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Residential New Construction Baseline Study

Rhode Island Energy

Developed For

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Executive Summary

The Rhode Island Residential New Construction (RNC) program provides financial incentives and technical resources to builders and homeowners to encourage efficient construction practices in new homes. The RNC program calculates energy savings by comparing the consumption of program homes to a hypothetical typical home. Periodic baseline studies, such as this one, inform the program about how typical new homes are constructed. This allows the program to claim savings against true market conditions, rather than against assumptions about builder practices.

About the New Construction Baseline Study

To understand the changing residential new construction market, Rhode Island Energy sponsored this study to characterize the single family[1] non-program new construction market, assess measure level efficiencies in non-program new homes, and quantify the level of energy code compliance in these homes. As part of the Cadeo team, NMR Group (hereafter, “we,” “the team,” or the “Cadeo team”) led this study.

Through on-site visits to 40 homes built between 2019 and 2022 as well as outreach to municipal building departments, the team gathered specific energy related data within homes that populates energy models used to assess code compliance and update assumptions in the hypothetical typical baseline home, called the User Defined Reference Home (UDRH). The User Defined Reference Home is used to quantify program savings.

This study builds on previous research efforts:

- The Baseline Study of Single-Family Residential New Construction that NMR conducted in Rhode Island in 2017.[2]

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[1] Single family homes considered in this study were detached homes as well as attached two-unit townhomes, i.e., attached homes that have their own utilities and are separated from the adjacent unit by a ground to roof wall.

[2] http://rieermc.ri.gov/wp-content/uploads/2018/03/ri-rnc-baseline-study_16jan2018_final.pdf

Research Objectives

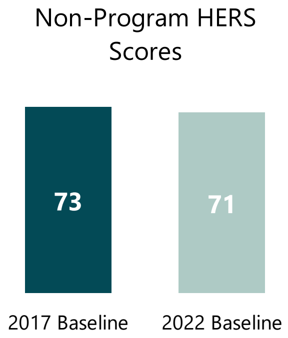
The objectives of this study included:

- Updating the baseline efficiencies for measures included in the UDRH.
- Estimating average code compliance for homes built under the Rhode Island State Building Code – 8 Energy Conservation Code.
- Comparing non-program on-site data to program home data, as well as comparing those to results from previous baseline studies.
- Understanding the extent to which building departments keep thorough and accurate records that could inform baseline efficiencies.

Key Findings

Our research drew out many findings related to baseline measure level efficiencies, how building practices have changed over time, and the level of code compliance. Below are a few of the more informative findings.

Comparisons



Non-program HERS scores have only improved slightly since the previous 2017 baseline study. The average unweighted Home Energy Rating System (HERS)[3] Index score (excluding solar PV) has improved by just 2 points over that time period from 73 to 71 (lower HERS scores mean higher efficiency). Custom homes performed better with an average HERS score (excluding PV)[4] of 68 compared to spec homes at 74. Five homes in the non-program sample had solar PV; with these PV systems included in the analysis, the average HERS score dropped to 63. This was primarily driven by custom built homes as well; including PV, the average custom home HERS score improved to 51, while spec homes including PV had an average score of 72.

A majority of measure level efficiencies have improved since the previous 2017 baseline including all building shell R-values; however, some measures have decreased in

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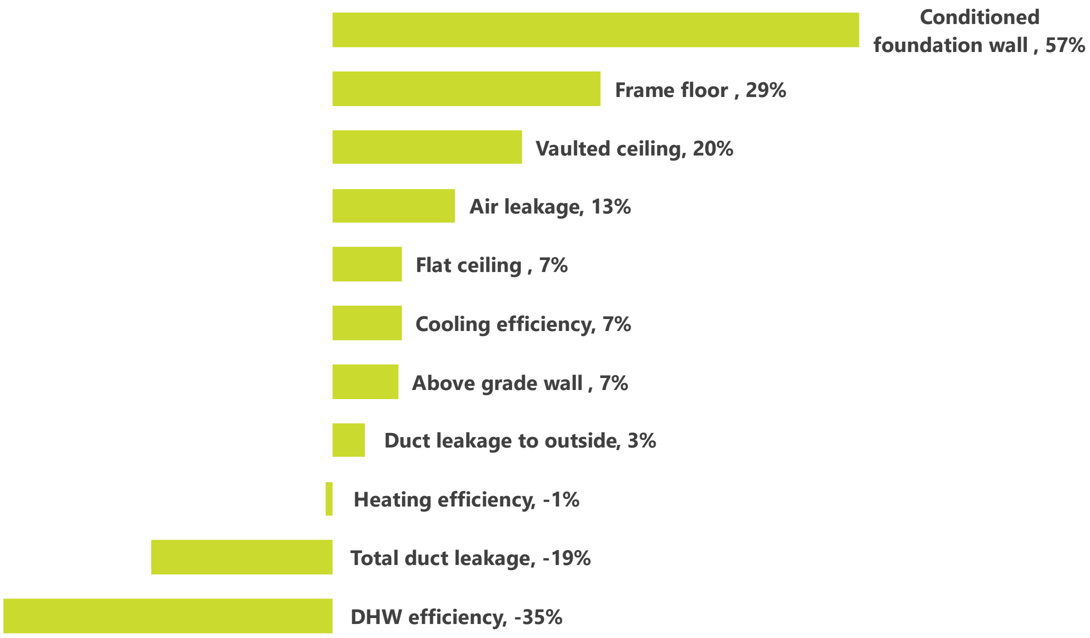
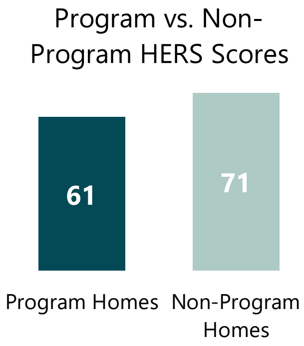
[3] A HERS Index score is a standardized assessment of a home's energy-efficiency performance based on the home's construction and energy-using equipment. RESNET oversees the process of scoring homes using the HERS index. RESNET's HERS Index is a widely adopted rating system used across the United States with standardized procedures, evaluator certification, and quality control infrastructure. A score of 100 means the home is as efficient as the RESNET defined reference home, which is based on the 2006 IECC. A score of zero signifies that a home uses no more energy than it produces on site with renewable sources and a score of less than zero signifies that home produces more renewable energy on site than it consumes.

[4] The RNC program does not factor PV into their program savings calculations, so it was decided to consider scores without PV. Additionally, the non-program onsite sample homes are visited post occupancy which allows time homeowners to potentially install solar PV on their own, while the program records reflect the homes right as they are finished. Solar PV would likely be installed at a later time and therefore would not show up in the program energy models on which this analysis relied.

efficiency. The largest improvements were in conditioned foundation walls which increased from an average insulation R-value of R7.9 to R18.2 and framed floors from R20 to R28.1. Cooling efficiency has improved, but both heating and domestic hot water efficiency both decreased since the previous baseline, particularly hot water heaters which decreased from an average 1.38 Energy Factor (EF) to 1.02 EF. In addition, duct leakage to the outside has decreased slightly, but total duct leakage has increased substantially since the previous baseline. The percentage improvement over the previous baseline for each key measure is shown in Figure 1.

Figure 1. Measure Level Percent Improvement





Program homes continue to outperform non-program homes, but the margin is decreasing. Program homes continue to outperform non-program homes, but the margin is decreasing. The average HERS score (excluding solar PV) for program homes (61) was better than non-program homes (71). Program homes performed better in each building shell and mechanical equipment measure category with the exception of conditioned foundation walls (program R15.8, non-program R18.2), and cooling efficiency (14.5 vs. 14.8 SEER), although these differences are not statistically significant[5]. Most measures in program homes improved since the previous baseline study with the exception of conditioned foundation walls (R18.3 down to R15.8) and

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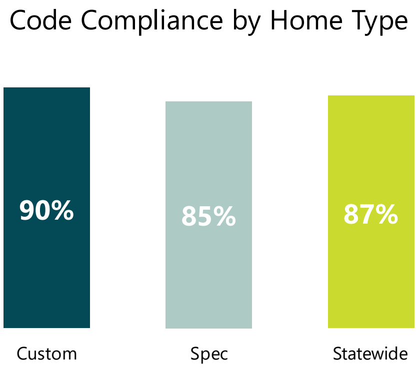
[5] Statistical significance by measure is displayed in comparison tables in Section 1. Changes in efficiency values over time are highlighted in this section regardless of statistical significance as they represent market trends. More detail on this can be found in Appendix A.5.

heating efficiency (94.7 AFUE to 94.2). It should also be noted that including solar PV in calculating HERS scores contributed more for non-program homes, which had higher solar PV penetration than program homes. Including PV in energy models resulted in a decrease in average HERS scores from 71 to 63 for non-program homes but only 61 to 60 for program homes.

