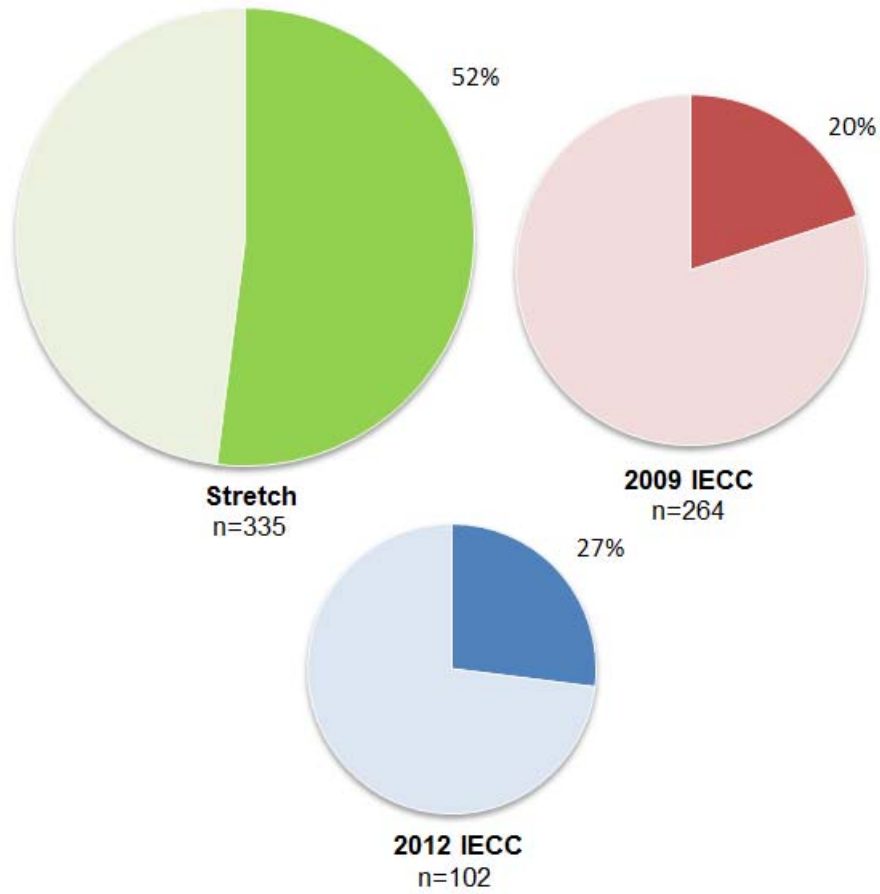
4.3 DUCT LEAKAGE TESTING

The 2009 IECC, 2012 IECC, and stretch codes require duct tightness be verified via post-construction or rough-in duct leakage testing. Where we found documentation that this requirement had been met, it took the form of either a duct leakage testing form submitted by the company that performed the duct leakage test, or a confirmed HERS certificate¹ showing the measured duct leakage values. Whenever we saw documentation that a home did *not* have ducts, we noted that no duct test would be required at that home. We identified three homes (all permitted under stretch code) with documentation that no ducts were present. In the absence of documentation to the contrary, we assumed that ducts were present. Figure 8 shows that homes permitted under the stretch code were the most likely to have documentation of duct leakage testing on file (52%), followed by homes permitted under 2012 IECC (27%), and homes permitted under 2009 IECC (20%). It should be noted that documentation of the presence or absence of ducts was inconsistent across the homes we reviewed, and our assumption that ducts were present in the absence of documentation to the contrary would have the effect of deflating the percentages in Figure 8 if a number of those homes were in fact built without ducts.²

¹ The Team also identified preliminary (based on plans) HERS certificates, but we did not consider these to be documentation of diagnostic test results.

² Our current baseline study efforts suggest it is reasonable to assume that ducts are present in the absence of more accurate information.

Figure 8. Documentation of Duct Leakage Testing by Code

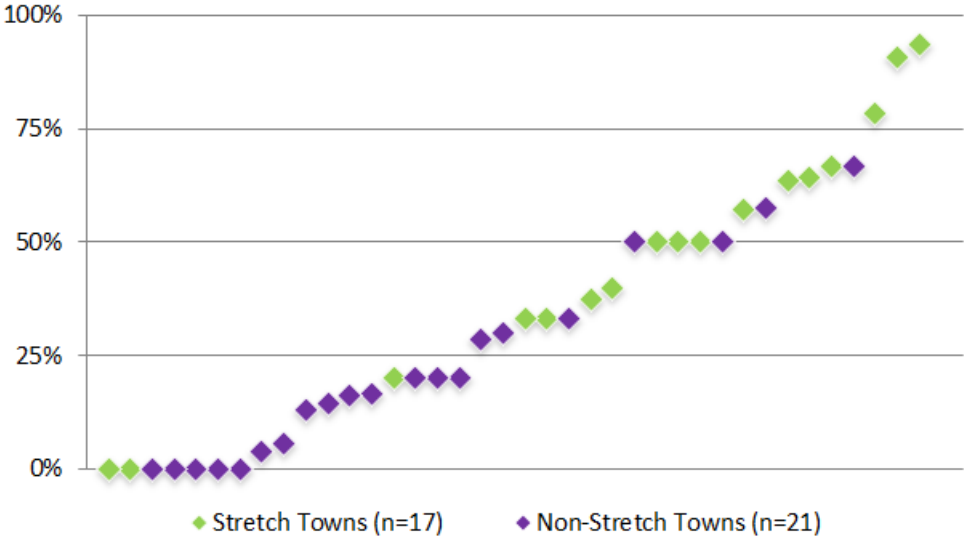


These results suggest that some homes may not be undergoing duct leakage testing during construction, particularly in non-stretch code towns. If the single-family compliance/baseline study finds non-compliance with the duct leakage requirements, then this may be a specific area of focus for the CCSI moving forward.