Code Compliance



Overall code compliance has increased since the previous study among non-program homes, and it is higher among custom built homes than spec homes. Energy code compliance, calculated using the MA-REC[6] approach, is 87% for the non-program sample of homes. Custom homes outperformed spec homes with 90% code compliance compared to 85% for spec homes. Overall code compliance is up from the previous 2017 baseline study which measured compliance at 80%.

Windows and air leakage had the highest rate of code compliance, and duct leakage the lowest. As shown in Figure 2, windows (97%), air leakage (95%), and foundation walls (94%) all showed high levels of code compliance. Duct leakage was the worst performing measure at just 68%, followed by ceilings (81%) and frame floors (82%).

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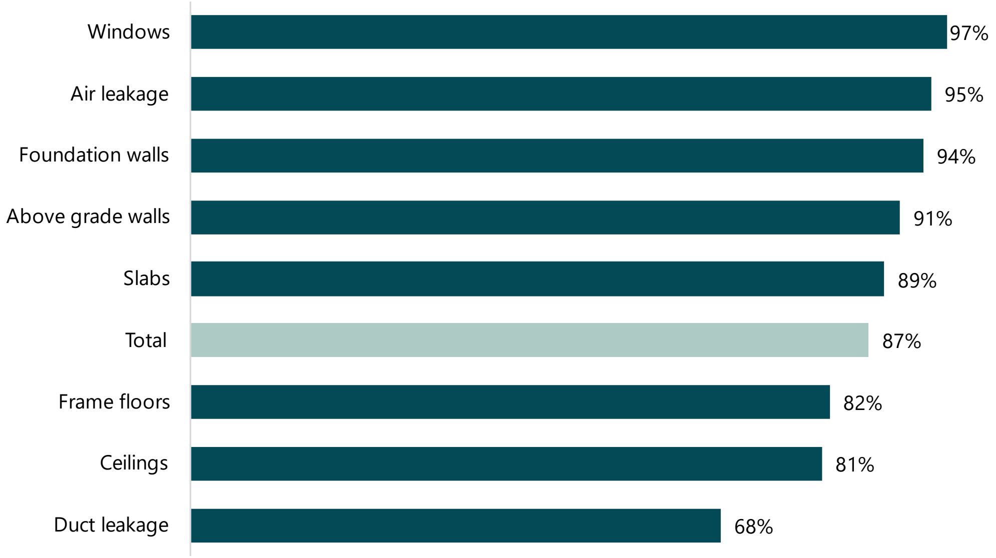
[6] See Appendix A.6 for full MA-REC methodology. This approach is so named due to being developed in Massachusetts but is not specific to code in that state and is easily adapted to any state code. This method is consistent with what was used in the prior Rhode Island baseline study.

Figure 2. Measure Level Code Compliance



UDRH Update

The following table represents the average measure specific results from this study, which are the recommended inputs to the User Defined Reference Home (UDRH). It should be noted that outliers were identified and removed for duct leakage values using interquartile range rule[7]. This rule was applied to all measure data sets, but no other outliers were identified. More detail on this methodology can be found in Appendix A.5.

Table 1. Recommended UDRH Inputs

	Units	Recommended URDH Input
Above grade wall	R-value	21.3
Above grade wall	U-value	0.062
Flat ceiling	R-value	39.0
Flat ceiling	U-value	0.039
Vaulted ceiling	R-value	36.9
Vaulted ceiling	U-value	0.035
Frame floor	R-value	28.1
Frame floor	U-value	0.070
Conditioned foundation wall	R-value	18.2
Duct leakage to outside	CFM25/ 100 sq. ft.	8.3*

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[7] https://online.stat.psu.edu/stat200/lesson/3/3.2

Total duct leakage	CFM25/ 100 sq. ft.	24.6*
Air leakage	ACH50	4.6
Heating efficiency (fossil fuel)	AFUE	91.4
Heating Efficiency (electric)	HSPF	10.3
Cooling efficiency	SEER	14.8
DHW efficiency (fossil fuel)	EF	0.89
DHW efficiency (electric)	EF	1.35

*Two outliers identified and removed. No other outliers identified for other measures.

Conclusions and Recommendations

Code Compliance. Statewide energy code compliance has improved since the previous baseline and is quite high overall (87%) using the MA-REC approach. However, some measures displayed lower levels of compliance, particularly duct leakage at 68%. Ceiling and frame floor code compliance have increased since the 2017 baseline but are still among the lowest performing measures.

Recommendation #1*: Focus code compliance training activities on measures with the lowest levels of compliance, specifically duct leakage. Compliance has dropped for duct leakage since the previous baseline from 72% to 68% and a majority (93%) of homes sampled in this study had ducts, presenting a large opportunity to increase compliance. Ceilings and frame floors continue to have lower compliance so should continue to be a focus in these trainings as well.*

Program effectiveness. Program homes continue to outperform sampled non-program homes, but there has been limited improvement in performance since the last baseline study. The 2017 baseline study found the average program HERS score to be 62, which has only decreased by one point to 61. Non-program homes have also seen limited improvement from an average HERS score of 73 to 71.

Recommendation #2*: The program should consider increasing the stringency of program requirements to increase the overall performance of program homes over the general market, otherwise program savings may decrease. This may involve increasing the minimum %*

savings thresholds for program Tiers or adopting a pay for performance type model similar to the Massachusetts program.[8]

Water heaters. The average efficiency of water heaters in non-program homes has decreased from 1.38 EF to 1.02 EF since the previous baseline study. This is driven by the decrease in prevalence of heat pump water heaters (HPWH). The current downstream water heating incentives (independent of RNC program) for HPWH are the same as those for gas tankless models.

Recommendation #3*: Increase incentives outside of the RNC program (downstream or midstream) for heat pump water heaters above the level of gas tankless models, or drop gas tankless incentives entirely, to drive adoption in new homes. While a builder or homeowner may not decide to participate in the RNC program for the whole home, they may decide to purchase an incentivized piece of equipment. Decreasing the upfront cost of HPWHs through incentives will make them a competitive choice for water heating.*

Building Department Data. The documentation available at building departments was found to be relatively sparse and rarely contained reliable data that could be used to determine UDRH values. The most common types of documentation found were permits and blueprints which specify what is *planned* to be installed in a new home, but documentation containing third party verification of building details was not commonly found.

Recommendation #4*: Focus code official trainings on consistently collecting third party verification of energy code compliance such as prescriptive checklists, blower door and duct blaster results, IECC certificates, or HERS ratings. Collecting building department data to inform UDRH values in future RNC baseline studies is still a worthwhile endeavor, but data from third party verified sources should be prioritized.*

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[8] https://www.masssave.com/-/media/Files/PDFs/Save/Residential/Pay-for-Savings.pdf

The study used two primary data collection activities to establish baseline practices: on-site inspections and building department data collection. See Appendix A for detailed information about each activity.

Sampling

NMR selected homes for on-site visits that reflect the level of construction activity in each of Rhode Island's five counties. Table 2 presents the sampling plan and achieved targets for the on-site inspections. The plan was based on single-family building activity by county using average annual single-family permits for 2019 and 2020 from the U.S. Census Building Department Survey. The sample (both targeted and achieved) mirrored that of the previous 2017 baseline study; a total of 40 visits, similar county breakdowns, and similar custom vs. spec breakdowns.

Table 2. County-Level On-site Targets and Final Samples

County	Average Annual Single-Family Permits 2019-2020	Share	On-site Target	Achieved Sample
Bristol	43	4%	3	2
Kent	136	14%	5	4
Newport	137	14%	5	6
Providence	358	36%	14	15
Washington	325	33%	13	13
Total	**998**	**100%**	**40**	**40**

The team acknowledges that there is always potential for sampling bias in a small sample of 40 homes recruited through voluntary participation. The team made many efforts to minimize sampling bias and achieved a diverse sample of homes. Participating homes were recruited through homeowners rather than through builders to avoid biasing the sample towards those builders who use more efficient construction practices and therefore may be more inclined to participate. Only one home per development was allowed to participate to avoid including homes built by the same builder with similar characteristics. The team sent postcards to a comprehensive list of non-program homes which included a QR code for ease of response and offered a $200 incentive to participate. The achieved sample was split relatively evenly between custom (18) and spec (22) homes[9]. Sampled new construction homes had built dates that spanned relatively evenly across the study time period (2019-2022). Most homes were single family detached homes but attached homes were also included in the sample, and the size of homes ranged from small (970 sq. ft.) to large (4,285 sq. ft.).

Recruitment

The sample for this study was comprised of homes permitted after August 1, 2019, to coincide with the adoption of Rhode Island State Building Code – 8 Energy Conservation Code (based on 2015 IECC)[10] and ensure that the homes were permitted under this code. The team reviewed and cleaned new electric service request data from 2019 to 2022 to narrow the sample down to only single family new homes that had not participated in the Rhode Island Energy new construction program. Postcards were sent to this comprehensive list which described the goals of the study and mentioned a $200 incentive offered for participation. The postcard also included a QR code which conveniently linked potential participants to a short survey where they could express interest in participating and provide contact information. Visits were then scheduled at the homeowner's convenience.

On-Site Data Collection

During onsite inspections, NMR technicians collected all necessary data at a home to calculate a HERS score and to create an energy model. Specifically, the types of data collected were:

- General Characteristics (home type, conditioned floor area, etc.)
- Building Shell Characteristics (insulation levels of walls, ceilings, floors, etc.)
- HVAC Equipment (type, fuel, and efficiency of heating and cooling systems)
- Domestic Hot Water Equipment (type, fuel, efficiency, water fixtures)
- Diagnostic Tests (blower door and duct blaster tests)
- Miscellaneous Data (ventilation, renewables, electric panel data, etc.)

In order to save time on site and have only one auditor conduct visits, Rhode Island Energy agreed to forego collecting full data on lighting and appliances for this study; only range and dryer fuels were collected. For the purpose of creating energy models, reasonable assumptions were used for these measures based on data collected in the previous new construction baseline in Rhode Island as well as a more recent one conducted in Massachusetts. The team acknowledges this as a limitation, but does not believe it would have a significant impact on the data presented here.

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[9] The split between custom and spec homes refers to the process under which the home was built and the involvement of the homeowner. Custom homes refer to those in which the homeowner had some level of control over the design and choices made in the building process, i.e., hired an architect or acted as the builder. Spec homes refer to those in which the builder was responsible for the plans and the building process and the homeowner either purchased the home finished or selected small upgrades to a building under construction.

[10] https://up.codes/viewer/rhode_island/ri-energy-conservation-code-2019

Building Department Data Collection

NMR collected data at building departments for each of the homes visited as part of the on-site data collection, as well as two other homes randomly selected from the new electric service request data from each town represented in the on-site sample. NMR requested various types of documentation from building departments that could potentially yield energy code compliance data such as building permits, blueprints, inspection checklists, REScheck files, or HERS rating certificates.

Analysis

Data collected at each home for this study went through a review and QC process by a different NMR technician that was not present on site. Once data was finalized, each component was analyzed to produce average R-values and efficiencies across the sample, split out by custom and spec homes. The resulting averages would serve as updated User Defined Reference Home (UDRH) values which we propose to be used by the RNC program to calculate savings.

Code compliance was measured using the MA-REC methodology developed by NMR in Massachusetts. Details on this methodology can be found in Appendix A.5. In short, this methodology uses REM/Rate[11], an energy modelling software, to develop a code compliance scoring system that is more focused on estimating energy consumption than other prescriptive methods. It establishes the relative importance of various building shell components based on energy consumption in order to develop a scoring system, and then assesses the level of compliance for each of those measures in each home compared to a reference home built to code minimum standards. This methodology has been used in several baseline and code compliance studies across New England, including the previous baseline study in Rhode Island in 2017.

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[11] REM/Rate is a residential energy modeling software that estimates energy consumption of homes based on the features included in the energy model. The models include information about the building shell, mechanical systems, lighting and appliances, and other energy-related features. REM/Rate is a RESNET approved software used to calculate and generate HERS Index scores.

Section 1 Comparisons

Previous Baselines

This section compares the current 2022 Rhode Island baseline results (homes built in the 2015 IECC[12] code cycle) to the previous Rhode Island RNC baseline study conducted in 2017 (2012 IECC homes). This allows us to see changes in builder practices over time.

Table 3 shows the HERS Index scores for the current and previous 2017 baselines, excluding solar PV. A score on the HERS Index is a rating of a home's energy efficiency based on its energy attributes. The average HERS score excluding solar PV has improved by just two points since the previous baseline, from an average of 73 to 71.

Table 3. Non-Program HERS Score Comparison to Previous Baseline, Excluding PV

	2017 Baseline	2022 Baseline
n	40	40
Mean	73	71
Min	45	52
Max	100	100

Table 4 shows the HERS Index scores for the current and previous 2017 baselines with PV included. Two of the 40 homes in the previous baseline had solar PV compared to five homes in the current study so the impact was larger on current study homes (changed by less than a point for the previous study). The average HERS score with PV included has decreased from an average of 73 to 63. The minimum score has also improved significantly to -35 (negative HERS scores are achieved by accounting for onsite generation like solar PV).

Table 4. Non-Program HERS Score Comparison to Previous Baseline, PV Included

	2017 Baseline	2022 Baseline
n	40	40
Mean	73	63[a]
Min	33	-35
Max	100	100

[a] Statistically significant difference at 90% confidence interval.

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[12] Rhode Island adopted a new code based on 2018 IECC in 2022. However, since all of the homes represented in this sample were already completed during data collection in the summer of 2022, they were confirmed to be permitted before the adoption of the new code and were therefore permitted under 2015 IECC.

Table 4 shows building component comparisons to the previous 2017 baseline study including building shell and mechanical equipment. It should be noted that in some cases, building department records were included in this analysis to increase the sample for select components where data was deemed reliable. Specifically, building department data was only deemed to be reliable enough to use in our analysis for above grade walls, ceilings, and framed floors. All other building department data for other shell and HVAC components was found to rarely be accurate and was therefore excluded. More detail on the reliability of building department data and its inclusion in these findings can be found in Section 3..

Statistically significant results are highlighted in the tables in this section with a superscript ‘a’. The team notes that while the statistically significant results indicate a larger change in specific values, they are not the only results that have implications for the program moving forward. Any change in measure level values represents the direction in which the market is trending regardless of statistical significance. Particularly of note would be measures that have decreased in efficiency, even if they are not statistically significant.

All building shell measures average R-values have increased since the previous study, the largest increase being in conditioned foundation walls which increased from R7.9 to R18.2. The tightness of the thermal envelope has also improved; air leakage has decreased from 5.3 to 4.6 ACH50. However, while duct leakage to the outside has decreased slightly, total duct leakage has increased since the previous study.

While cooling system efficiency has improved since the previous baseline, both heating and hot water heater efficiency have decreased. The lower heating efficiency in this baseline was driven by lower furnace efficiency at 90.9 AFUE, while the drop in hot water heater efficiency was driven by fewer heat pump water heaters in sampled homes which tends to increase average efficiency.

Table 5. Non-Program Building Component Comparison to Previous Baseline

	Units	2017 Baseline	2022 Baseline
Above grade wall	R-value	19.8 (n=40)**	21.3^{a*} (n=75)
Flat ceiling	R-value	36.1 (n=32)	39.0^{a*} (n=65)
Vaulted ceiling	R-value	29.4 (n=22)	36.9^{a*} (n=24)
Frame floor	R-value	20 (n=22)	28.1^{a*} (n=57)
Conditioned foundation wall	R-value	7.9 (n=12)	18.2^{a} (n=21)
Duct leakage to outside	CFM25/ 100 sq. ft.	8.6 (n=36)	8.3 (n=45)
Total duct leakage	CFM25/ 100 sq. ft.	20.6 (n=37)	24.66 (n=43)

Air leakage	ACH50	5.3 (n=39)	4.6 (n=40)
Heating efficiency	AFUE	92.1 (n=40)	91.4 (n=47)
Cooling efficiency	SEER	13.7 (n=45)	14.8[a] (n=59)
DHW efficiency	EF	1.38 (n=42)	1.02[a] (n=41)

[a]Statistically different at 90% confidence interval.

*Average values combine both onsite and building department data. Otherwise, values are only based on onsite data. Details on the accuracy of building department data and the decision to include it can be found in Section 3.

**The n values in this table represent occurrences of the measure within the sample of homes, e.g., heating efficiency n would be number of fossil fuel heating systems with an AFUE value found in program/ non program homes.

Program vs. Non-Program Homes

This section describes the comparison for key measures between the 40 sampled non-program homes and a population of program homes built during the study period. The average values from on-sites were compared to the REM/Rate files of 441 program homes.[13]

Table 5 shows HERS scores for program and non-program homes. The HERS scores for non-program homes were modeled using data from on-site inspections conducted by NMR between July and September 2022. The HERS scores for program homes were modeled using data submitted to the program by HERS raters who were contracted by builders or homeowners as part of the program application process.

Because the program does not claim savings for solar PV systems, the table below presents HERS score comparisons with solar PV systems removed from the energy models. Without including solar PV, program homes outperform non-program homes in average HERS score by ten points (61 for program and 71 for non-program).

Table 6. Program vs. Non-Program HERS Score Comparison Without Solar PV

	Program Homes	Non-Program Homes
n	441	40
Mean	61	71
Min	32	52

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[13] All non-program HERS models were created in REM/Rate version 16.3.2, the most up-to-date version of the software that would have been used for homes built at this time. All program home energy models were re-run in that same version of REM/Rate to ensure consistent comparisons. The Rhode Island RNC program provided evaluators with REM/Rate files for program homes built within the same time frame as the homes included in the on-site inspections.

Max	106	100

Program homes only slightly overperformed non-program homes when solar PV is included in the energy models, as shown in Table 6. A total of eight program homes had solar PV out of the 441 analyzed and five non-program homes had PV out of the 40 sampled homes. Including the PV systems had a much larger effect on the non-program home average HERS score which decreased by eight points from 71 to 63. The average program HERS score only decreased by one point from 61 to 60. This represents a smaller gap between program and non-program scores than was observed in the 2017 baseline (62.3 and 72.5, respectively). Despite program homes having a lower average HERS score, the upper and lower bounds of scores were lower for non-program homes (100 vs. 106 and -35 vs. -14, respectively).