Figure 9 displays the percentage of homes per town with documentation of duct leakage testing on file for the 38 towns with at least 5 homes. Zero percent of the homes in seven towns had documentation of duct testing on file, including two stretch code towns. Stretch code towns were more likely than non-stretch code towns to have documentation of duct testing on file for at least one-half of the homes permitted within their jurisdiction.

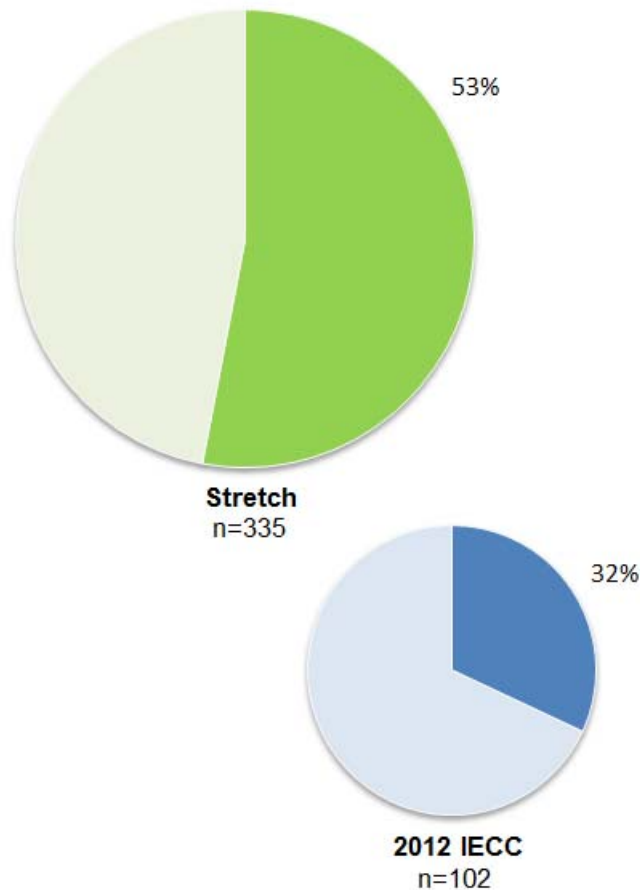
Figure 9. Percent of Homes with Documentation of Duct Testing by Town



4.4 AIR LEAKAGE TESTING

Air leakage testing is required for homes permitted under 2012 IECC. Additionally, air leakage testing is a component of a HERS rating, which is required for homes permitted under the stretch code. Where we found documentation that this requirement had been met, it took the form of either a blower door testing form, submitted by the company that performed the blower door test, or a confirmed HERS certificate. Just over one-half (53%) of homes permitted under the stretch code had documentation of a blower door test on file (Figure 10). Just under one-third (32%) of homes permitted under 2012 IECC had documentation of a blower door test on file.

Figure 10. Documentation of Air Leakage Testing by Code



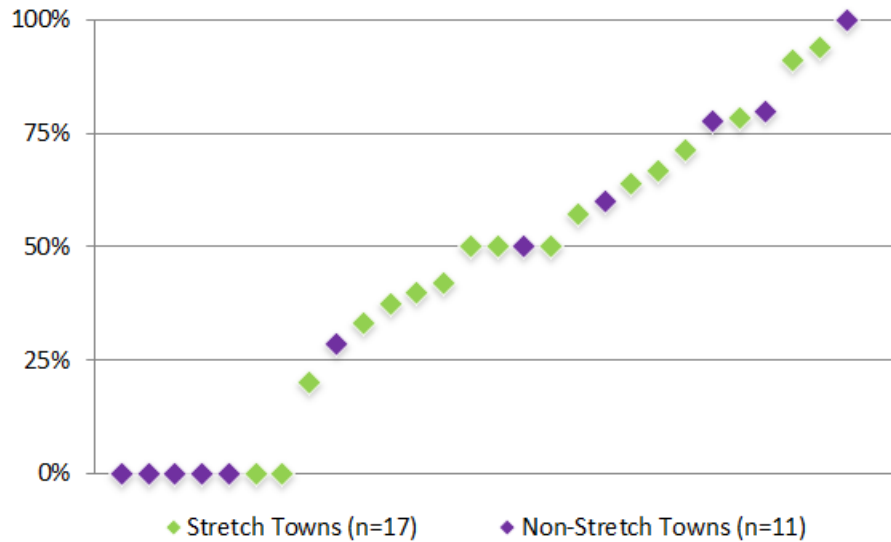
As with duct leakage documentation, these results suggest that some homes may not be receiving blower door tests during the construction process, particularly in homes built under the 2012 IECC. Air leakage testing is a new mandatory requirement for the 2012 IECC and it is possible that the market is a little slow to incorporate blower door tests for all homes. Again, if the single-family compliance baseline study finds non-compliance with air leakage requirements, then this may be a particular area of focus for the CCSI moving forward.

Figure 11 displays the percentage of homes permitted under 2012 IECC or stretch code per town with documentation of air leakage testing on file. Only towns with at least five homes



permitted under the 2012 IECC and stretch codes were included in Figure 11. None of the homes in seven towns had documentation of air leakage testing on file, including two stretch code towns. The percentage of homes with documentation of air leakage testing ranged from 20% (1 of 5 homes) to 100% among the remaining towns. Although homes permitted under the stretch code were more likely to have documentation of air leakage testing on file, the town with this documentation on file for 100% of homes was a non-stretch code town.

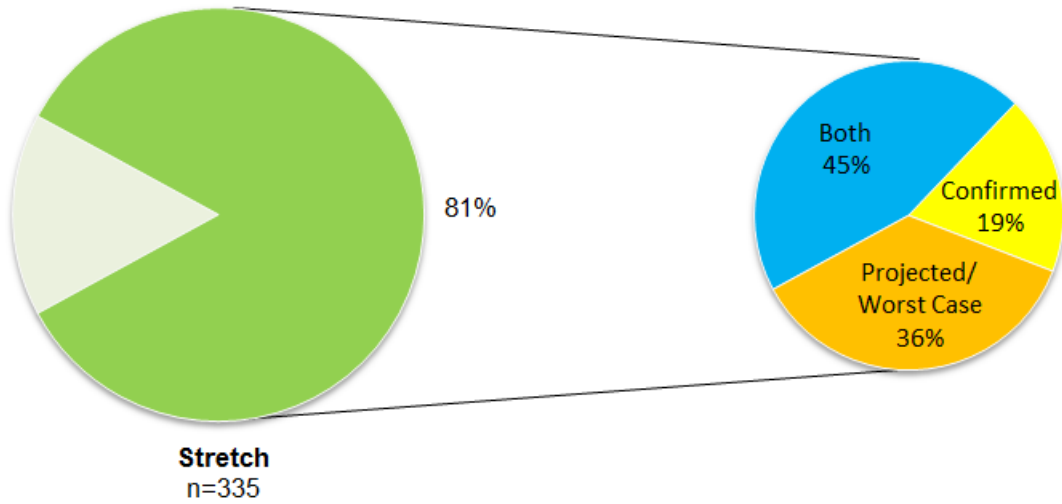
Figure 11. Percent of Homes with Documentation of Air Leakage Testing by Town



4.5 HERS RATING

The stretch code requires that homes undergo third party verification and achieve a certain HERS score. We found that HERS ratings were filed using a variety of documents, the most common of which was a HERS certificate. We encountered several different types of HERS certificates in our review, including projected and worst case HERS certificates based on plans, and confirmed HERS certificates based on actual inspections. Sometimes a projected HERS rating was documented on an ENERGY STAR Verification Summary or in an affidavit signed by the architect or HERS rater stating that the home should meet stretch code requirements. Figure 12 displays the types of HERS rating documentation we found on file for homes permitted under stretch code. Over four-fifths (81%) of the homes permitted under the stretch code had some type of a HERS rating on file. Over one-third (36%) of the stretch code homes with HERS ratings on file had a projected or worst case HERS rating documented, while 19% had a confirmed HERS certificate on file, and 45% had both a projected and a confirmed HERS rating on file.

Figure 12. Documentation of Any HERS Rating



Projected and worst case HERS ratings are based on plans and not inspections of the actual home. Stretch code homes with only a projected or worst case HERS rating on file have been excluded from Figure 13, which shows that just over one-half (51%) of homes permitted under the stretch code had a confirmed HERS certificate on file.

Figure 13. Documentation of Confirmed HERS Rating

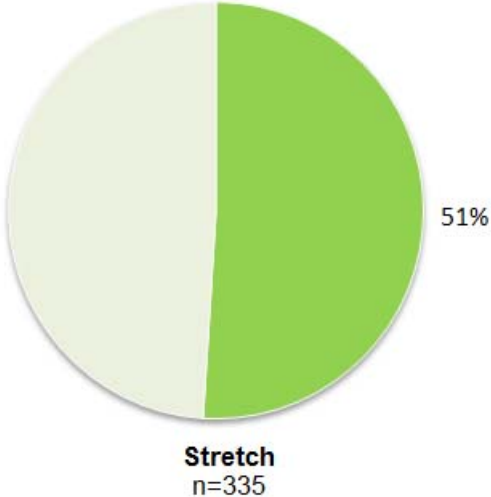
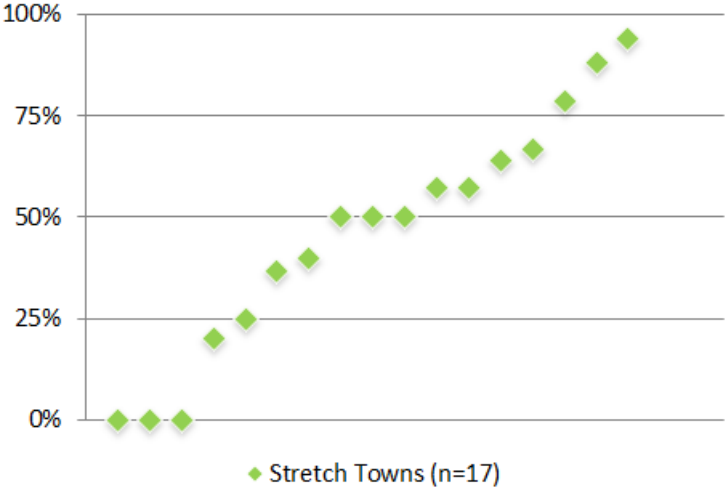