Table 7. Program vs. Non-Program HERS Score Comparison with Solar PV

	Program Homes	Non-Program Homes
n	441	40
Mean	60	63
Min	-14	-35
Max	106	100

[a] Statistically significant difference at 90% confidence interval.

Table 7 shows measure level comparisons between program and non-program homes including building shell measures and mechanical equipment. Program homes outperformed non-program homes for all measures with the exception of conditioned foundation walls and cooling efficiency. It should be noted that the n values indicated for each measure refer to the number of occurrences of that measure within the sample and so can be higher than the number of homes since some homes may contain more than one of that measure type.

Table 8. Program vs. Non-Program Building Component Comparison

	Units	Program homes	Non-program homes
Above grade wall	R-value	21.6 (n=441)	21.3* (n=75)
Flat ceiling	R-value	41.7 (n=498)	39.0[a]* (n=65)
Vaulted ceiling	R-value	41.2 (n=131)	36.9[a]* (n=24)
Frame floor	R-value	30.1 (n=265)	28.1[a]* (n=57)

Conditioned foundation wall	R-value	15.8 (n=39)	18.2 (n=21)
Duct leakage to outside	CFM25/ 100 sq. ft.	2.8 (n=370)	8.3[a] (n=45)
Total duct leakage	CFM25/ 100 sq. ft.	5.0 (n=370)	24.6[a] (n=43)
Air leakage	ACH50	3.2 (n=415)	4.6[a] (n=40)
Heating efficiency	AFUE	94.2 (n=278)	91.4[a] (n=47)
Cooling efficiency	SEER	14.5 (n=284)	14.8 (n=59)
DHW efficiency	EF	1.48 (n=415)	1.02[a] (n=41)

[a] Statistically significant difference at 90% confidence interval.

*Average values combine both onsite and building department data. Otherwise, values are only based on onsite data.

Section 2 Code Compliance

This section describes the results from a code compliance analysis conducted to assess the rate at which homes in the sample (and specific building components within the homes) comply with the governing building code; in this case based on 2015 IECC. Understanding code compliance levels can help to assess remaining opportunities for program intervention via code compliance enhancement activities and provide guidance on specific measures that need improvement.

Code compliance was measured using the MA-REC methodology, as described in Appendix A.5. The overall code compliance rate for non-program homes was 87% on average; an increase from 80% in the previous baseline study. Custom built homes (90% compliance) performed better than spec homes (85% compliance) overall and for each individual measure. The measures with the lowest level of compliance were duct leakage, ceilings, and frame floors. Despite being among the worst performing measures in this study, compliance for ceilings and floors has increased since the previous baseline (from 55% and 70%, respectively), while duct leakage compliance has decreased (to 68% from 72% in the previous baseline).

Table 8 details the level of code compliance of the 40 visited non-program homes, overall and by specific measure. Although this study is not intended to directly evaluate code compliance enhancement initiatives, these compliance values are recommended to be used as a savings baseline for any such activities conducted by Rhode Island Energy.

Table 9. Average Non-Program Measure Level MA-REC Code Compliance

	Custom	Spec	Statewide
n	18	22	40
Windows	98%	96%	97%
Air leakage	98%	92%	95%
Foundation walls	99%	90%	94%
Above grade walls	93%	89%	91%
Slabs	92%	88%	89%
Frame floors	83%	82%	82%
Ceilings	82%	81%	81%
Duct leakage	73%	64%	68%
Total	**90%**	**85%**	**87%**

In relation to air leakage specifically, the Rhode Island State Building Code – 8 Energy Conservation Code maximum air change rates per hour decreased by year as seen in Table 9. All other measures had consistent prescriptive requirements across this time period. The compliance rates for air leakage steadily decreased year over year in response to the more stringent requirements; note the small sample sizes in 2019 and 2022.

Table 10. Air Leakage MA-REC Code Compliance by Year Built

	Maximum ACH50 code requirement	n	Compliance
2019	8	2	100%
2020	7	12	97%
2021	6	19	94%
2022	5	6	90%

Program homes (97% compliance) perform better than non-program homes (87%) in overall code compliance and for each measure considered individually.

Table 11. Program vs. Non-Program MA-REC Code Compliance

	Program homes	Non-program homes
n	472	40
Windows	98%	97%
Air leakage	100%	95%
Foundation walls	99%	94%
Above grade walls	97%	91%
Slabs	99%	89%
Frame floors	92%	82%
Ceilings	98%	81%
Duct leakage	93%	68%
Total	**97%**	**87%**

Section 3 Building Department Data

This section presents the results from building department data collection undertaken for the baseline study. The NMR team collected building department data for each of the 40 homes that were visited onsite, as well as two additional homes from each municipality (randomly selected from the new electric service data) represented in that sample, resulting in a total of 120 homes. Based on the locations of the onsite sample, this resulted in visiting building departments from 27 of the 39 municipalities in Rhode Island. This data collection was intended to answer two questions: how thorough are building departments in keeping records that could inform key measure efficiencies, and how accurate is that information compared to onsite data?

Availability of Building Department Data

Out of the sample of 120 homes for which building department data collection was attempted, NMR was able to collect documentation for 110. Of the 10 homes for which data was not able to be collected it was either because a) the files that were available did not provide any meaningful information, b) the department denied the request, or c) the department was or became unresponsive.

Table 11 shows the frequency that NMR was able to obtain different types of documentation for the sample of homes. Permits (98% of homes) and blueprints (72% of homes) were the most common type of documentation available at building departments. Blower door (61%) and duct blaster (41%) results were reasonably available, but other documents such as energy code checklists or certificates were rarely found. Some examples of documentation obtained from building departments can be found in Appendix C.

It should be noted that although permits and blueprints were frequently found and could sometimes provide useful information, they are not always a reliable source of efficiency data. Permits rarely contain specifics on building shell or mechanical efficiencies; they typically only contain general information about the type of building or piece of mechanical equipment being installed. Blueprints sometimes specify building shell R values or mechanical efficiencies; however, they are often simply code minimum values and are more like instructions for the contractors on what to install, not actual verified values of what was installed. The ideal documentation that would provide the most reliable data on installed R-values and mechanical efficiencies would be those that involve third party verification such as compliance checklists or IECC or HERS certificates; unfortunately, those were among the least common documents found.

Table 12. Building Department Document Type Availability

Type	Availability
n	120
Permit	98%
Blueprints	72%
Blower Door Results	61%
Duct Leakage Results	41%
Inspection Checklist	12%
IECC Energy Certificate	11%
Compliance Certificate	8%
HERS Certificate	7%
ENERGY STAR Home Certification	1%

Table 12 shows the frequency in which NMR was able to obtain efficiency values for various measures from the building department files. Air leakage (63% of homes) was the most common measure for which data was obtained. Building shell R-values were also obtained relatively frequently for ceilings (61%), walls (59%), and floors (47%). Mechanical system efficiencies were rarely obtained from building department files.

Table 13. Building Department Measure Level Availability

Type	Statewide
n	120
Air Leakage	63%
Ceiling R-value	61%
Wall R-value	59%
Floor R-value	47%
Duct Leakage	43%
Window U-factor	26%
Heating efficiency	18%
Cooling efficiency	11%
DHW efficiency	10%

Accuracy of Building Department Data

NMR collected building department data from each of the 40 homes visited onsite. This allowed the team to compare on-site data to building department data for the same homes. Table 13 shows the number of homes with available data to compare from both sources (onsite and building department) for each metric, and how often the values for that metric matched one another. This table represents only the data from the 40 homes in which we collected *both* onsite data and building department data, not the entire building department sample of 120 homes.

It should be noted that for air and duct leakage a 'rough' match approach was used to reflect that these numbers are based on field tests which can vary slightly. For all other metrics, the match had to be an exact value. Building department values for wall (76% matching), floor (70%), and ceiling (55%) R-values were the most accurate to data collected onsite. Mechanical efficiencies and duct leakage values were rarely accurate in the building department data.

The team presented these results to Rhode Island Energy preliminarily to consult them on which values (if any) from the building department data were accurate enough to include in analysis alongside onsite data. If accurate, the inclusion of this data would provide a larger sample of homes for the analysis. Based on this consultation, the team decided that only values for walls, floors, and ceilings were accurate enough to include in the combined analysis with onsite data.

Table 14. Building Department Data Accuracy

Type	Homes with Available Data	Matches	Match %
Wall R-value	29	22	76%
Floor R-value	23	16	70%
Ceiling R-value	29	16	55%
Air Leakage	28	10	36%
DHW efficiency	4	1	25%
Heating efficiency	7	1	14%
Duct Leakage	17	1	6%
Cooling efficiency	2	0	0%

Despite the limited accuracy of measure level efficiencies described in the table above, the average values across all of the building department data are relatively close to those found during onsite visits, as shown in Table 14. . The building department column presents average values from available data collected at building departments for that sample of 120 homes, and the onsite column presents average values from data gathered onsite only. The widest gap in building department and onsite data was in total duct leakage in CFM25 per 100 sq. ft., which would be 5.8 solely based on building department data but was found to be 22.7 from onsite testing. There was also a large gap in DHW efficiency, however this may be driven by the lack of availability of building department data for this metric (n=7).

Table 15. Building Department vs. Onsite Measure Level Comparison

Type	Building Department	Onsite	% Difference
Air Leakage (ACH50)	3.8 (n=76)	4.6 (n=40)	21%
Ceiling R-value	38.6 (n=73)	38.9 (n=31)	1%
Wall R-value	20.9 (n=56)	21.2 (n=40)	1%
Floor R-value	28.8 (n=58)	27.3 (n=22)	5%
Duct Leakage (CFM25/100sq. ft.)	5.8 (n=75)	22.7 (n=68)	291%
Heating efficiency (AFUE)	92.1 (n=22)	91.4 (n=47)	1%
Cooling efficiency (SEER)	16.1 (n=17)	14.8 (n=59)	8%
DHW efficiency (EF)	0.90 (n=7)	1.02 (n=41)	13%

Section 4 Building Shell

This section describes high level findings from onsite visits, broken out by specific building shell components. Detailed tables on each building shell component can be found in Appendix B.2.

General Characteristics

The average conditioned floor area of new homes has decreased since the previous study. Sampled homes in the 2017 baseline study had an average of 2,339 square feet of conditioned floor area, this has decreased slightly to 2,185 square feet in the current study. Custom homes were still larger on average than spec homes, but the gap between them has decreased. The average conditioned area of inspected homes in the previous study was 3,099 square feet for custom homes and 2,097 for spec homes; in the current study custom homes were 2,285 square feet on average, only slightly larger than the average spec home at 2,103 square feet.

HERS scores have improved in non-program homes since the previous study. The average HERS score in sampled homes in the current study was 63, an improvement over the previous study average of 72.5. This was largely driven by custom homes, which saw an improvement from 62.5 to 51, compared to spec homes which improved from 75.7 to 72. The improvement in HERS score is also driven by larger adoption of PV; excluding PV from models increases the average HERS score to 71 overall. PV was found most commonly in custom homes; without PV the custom home average score increases from 51 to 68, while spec homes increase from 72 to 74.

Air Infiltration and Ventilation

Air infiltration has decreased since the previous study. The average air changes per hour at 50 pascals of pressure (ACH50) measured by a blower door test decreased from 5.3 to 4.6.

None of the non-program sampled homes in this study contained mechanical ventilation. Despite the decrease in infiltration noted above (tighter homes), mechanical ventilation such as HRVs, ERVs, or automated bath fans were not found at any homes visited during this study. Mechanical ventilation is typically recommended (and often required by code) when air leakage numbers fall below 3 ACH50, 8 homes in the sample were below that threshold but did not contain mechanical ventilation.

Above Grade Walls

The average R-value of conditioned to ambient above grade walls has improved since the previous study. The 2017 baseline study found an average wall R-value of 19.8, this has improved to 21.3 in this study. Custom homes generally had higher wall R-values with an average of 22.1 compared to spec homes at 21.

Fiberglass batts are still the most common insulation type in above grade walls, but closed cell spray foam has increased in popularity. A vast majority (86%) of conditioned to ambient walls found in this study were insulated with fiberglass batts, an even higher proportion than in the previous study (70%). However, closed cell spray foam has become a more popular option, found in 12% of walls in this study compared to just 1% in the previous study. Spray foam continues to be more common in custom homes (19%) rather than spec homes (4%). Custom homes also perform better regarding insulation installation quality, 62% of walls in custom homes were deemed to be Grade 1 installation compared to 42% in spec homes. It should be noted that insulation referred to here is cavity insulation, no continuous rigid insulation was observed in conditioned to ambient walls.

Flat Ceilings

Flat ceiling R-values have increased since the previous study. The average R-value of flat ceiling insulation has increased from 36.1 to 39 since the 2017 baseline. Spec homes (R39) performed slightly better than custom homes (R38.7) for flat ceiling insulation.

Fiberglass batts remain the most common insulation type used in flat ceilings, but loose blown cellulose has become more common. Fiberglass batts were found as the primary insulation type in 76% of flat ceilings (72% in previous study). Loose blown materials have become more common, cellulose increasing from 5% in the previous study to 12% in the current study, and loose blown fiberglass increasing from 4% to 7% of flat ceilings.

Vaulted Ceilings

Vaulted ceiling average R-values have increased since the previous study. The 2017 baseline study found an average vaulted ceiling R-value of 29.4, this has increased to 36.9. Similar to the previous study, custom homes performed better than spec homes in vaulted ceiling R-values, R38.3 to R31.8.

Spray foam has become the dominant insulation type found in vaulted ceilings. The most common insulation types found in vaulted ceilings in the current study were open cell (low density) spray foam (37%) and closed cell (high density) spray foam (36%). The previous 2017 baseline had found fiberglass batts to be the most common insulation type (61% of vaulted ceilings), whereas open cell and closed cell spray foam were not as common (19% and 8%, respectively).

Framed Floors

Insulation R-value has increased in framed floors over unconditioned basements. The average R-value of framed floors separating conditioned space and unconditioned basement has increased from R20 in the previous study to R28.1.

The share of framed floors that are uninsulated has decreased significantly since the previous study. The 2017 baseline found that 28% of framed floors over unconditioned basements were uninsulated, this has decreased to just 9%.

Foundation Walls

The average R-value of conditioned foundation walls has improved since the last baseline. The mean R-value has improved from 7.9 to 18.2; more than doubling the level of insulation since the previous study. It should be noted that the previous study had multiple conditioned basements with no insulation while this study observed just one such basement.

The most common type of insulation used on conditioned foundation walls was high density closed cell spray foam. Spray foam was used in 33% of conditioned basements observed during this study, including all of the conditioned basements in custom built homes. The most common type of insulation in the previous baseline was fiberglass batts (46%). Installation quality has also increased; 67% of insulation was rated as Grade 1 (best quality) in this study compared to only 13% in the previous study.

Rim Joists

The most common type of insulation used for rim joists was fiberglass batts, and nearly half (49%) of those were rated as a high-quality (Grade 1) installation. The average R-value of rim joist insulation between conditioned space and ambient conditions is 22.0, and the average between unconditioned space and ambient conditions is actually higher at 24.2. The most common insulation type used was fiberglass batts (70%), with high density closed cell spray foam being the second most common (19%).

Fenestration

Triple pane, argon filled windows have become more common, and the average U-factor of windows has improved slightly. Double pane windows with low-e coating remain the most common window type, although their share has decreased to 67% of windows from 74% in 2017. Triple pane windows with low-e coating and argon gas filler have become more common (10% now vs. <1% in 2017). The average U-factor for windows has improved slightly to 0.30 from 0.31 in the 2017 baseline.

Section 5 Mechanical Equipment

This section describes high level findings from onsite visits, broken out by specific mechanical equipment categories. Detailed tables on each building shell component can be found in Appendix B.3.

Heating

Furnaces remain the most common primary heating system type, and their prevalence has increased slightly over the previous study. The presence of furnaces as primary heating systems increased from 70% in the previous study to 75%, while boilers have decreased statewide from 17% to 12%. Ductless mini split heat pumps were not found to be a primary heating system at any homes in the previous study, but now account for primary heating at 5% of homes.

The average AFUE of fossil fuel fired heating systems has decreased since the last study. The average AFUE across all the fossil fuel heating systems is 91.4, down from 92.1 in the previous study. The decrease in AFUE was driven by furnaces which made up 75% of heating systems and had an average AFUE of 90.9. Boilers had a higher average AFUE at 95.0 but made up only 12% of heating systems. However, the share of ENERGY STAR qualified heating systems increased from 24% of primary heating systems to 62%.

Propane remains the most common primary fuel for heating systems throughout the state, and its prevalence has increased. The usage of propane as a primary heating fuel has increased from 45% in the previous study to 62% in the current study, while natural gas decreased from 42% to 28%. The usage of electric primary heating systems increased statewide from 7% to 10%.

Cooling

The presence of central air conditioning (CAC) has marginally increased since the previous study. Central air conditioners were found in 88% of homes statewide, up from 83% in the previous study. Air-source heat pumps (ASHP) slightly increased in prevalence from 3% of homes to 5%. While ductless mini-split heat pumps were not found to be primary cooling systems at any of the homes in the previous study, they now account for 5% of homes. Room air conditioners remain rare, observed in only 2% of homes. The previous study reported that 8% of homes did not have any cooling installed, however all homes in the current study had some kind of cooling system.

The average efficiency of primary cooling systems has improved. The Seasonal Energy Efficiency Ratio (SEER) for primary cooling systems ranged from 13.0 to 20.0 SEER, with an average of 14.2 SEER, up from 13.7 SEER in the previous baseline. This is in part driven by the increased share of heat pumps being used as primary cooling, which had an average SEER of 19.2.