Figure 14 displays the percentage of homes with confirmed HERS ratings on file for each stretch code town with at least five homes. None of the homes in three stretch code towns had a confirmed HERS rating on file. The percentage of homes with a confirmed HERS rating on file for the remaining 14 towns ranged from 20% (1 out of 5 homes) to 94% (16 out of 17 homes).

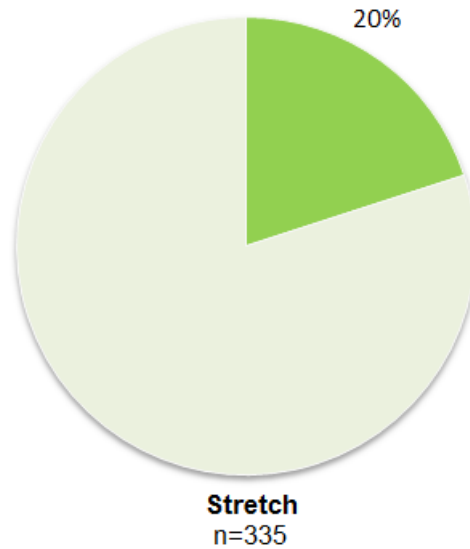
Figure 14. Percent of Homes with Confirmed HERS Rating Documented by Town



4.6 ENERGY STAR HOMES THERMAL ENCLOSURE CHECKLIST

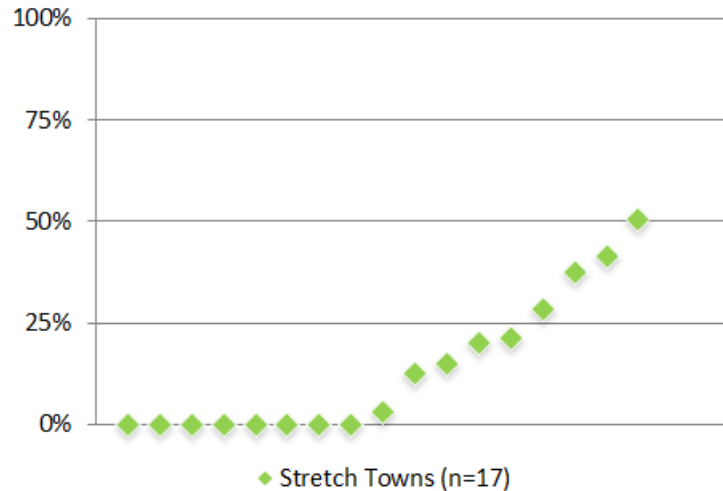
Another stretch code requirement is that builders and HERS raters complete the ENERGY STAR Homes thermal enclosure checklist. However, an ENERGY STAR Homes thermal enclosure checklist was on file for only one-fifth (20%) of the stretch code homes we reviewed.

Figure 15. Documentation of ENERGY STAR Homes Thermal Enclosure Checklist



Eight of the 17 stretch code towns with at least five homes did not have an ENERGY STAR Homes thermal enclosure checklist on file for any homes permitted in their jurisdiction. The percentage of homes with these checklists on file ranged from 3% (1 of 34 homes) to 51% (44 of 86 homes) for the remaining stretch code towns.

Figure 16. Percent of Homes with ENERGY STAR Homes Thermal Enclosure Checklist by Town