More homes are using ENERGY STAR qualified cooling systems. About 29% of the 48 CAC systems met ENERGY STAR criteria at the date of manufacture. This is an increase from the previous study where only 12% of CAC systems met ENERGY STAR criteria. One third (33%) of CACs in spec homes were ENERGY STAR, compared to 24% in custom homes.

Thermostats

While programmable thermostats have seen a decrease, Wi-Fi enabled and smart thermostats have seen an increase since the last study. The presence of programmable thermostats has decreased from 83% in the previous study to 56%, while the share of Wi-Fi enabled and smart thermostats combined have increased from 4% to 31%. Manual thermostats have not seen any changes and remain a small portion of thermostats in sampled homes at 13%.

Domestic Hot Water

The share of instantaneous water heaters has increased, while the share of storage standalone and heat pump water heaters has decreased since the last baseline. Instantaneous water heaters grew from 16% of systems in the previous study to 49% in this study, a 33% increase. Storage standalone systems decreased from 49% of systems to 34%. Heat pump water heaters decreased from an 18% share of systems in the previous study to a 5% share of systems in this study.

The average efficiency of water heaters has decreased since the previous study. The average Energy Factor (EF) of water heaters has decreased from 1.38 in the previous study to 1.02 in the current study. This decrease is largely driven by the decreased prevalence of heat pump water heaters in the current study, which can have EFs of over 3 and therefore drive average efficiency up. Instantaneous water heaters made up nearly half of all systems; their average efficiency was 0.92 EF.

Propane has become the most common water heater fuel, overtaking electricity since the previous study. Propane was used as the fuel for 59% of waters heaters found in this study, up from just 18% in the previous study. Electric water heaters have decreased in prevalence from 53% in the previous study to 29% in this study. This is driven by the increase in instantaneous water heaters and decrease in storage tanks and heat pump water heaters noted above.

ENERGY STAR qualified water heater adoption has increased. The share of ENERGY STAR qualified water heaters rose from 46% in the previous baseline to 62% in this study.

Duct Systems

Duct leakage to the outside has decreased slightly since the previous study, but total leakage has increased. Total duct leakage (to conditioned or unconditioned space) has increased from 20.6 CFM25/ 100 sq. ft. to 24.6. Leakage to the outside (to unconditioned spaces only) has decreased from an average of 8.6 CFM25/ 100 sq. ft. to 8.3.

Ducts are most frequently installed in unconditioned basements and vented attics. Most homes have some amount of ducts either in unconditioned space or vented attics (34% and 30%, respectively). The majority of homes contained some type of insulated ducts. More than half of the ducts observed in homes (60%) were insulated with fiberglass wrap, while 36% of ducts observed in homes were insulated with bubble wrap. Only 2% of ducts were uninsulated.

Renewables and Electric Vehicles

Solar PV penetration has seen an increase since the last study. Solar photovoltaic systems present in sampled homes increased from 5% to 12%. The mean PV capacity also increased from 6.7 kW to 9.8 kW. One home had battery storage along with their solar PV system and two homes had electric vehicles.

Appendix A Detailed Methodology

Appendix A provides the detailed research questions we sought to answer through this research and the detailed methodology for each of the research tasks undertaken to answer those research questions.

A.1 Key Research Questions

- Statewide, what are the baseline efficiencies for measures included in the UDRH?
    - Which baseline measures have improved since the last study was conducted?
- Statewide, what are the average prescriptive code compliance levels of homes built under the Rhode Island State Building Code – 8 Energy Conservation Code?[14]
    - How do current compliance rates compare to those calculated under previous evaluations?
    - Which measures could provide the largest savings opportunities for code support program's going forward?
- How does measure level efficiency of non-program homes compare to program homes?
- How thorough and accurate is building department data compared to on-site data?

A.2 Sampling

NMR selected homes for on-site visits that reflect the level of construction activity in each of Rhode Island's five counties. To minimize self-selection bias, NMR recruited the owners or occupants of the homes, rather than the builders which is consistent with previous studies.

Table 15 presents the sampling plan and achieved targets for the on-site inspections. The plan was based on single-family building activity by county using average annual single-family permits for 2019 and 2020 from the U.S. Census Building Department Survey.

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[14] https://rules.sos.ri.gov/regulations/part/510-00-00-8

Table 16. County-Level On-site Targets and Final Samples

County	Average Annual Single-Family Permits 2019-2020	Share	On-site Target	Achieved Sample
Bristol	43	4%	3	2
Kent	136	14%	5	4
Newport	137	14%	5	6
Providence	358	36%	14	15
Washington	325	33%	13	13
Total	**998**	**100%**	**40**	**40**

The team proposed a soft target of between 50% and 60% spec-built homes as opposed to custom built. The final sample of 40 on-site homes contained 22 (55%) spec-built homes and 18 (45%) custom homes. The construction type was be determined during recruitment by asking homeowners the following question:

How did you purchase your home?

1. Purchased land and worked with an architect and/or builder to build the home. **(Custom)**

2. Had a house plan and a lot and hired a contractor/builder to build the home. **(Custom)**

3. I am the owner and builder. **(Custom)**

4. Purchased a lot from a builder, selected one of several house plans offered by the builder and selected from various available upgrade options. **(Spec)**

5. Purchased a home that was under construction and selected from various available upgrade options. **(Spec)**

6. Purchased a finished home. **(Spec)**

Potential Bias: Despite efforts to avoid it, the team acknowledges that there is always potential for sampling bias in a sample of 40 homes conducted through voluntary participation. Some homeowners may be encouraged to participate because they believe their home is highly efficient and are proud of it, while others who believe their home to be efficient may not see the value in an energy audit and will therefore refuse. Conversely, those who do not believe their home to be efficient may be encouraged to participate to find ways to improve it, while others may avoid participating if they are concerned their home may not meet code.

The team made many efforts to minimize sampling bias and achieved a diverse sample of homes. Participating homes were recruited through homeowners who had purchased and occupied the homes rather than through builders to avoid biasing the sample towards those who use more efficient building practices and therefore may be more inclined to participate. Sampled homes were spread across the time period in which this study was interested in; 2 were built in 2019 (only homes built from August 2019 or after qualified due to the timing of code implementation), 12 in 2020, 19 in 2021, and 6 in 2022. Most homes were single family detached homes, but one single family attached home (2%) was also included in the sample. Homes ranged from small (970 sq. ft.) to large (4,285 sq. ft.).

A.3 Recruitment

The sample for this study was comprised of homes permitted after August 1, 2019 to ensure that the homes were permitted under Rhode Island State Building Code – 8 Energy Conservation Code. NMR identified potential sample homes using new electric service requests for late 2019 through early 2022 (to date). The team reviewed and cleaned the new service request data to develop a comprehensive list of new single-family homes that had been sold and were occupied at the time of recruitment. In addition to eliminating multifamily properties and those that were not new construction, NMR compared the list to a list of low-rise RNC program participants to identify only non-participants eligible for the on-site inspections.

The team sent a postcard with the Rhode Island Energy logo to each prospective participant that described the study, the $200 incentive, and provided contact information to address any questions. The postcard contained a QR code that linked potential participants to an online form where they could express interest in participating or learn more about the study. The online form allowed respondents to enter contact information if they were interested in participating. NMR contacted and recruited participants in an attempt to create a sample matching the targets in Table 15 above. The overall completion rate based on the number of postcards mailed was a little over 3% as shown in Table 16.

Table 17. Sample Disposition and Response Rates

	New Electric Service Requests	Postcards Mailed	Survey Responses	Achieved Onsite Sample
Count	3,041	1,169	90	40

In addition to county and custom/spec targets, NMR recruited only one home per housing development to avoid sampling multiple houses built by the same builder with similar building characteristics.

A.4 On-Site Data Collection

A.4.1 On-Site Data Collection Form

The NMR team developed an electronic data collection form specific to the data of interest to this project. The form was an updated version of the data collection form that was used in the previous single-family compliance/baseline study in Rhode Island, as well as similar studies in Massachusetts and Vermont. The level of detail collected was meant to meet the minimum input requirements to develop a HERS assessment. The form included built-in quality control mechanisms that ensured all the necessary data were gathered while auditors were on site. Additionally, using an electronic data collection form allowed the team to upload data to a server to perform quality control in a timely manner.

The team completed data collection forms for each home based on the data collected during the site visits. Each of the data collection forms were reviewed in the office by an experienced auditor or analyst who was not present during the on-site inspection. This process allowed the team to conduct an unbiased review of the data from each site and ensure that the information included in the forms was comprehensive, consistent, and accurate.

A.4.2 Data Collection Procedures

As previously mentioned, during the on-site inspections the team collected the data necessary to conduct a HERS assessment and build detailed energy models. The value of baseline studies is contingent upon the premise that data collected at one home are directly comparable to data collected at another home. Therefore, all assigned field staff had project-specific training to ensure consistent data collection practices.

The inspections were conducted by a HERS rater and took approximately three to four hours each. It should be noted that in the interest of budget, Rhode Island Energy decided to forego collecting lighting and appliance data other than range and clothes dryer fuel type at on-site inspections.

The on-site data collection consisted of a detailed physical inspection of all visited homes, including diagnostic testing. Specifically, trained auditors visited each home to conduct a thorough visual inspection of the construction features and equipment. Specific data collection inputs are detailed in Table 17.

Table 18. Data Collection Inputs

General Characteristics	Building Shell	HVAC Equipment
• House type • Conditioned Floor Area (CFA) • Conditioned Volume (CV) • Stories • Bedrooms • Basement details • Orientation • Home Age	• Area, framing, insulation type, R-value, installation grade, and location for the following: o Walls o Ceiling o Frame floors o Rim/band joists o Slab floors o Foundation walls • Frame type, area, number of panes, low-e coating, U-factor, SHGC*, and orientation for: o Windows, doors, and skylights	• Type, fuel, capacity, efficiency, age, ENERGY STAR status, and location • Presence of pipe insulation • Presence of ECMs and boiler outdoor reset controls • Count, type, and setpoints of thermostats
DHW Equipment	**Diagnostic Tests**	**Miscellaneous**
• Type, fuel, capacity, efficiency, age, ENERGY STAR status, and location of water heaters • Presence and R-value of pipe insulation or tank wrap • Presence of aerators and flow rates for showerheads and faucets	• Blower door • Duct blaster o Total leakage o Leakage to outside (LTO) o Duct locations and insulation levels	• Mechanical ventilation (ERVs and HRVs) • Presence of renewables (PV, battery storage, EVs) • Electric panel size and meter type • Clothes washer, dryer, and oven/range type and fuel

*U values and SHGC are typically only obtained through model number lookups or from the presence of NFRC stickers, however these are typically removed after occupancy. Only verified values were used in analysis and so the n is usually low.

A.5 Analysis

Data collected at each home for this study went through a review and QC process by a different NMR technician that was not present on site. Once data was finalized, each component was analyzed to produce average R-values and efficiencies across the sample, split out by custom and spec homes. The resulting averages would serve as updated User Defined Reference Home (UDRH) values which we propose to be used by the RNC program to calculate savings.

The team identified outliers in our datasets using the interquartile range rule, and then further investigated any of those outliers to understand their validity. Using this method, only outliers in duct leakage were identified and removed; data was unaltered for all other measures. The interquartile range rule is meant to call attention to *possible* outliers in a dataset, and act as a prompt to investigate certain data points further. In the example of duct leakage, further investigation of these identified possible outliers prompted us to look back at the circumstances of those tests at those particular homes to look for irregularities. Examples might include the functioning of testing equipment, accessibility of all duct registers, or other notes or photos from technicians that would lead us to believe the test was not performed in ideal conditions. After review, the team concluded that these identified potential outliers did indeed represent erroneous data points and therefore they were removed. Although this method was applied to all measures analyzed in this study, duct leakage and air leakage were the most likely areas to have true outliers that should be investigated, as they rely on field testing that could lead to incorrect results. In all other cases (building shell measures or mechanical equipment), data points are verified values (R value, AFUE, SEER, etc.) and so are unlikely to be errors that would merit exclusion from analysis even if they fall outside of the interquartile range. In these cases, potential 'outliers' identified through this method would simply indicate builders who are either going above and beyond or falling behind code, which would be representative of the broad range of practices in the general market.

The team also tested results for statistical significance, both between custom and spec homes in our non-program sample as well as between the current baseline and previous baseline and between program and non-program homes. Statistically significant results are flagged in each table containing those results. Regardless of whether these comparisons were statistically significant or not, they still represent differences in conditions between the two groups that we feel should be highlighted. In cases where results are statistically significant perhaps those differences should be taken as particular areas of focus, but even in cases where they are not these differences still represent the direction in which building practices are trending and therefore should be noted. In addition, average results from this study are still the basis for recommendations to update the UDRH, regardless of whether they are statistically significant from the previous baseline or from the program home sample.

A.6 Code Compliance

Compliance with the Rhode Island State Building Code – 8 Energy Conservation Code was measured using the MA-REC approach developed by NMR in Massachusetts. This approach uses energy modeling to develop a code compliance scoring system that is more calibrated to estimated energy consumption than aa traditional prescriptive approach such as PNNL's REScheck software[15]. Unlike the PNNL approach, the MA-REC approach focuses only on code requirements that directly impact energy consumption. The methodology does not account for administrative or non-energy-related code requirements, and it does not consider the compliance path utilized by the builder. This methodology compares homes to the 2015 IECC prescriptive requirements, with Rhode Island amendments. Thus, the MA-REC approach does not account for trade-offs that may take place under the UA trade-off and performance paths for compliance. For this reason, it is possible that the MA-REC approach overstates the level of non-compliance and potential savings associated with homes that use the UA trade-off or performance paths for compliance. These paths allow for prescriptive non-compliance with certain measures assuming there are other measures that exceed the prescriptive requirements. The MA-REC approach does not attempt to address these complicating factors and this should be considered when reviewing the results associated with this methodology.

The MA-REC approach utilizes REM/Rate energy consumption estimates to determine the relative importance of various code-related building components.[16] The consumption estimates of individual measures are compared to the overall estimated consumption for a sample of homes to develop a detailed point system that is calibrated to overall estimated energy consumption.

A ten-point scale is used in which the most impactful measure (in terms of relative estimated energy consumption) receives an achievable score of ten points. Other measures are compared to the most important measure to develop an achievable point value between zero and ten points. The following formula provides an example of how the total possible points for each measure is developed (in this case, assuming window U-factor was the most important measure in terms of relative consumption):

$$Points_{Possible} = \frac{(P_{TC} \times 10)}{W_{TC}}$$

Where:

$$P_{TC} = Percentage\ of\ Total\ Consumption\ for\ Any\ Measure$$

$$W_{TC} = Window\ Pecentage\ of\ Total\ Consumption$$

The example below details how this calculation works for floors.

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[15] https://www.energycodes.gov/rescheck

[16] REM/Rate is an energy modeling tool that is used to develop Home Energy Rating Scores (HERS) and to support many residential new construction programs.

$$Points\ Possible\ Floors\ is\ 4.1. = \frac{(8.2\% \times 10)}{20\%}$$

Where:

$$P_{TC\ \mathrm{Floors}} = Percentage\ of\ Total\ Consumption\ for\ Floors\ is\ 8.2\%$$

$$W_{TC} = Window\ Pecentage\ of\ Total\ Consumption\ is\ 20\%$$

Once the point system is developed, two models are used to calculate compliance for each home. One is an as-built model, or a model that represents the home as it actually exists, and the other is a code-built model that represents the same home built to meet prescriptive code requirements. The measure-level percentage change between the code-built models and as-built models is used to assign a point value to each of the measures included in this methodology. If the as-built model meets or exceeds the code for a given measure (less consumption), that measure is provided with the total possible points.[17] If the as-built model is less efficient than code, then the measure is provided with partial credit depending on the percentage change of the as-built consumption relative to the code-built consumption. The following formulas are used for these calculations:

$$PC_{Base} = \frac{(CB_{Cons} - AB_{Cons})}{AB_{Cons}}$$

Where:

$$PC_{Base} = Percentage\ difference\ between\ "code - built"\ and\ "as - built"\ models$$

$$AB_{Cons} = As - built\ consumption$$

$$CB_{Cons} = Code - built\ consumtpion$$

Below is an example of how this step in the calculation would work for a home that does not meet the floor code provision. In this scenario, the as-built model has a higher consumption than the code-built model because the code-built home is more efficient.

$$Percentage\ difference\ for\ Floors\ (PC_{Base})\ is - 0.4\ = \frac{(3\ \mathrm{MMBtu} - 5\ \mathrm{MMBtu})}{5\ \mathrm{MMBtu}}$$

Where:

$$AB_{Cons} = 5\ MMBtu\ for\ Floor\ Consumption$$

$$CB_{Cons} = 3\ MMBtu\ for\ Floor\ Consumption$$

The last step in the calculations is to convert the percentage difference in consumption between the models into an adjusted score for that component.

Where:

---

[17] By providing only the maximum possible points this method does not apply extra credit for exceeding the prescriptive code requirements.

$$Points_{Scored} = \begin{cases} Points_{Possible} \times (1 + PC_{Base})\ if\ PC_{Base} < 0 \\ Points_{Possible}\ if\ PC_{Base} \geq 0 \end{cases}$$

Once again, this step is shown using the same floor example from above. The first equation from above is used since the code-built model is more efficient than the as-built model. Had the as-built model been more efficient than the code-built model, the home in this example would receive the full 4.1 points for floors.

$$\text{Points Scored for Floors is } 2.5 = 4.1 \times (1 - 0.4)$$

Where:

$$PC_{Base}\ for\ Floors = -0.4$$

$$Points\ Possible\ Floors = 4.1$$

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

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

The number of points applied to individual components varies depending on the sample of homes and the code that is under consideration. For example, the distribution of points for 2015 IECC compliance would differ from 2018 IECC compliance because certain measures might not be applicable to the 2015 IECC. The total possible points per measure varies between the samples because the relative impact of the measures shifts between different codes and between different samples of homes; hence, it is critically important for the sample to represent the market. However, the relative number of possible points across the codes is not a critical comparison because the objective of this methodology is to compare compliance percentages. The total possible points simply provides an anchor with which to calculate the compliance percentages, or for determining the relative weight of each measure. This approach is similar to the PNNL scoring system, in which the total possible points varies across different codes due to the number and importance of various code requirements and scores are normalized from 0% to 100% to facilitate cross code comparisons.