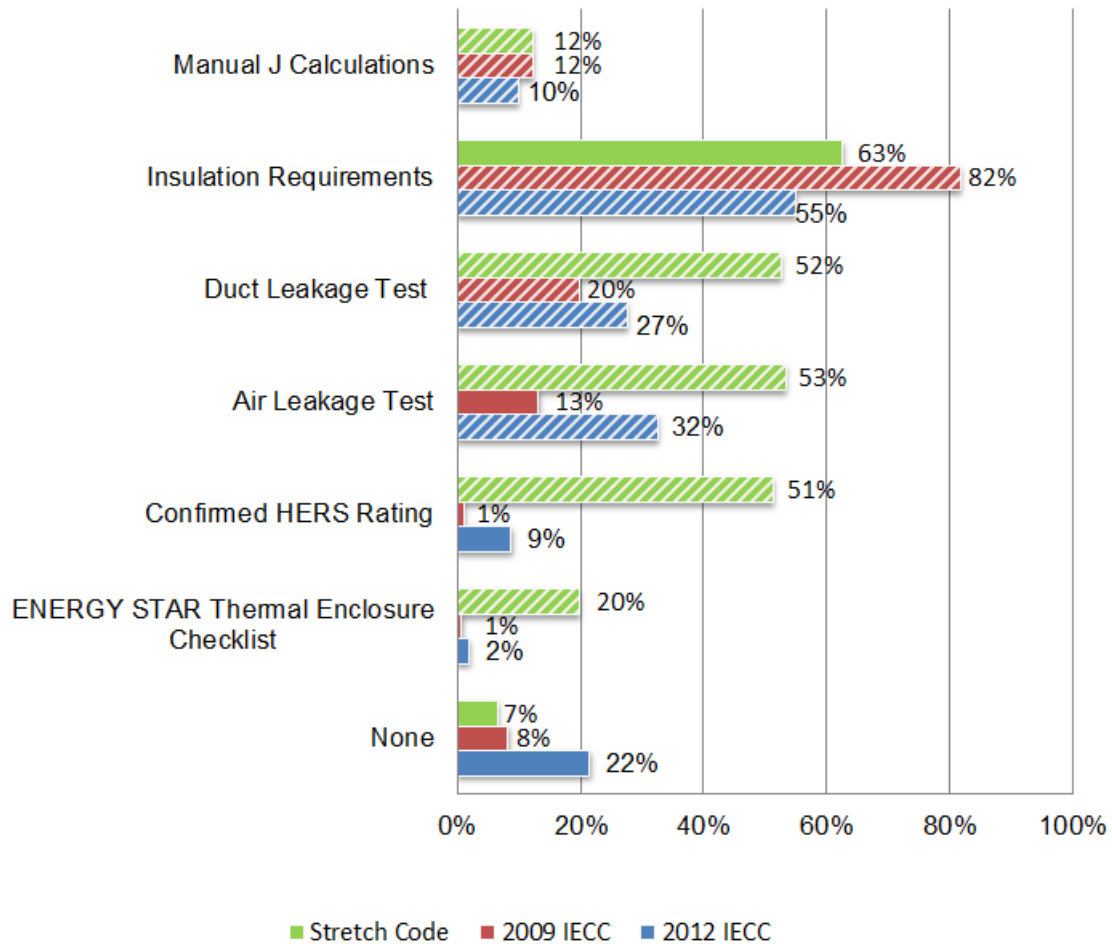
4.7 SUMMARY OF ENERGY-RELATED DOCUMENTATION

Figure 17 provides a summary of the documentation of energy-related requirements we found in our reviews of the different codes under which homes were permitted. Unlike in the previous sections that look at each requirement individually, Figure 17

displays the percentage of homes with documentation of the requirement regardless of whether it was required by the code the homes were permitted under. Striped bars indicate that the documentation is required under the various code versions. For example, a HERS rating is only required by the stretch code. However, 9% of homes permitted under 2012 IECC and 1% of homes permitted under 2009 IECC had a confirmed HERS rating on file; these are generally homes that comply with the code using the performance path. In addition, air leakage testing is not required by 2009 IECC; however, we found documentation of air leakage tests for 13% of homes permitted under 2009 IECC. Only the stretch code requires the use of the ENERGY STAR Homes thermal enclosure checklist. However, 1% of the 2009 IECC and 2% of the 2012 IECC homes had an ENERGY STAR Homes thermal enclosure checklist on file.³ Depending on the code under which homes were permitted, as many as 7% to 22% did not have documentation of any of the items listed in Figure 17. A table further breaking this information out by Residential New Construction program participation is provided in [Appendix C](#).

Figure 17. Summary of Energy-Related Documentation by Code

³ We cross referenced the homes we reviewed with homes that went through the RNC program, and determined that these 2009 IECC and 2012 IECC homes with ENERGY STAR Homes thermal enclosure checklists on file did not participate in the program.



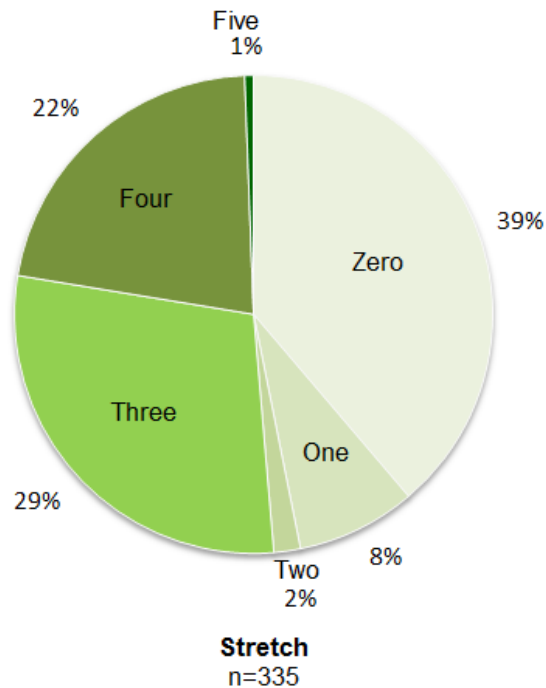
4.8 STRETCH CODE

Homes permitted under the stretch code require the following:

- Heating and cooling equipment sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J
- Duct tightness verified via post-construction or rough-in duct leakage testing
- HERS rating assigned by a third party
 - Air leakage testing (standard requirement of a HERS rating)
- Completion of ENERGY STAR Homes thermal enclosure checklist

Figure 18 displays how many of these five requirements were documented for the 335 stretch code homes in our sample.⁴ Only 1% of the homes permitted under stretch code had documentation of all five of these requirements on file. Just over one-fifth (22%) of stretch code homes had four out of five requirements documented, just under one-third (29%) had three out of five requirements documented, and 10% had only one or two out of five requirements documented. Over one-third (39%) stretch code homes did not have documentation on file for any of these five requirements. Among these five requirements, stretch code homes were most likely to have air leakage testing documented and least likely to have manual J calculations documented.

Figure 18. Number of Stretch Code Requirements Documented



⁴ Although the air leakage testing is part of the HERS rating and is not necessarily an additional, separate requirement, we treat it as its own item here because it can be documented separately from a confirmed HERS rating. If a home had a confirmed HERS rating on file, we automatically recorded that air leakage testing had been conducted. However, it is possible for a home to have no HERS rating or only a projected HERS rating documented, but also have an air leakage testing form on file. In these cases we recorded that an air leakage test had been conducted, but not a confirmed HERS rating.

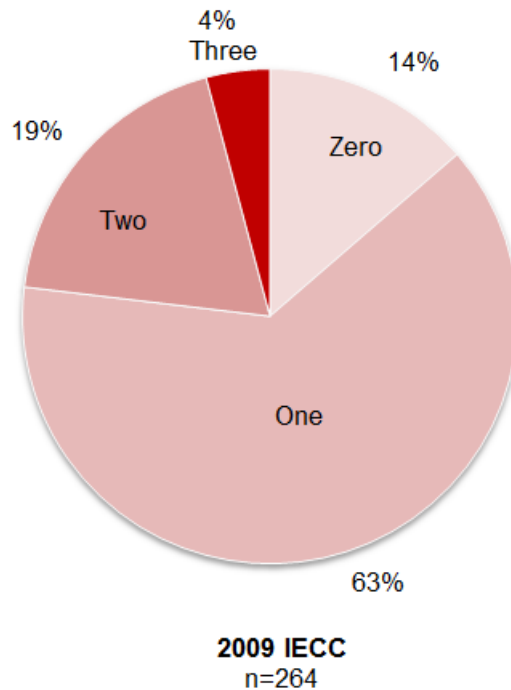
4.9 2009 IECC

Homes permitted under 2009 IECC require:

- Heating and cooling equipment sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J
- Duct tightness verified via post-construction or rough-in duct leakage testing
- A series of insulation requirements

Four percent of homes permitted under 2009 IECC had documentation of all three of these requirements on file (Figure 19). Just under one-fifth (19%) of homes permitted under 2009 IECC had two of three requirements documented, while over one-half (63%) had only one of three requirements documented. Over one in ten (14%) homes permitted under 2009 IECC did not have documentation on file for any of these three requirements. Homes permitted under 2009 IECC were most likely to have insulation requirements documented and least likely to have manual J calculations documented.

Figure 19. Number of 2009 IECC Requirements Documented



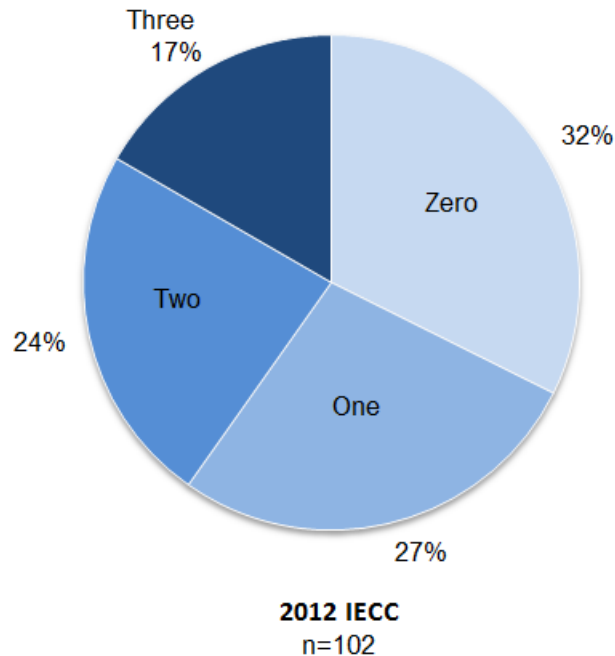
4.10 2012 IECC

Homes permitted under 2012 IECC require:

- Heating and cooling equipment sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J
- Duct tightness verified via post-construction or rough-in duct leakage testing
- A series of insulation requirements
- Air leakage testing

None of the 102 homes permitted under 2012 IECC had documentation of all four of these requirements on file. As shown in Figure 20, less than one-fifth (17%) of homes permitted under 2012 IECC had three of four requirements documented, about one-quarter (24%) had two of four requirements documented, and 27% had one of four requirements documented. Around one-third (32%) of homes permitted under 2012 IECC did not have any of the four requirements documented. Like homes permitted under 2009 IECC, homes permitted under 2012 IECC were most likely to have insulation requirements documented and least likely to have manual J calculations documented.

Figure 20. Number of 2012 IECC Requirements Documented



5. CONCLUSIONS

Energy-related code requirements are not consistently being documented at building departments. None of the energy-related items including Manual J calculations, insulation levels, duct leakage testing, air leakage testing, HERS ratings, or the use of the ENERGY STAR Thermal Enclosure checklist was documented 100% of the time where required by code. The percentage of requirements documented ranged from a low of 10% of homes permitted under 2012 IECC with Manual J calculations documented to a high of 82% of homes permitted under 2009 IECC with insulation levels documented.

Very few homes had documentation of all energy-related code requirements. Only 4% of homes permitted under 2009 IECC and 1% of stretch code homes had documentation on file for all energy-related requirements. None of the homes permitted under 2012 IECC had all energy-related requirements documented. Most homes had documentation of at least one but not all of the energy-related items required by the code under which they were permitted.

Much variation exists between and within towns in terms of energy-related code requirement documentation. Very few towns had a required document on file for 100% of homes. Some towns had no homes with a required document on file, but it was more common for between 1% and 99% of homes in a given town to have a particular document on file.

Duct leakage and air leakage documentation is lacking, particularly in non-stretch code municipalities. Only 20% of homes built under the 2009 IECC and 27% of homes built under the 2012 IECC had documentation showing duct leakage testing took place (a mandatory requirement under both). Even stretch code homes only had documentation of duct leakage testing for 52% of homes. Air leakage testing is a mandatory requirement under both the 2012 IECC and stretch code, yet only 32% of homes permitted under 2012 and 53% of stretch code homes had documentation verifying blower door tests took place. These results suggest that some homes may not be receiving duct blaster and/or blower door tests as part of the construction process. If the single-family compliance/baseline study finds non-compliance for these measures, then this may be an area of focus for the CCSI moving forward.

Code officials are not using REScheck checklists. Many builders use REScheck to show compliance with the energy code. When printing a REScheck compliance certificate it is accompanied by a checklist that is meant to be populated by code officials when they verify the insulation values shown in the builder-submitted REScheck certificate. The checklists cover an array of mandatory requirements for code officials to verify during their onsite inspections. Of the 237 REScheck files reviewed, only one contained a populated checklist. These findings suggest that: 1) code officials may not be verifying the insulation levels indicated on REScheck certificates, and 2) code officials may not be confirming that the mandatory requirements listed on the checklist are in compliance.

There is very little documentation that Manual J calculations are being conducted. All three of the codes considered in this study require that heating and cooling systems are sized using Manual J. We found documentation of manual J calculations in 10% of homes built under the 2012 IECC and 12% of homes build under the stretch code or 2009 IECC.



Stretch code homes rarely have documentation filed showing that the ENERGY STAR homes thermal enclosure checklist was completed. Only 20% of the stretch code homes included in our analysis had documentation that the thermal enclosure checklist was completed.

APPENDIX A: HOMES PER TOWN BY CODE

Table 3 displays the number of homes sampled per town by the code under which the homes were permitted. We only reviewed one home per development in order to keep our data requests manageable for the building department staff that assisted in our research. For developments, we assumed that all of the homes have the same documentation and were permitted under the same code as the one home that was reviewed.

In Table 3, columns labeled “Rev” include counts of homes for which we reviewed all energy-related documentation filed at the building department, including one home among each development. The columns labeled “+Dev” in Table 3 include counts of homes in developments for which we did not review documentation filed at the building department, but instead assumed to be the same as the one home per development we reviewed. We reviewed a total of 172 stretch code homes, 127 2009 IECC homes, and 74 2012 IECC homes. Our assumption regarding development homes increases the stretch code sample size by 163 homes (to 335), 2009 IECC by 137 (to 264), and 2012 IECC by 28 (to 102). In Table 3 there are three towns that are listed twice: Acushnet, Holliston, and Westford. These are the only three towns in our sample that include both homes permitted under stretch code and homes permitted under another code (2009 IECC, 2012 IECC, or both). Note that although Hampden, Milford, and Chatham were selected during the sampling process, these towns do not appear in Table 3. All of the sampled homes in Hampden were permitted under 2007 IECC and were therefore excluded from our analysis. Staff at the Milford and Chatham building departments were unable to provide us with the documentation for the homes we requested.



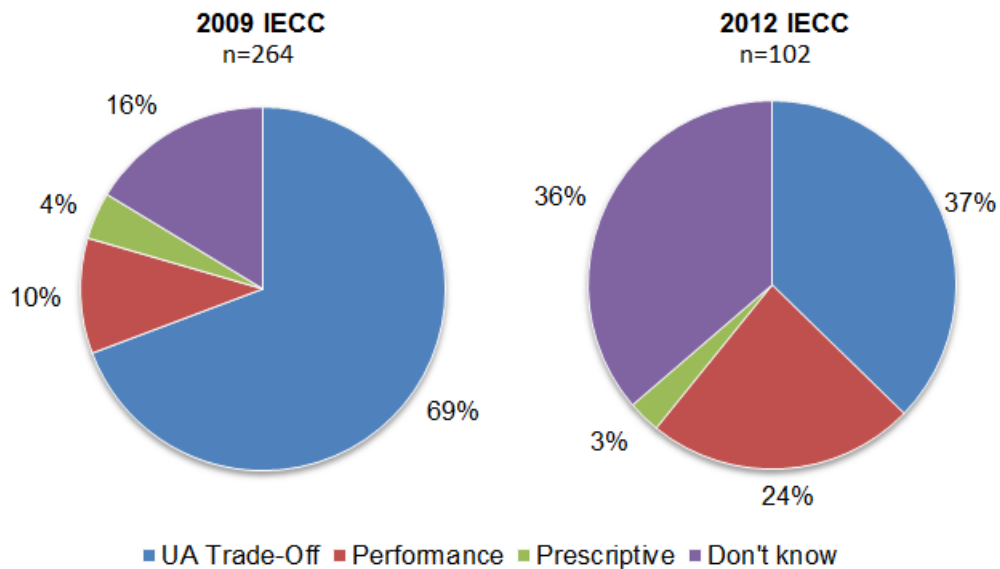
Table 3. Sampled Homes by Town

Town	Stretch		Town	2009 IECC		2012 IECC	
	Rev	+Dev		Rev	+Dev	Rev	+Dev
Acton	2	13	Barnstable	11	4	3	6
Ashland	4	30	Bellingham	5	1	10	
Ayer	3		Brewster	6			
Bedford	20		Falmouth	12	11	4	4
Belchertown	8		Harwich	3	1	1	
Belmont	13	1	Haverhill	3		5	
Concord	9	3	Hudson	10	17	1	
Gloucester	8		Littleton	13	1	7	3
Hopkinton	8		Ludlow	4	5	2	1
Kingston	4	6	Lunenburg	3	8		
Lakeville	10	4	Methuen	2		3	
Lancaster	2		North Andover	3		3	
Mashpee	18	68	Northbridge			1	
Maynard	5	12	Plymouth	6	25	1	9
Mendon	3		Salisbury			4	
Millbury	1		Shrewsbury	6	13	5	2
Milton	7		Swansea	4		1	
Newton	4	1	Taunton	2	3	4	1
Rockland	2		Wareham	9	6	6	2
Scituate	4		West Springfield	3		2	
Shirley	1		Westborough	3			
Truro	5	1	Weymouth	2		5	
Wayland	13	21	Wrentham	7		3	
Acushnet	16	3	Acushnet	1	1		
Holliston	1		Holliston	6	41	3	
Westford	1		Westford	3			
Total	172	163	Total	127	137	74	28

APPENDIX B: 2009 AND 2012 IECC COMPLIANCE PATHS

The team looked for and reviewed prescriptive checklists and REScheck files as part of this analysis. Among the information included in these documents is the compliance path used by homes permitted under 2009 or 2012 IECC. If neither a prescriptive checklist nor a REScheck certificate was on file, but a HERS rating was on file, we assumed a home used the performance path. We were able to determine the compliance path for 83% of homes permitted under 2009 IECC and for 64% of homes permitted under 2012 IECC. UA trade-off was the most common compliance path used for homes permitted under 2009 IECC, accounting for at least 69% of the homes in our analysis. UA trade-off was also commonly used for homes permitted under 2012 IECC, accounting for at least 37% of homes. It appears that the performance path has grown in usage over time, from at least 10% of homes permitted under 2009 IECC to at least 24% of homes permitted under 2012 IECC. This may be due to the fact that diagnostic testing is now a mandatory requirement for both air and duct leakage and typically requires a HERS rater for documentation.

Figure 21. 2009 and 2012 Compliance Paths



APPENDIX C: COMPARISON OF MASSACHUSETTS RESIDENTIAL NEW CONSTRUCTION PROGRAM HOMES AND NON- PROGRAM HOMES

Table 4 compares the percentage of energy-related criteria documented between homes that went through the Residential New Construction program and those that did not. Meaningful comparisons cannot be drawn between program and non-program homes permitted under 2012 IECC due to the fact that only four 2012 IECC homes went through the program. Program homes permitted under stretch code were more likely to have manual J calculations, verification of duct leakage and air leakage testing, and a confirmed HERS rating, and less likely to have an ENERGY STAR thermal enclosure checklist than non-program homes. Meanwhile, program homes permitted under 2009 IECC were more likely to have insulation levels documented, and less likely to have verification of duct leakage and air leakage testing. Program homes permitted under stretch code and 2009 IECC were less likely to have no energy-related documentation on file than non-program homes.

Table 4. Documentation for ENERGY STAR and Non-Program Homes

Documentation	Non-Program Homes			Program Homes			Total Homes		
	Stretch	2009	2012	Stretch	2009	2012	Stretch	2009	2012
<i>n</i>	232	229	98	103	35	4	335	264	102
Manual J	4%	14%	10%	31%	0%	0	12%	12%	10%
Insulation Requirements	58%	80%	57%	74%	94%	0	63%	82%	55%
Duct Leakage Test	43%	22%	27%	74%	3%	2	52%	20%	27%
Air Leakage Test	44%	15%	32%	74%	0%	2	53%	13%	32%
Confirmed HERS Rating	41%	1%	9%	74%	0%	0	51%	1%	9%
ENERGY STAR Thermal Enclosure Checklist	24%	1%	2%	10%	0%	0	20%	1%	2%
None of the Above	9%	10%	21%	2%	0%	1	7%	8%	22%