A.7 Building Department Data Collection

NMR attempted to review building department files for each home that participated in the on-site inspections. Additionally, for each on-site home, NMR attempted to review building department files for two more homes in the same municipality as each on-site visit. This would result in a sample of building department files for 40 on-site homes and 80 additional homes. The additional two homes in each town were randomly selected from the new permanent electric service request data. NMR did not select homes based on the completeness of their building permit files to avoid potential bias towards more efficient builders who might be more likely to file complete energy performance paperwork.

Specifically, NMR attempted data collection from building departments using a few different methods. The first step was to conduct background research on the specified municipalities' website to see if building department documentation was available in an online format available to download. This has been a common response from various towns when conducting this type of data collection in the past. If documentation was not available on the town website, NMR technicians contacted the building department via email and by phone to request documentation. The preferred outcome was to have the requested files sent via email or fax to avoid travel, but if that was not possible then technicians would travel to the building department to view documents in person and take photos. Occasionally, technicians were requested to file Freedom of Information Act requests before the building department would provide files. The specific file types that were requested using any of the above methods were as follows:

- Building permits
- Blueprints
- REScheck files
- Prescriptive energy code checklists
- HERS rating certificates
- IECC certificates
- Blower door results
- Duct leakage results
- ENERGY STAR homes submittals
- Manual J documentation

Once documentation was obtained, NMR technicians reviewed the files and transcribed various equipment and building shell component types and efficiency values into the data collection form. Overall, NMR was able to collect at least some usable data from 110 (92%) out of the 120 total sample of homes from building departments. Of the 10 homes for which data was not able to be collected it was either because a) the files that were available did not provide any meaningful information, b) the department denied the request, or c) the department was or became unresponsive.

Appendix B Detailed Findings

In this section, we provide detailed findings from the on-site data collection, broken out by measure category and by custom homes and spec homes. To increase sample sizes, building department data was included in a limited number of tables where it was found to be accurate enough in comparison to onsite data. Specifically, building department data was used to calculate average R-values of walls, ceilings, and floors. The team presented a comparison of building department and onsite data from the same homes to Rhode Island Energy and made the decision on which data to include with their consultation. Tables are broken down into custom and spec homes as well as a statewide value. Significance testing was performed between custom and spec results, significantly different results are notated with the ^{a} superscript symbol.

B.1 General Home Characteristics

Table 19. Home Type

	Custom	Spec	Statewide
n	18	22	40
Detached Single-Family	100%	95%	98%
Attached Single-Family	--	5%	2%

Table 20. Home Age

	Custom	Spec	Statewide
n	18	22	40
2019	--	9%	5%
2020	33%	32%	32%
2021	56%	41%	48%
2022	11%	18%	15%

Table 21. Number of Bedrooms

	Custom	Spec	Statewide
n	18	22	40
Mean	3.1	3.0	3.0
Min	1.0	2.0	1.0
Max	4.0	4.0	4.0

Median	3.0	3.0	3.0
Std. Dev.	0.8	0.6	0.7

Table 22. Total Occupants per Home

	Custom	Spec	Statewide
n	18	22	40
1	11%	9%	10%
2	50%	41%	45%
3	22%	23%	22%
4	11%	5%	8%
5	--	18%	10%
6	6%	--	2%
7	--	5%	2%

Table 23. Total Stories

	Custom	Spec	Statewide
n	18	22	40
1	28%	45%	38%
2	67%	55%	60%
3	6%	--	2%

Table 24. Conditioned Floor Area

	Custom	Spec	Statewide
n	18	22	40
Mean	2,285	2,103	2,185
Min	970	1,150	970
Max	3,412	4,285	4,285
Median	2,245	1,928	2,084
Std. Dev.	663	738	702

Table 25. HERS Score

	Custom	Spec	Statewide
n	18	22	40
Mean	51	72	63
Min	-35	34	-35
Max	74	100	100

Table 26. Program and Non-Program Average HERS Score by Homes Size

	Program	Non-Program
n	441	40
Less than 1,800 Sq. Ft.	60	71
1,800 to 2,400 Sq. Ft.	66	59
Over 2,400 Sq. Ft.	62	61

B.2 Building Shell

B.2.1 Air Infiltration and Ventilation

Table 27. Air Infiltration (ACH50)

(Onsites: Conditioned spaces within building envelope)

	Custom	Spec	Statewide
n	18	22	40
Mean	3.8	5.2[a]	4.6
Min	1.1	2.6	1.1
Max	6.3	11.6	11.6
Median	3.8	5.2	4.5
Std. Dev.	1.7	2.0	2.0

B.2.2 Walls

Table 28. Average Wall R-Values

(Onsites: Conditioned to Ambient)

	Custom	Spec	Statewide
n	18	22	40
Mean	22.1	21.0	21.5
Min	19.0	20.0	19.0
Max	33.0	22.0	33.0
Median	21.0	21.0	21.0
Std. Dev.	4.0	0.3	2.7

Table 29. Average Wall R-Values – Combined Data

(Combined Onsites and Building Department: Conditioned to Ambient)

	Statewide
n	75
Mean	21.3
Min	19.0
Max	39.0
Median	21.0
Std. Dev.	2.6

Table 30. Primary Insulation in Above Grade Walls

(Onsites: Conditioned to Ambient)

	Custom	Spec	Statewide
n	18	22	40
Fiber Glass Batts	81%	91%	86%
CCF spray foam (high density)	19%	4%	12%
Rock wool board	NA	5%	3%

Table 31. Insulation Grade* in Above Grade Walls

(Onsites: Conditioned to Ambient)

	Custom	Spec	Statewide
n	18	22	40
1	62%	42%	52%
2	38%	58%	48%
3	NA	NA	NA

* When insulation was not visible (e.g., an enclosed cavity), the installation Grade was determined based on other areas of the home. For example, if exterior wall insulation was visible in an unfinished walkout basement and assigned a Grade II installation, then the above grade walls for that home were typically also given that Grade.

Table 32. Average Wall R-Values

(Onsites: Conditioned to Ambient, Garage, Basement, and Attic Combined)

	Custom	Spec	Statewide
n	18	22	40
Mean	22.1	20.4	21.2
Min	19.0	9.3	9.3
Max	33.0	21.0	33.0
Median	21.0	21.0	21.0
Std. Dev.	4.0	2.5	3.3

Table 33. Primary Insulation in Above Grade Walls

(Onsites: Conditioned to Ambient, Garage, Basement, and Attic Combined)

	Custom	Spec	Statewide
n	18	22	40
Fiber Glass Batts	81%	91%	86%
CCF spray foam (high density)	19%	4%	11%
Rock wool board	NA	5%	3%
FGB and Polyisocyanurate (foil faced)	1%	NA	<1%
FGB and XPS (pink/blue/green)	<1%	NA	<1%
None	NA	0%	0%

Table 34. Insulation Grade in Above Grade Walls

(Onsites: Conditioned to Ambient, Garage, Unconditioned Basement, and Attic Combined)

	Custom	Spec	Statewide
n	18	22	40
1	63%	43%	52%
2	37%	57%	47%
3	NA	<1%	<1%

Table 35. Average Wall R-Values

(Onsites: Conditioned to Garage)

	Custom	Spec	Statewide
n	10	15	25
Mean	23.4	20.5	21.7
Min	21.0	15.0	15.0
Max	33.0	21.0	33.0
Median	21.0	21.0	21.0
Std. Dev.	5.1	1.6	3.6

Table 36. Average Wall R-Values

(Onsites: Conditioned to Unconditioned Basement)

	Custom	Spec	Statewide
n	11	15	26
Mean	21.7	19.1	20.2
Min	19.0	1.0	1.0
Max	33.0	21.0	33.0
Median	21.0	21.0	21.0
Std. Dev.	3.8	5.4	4.9

Table 37. Average Wall R-Values

(Onsites: Conditioned to Attic)

	Custom	Spec	Statewide
n	5	9	14
Mean	23.4	21.0	21.9
Min	21.0	20.0	20.0
Max	27.0	22.0	27.0
Median	21.0	21.0	21.0
Std. Dev.	3.3	0.5	2.2

B.2.3 Ceilings

Table 38. Vented Attic Ceiling R-values

	Custom	Spec	Statewide
n	10	21	31
Mean	38.7	39.0	38.9
Min	38.0	28.9	28.9
Max	42.6	49.0	49.0
Median	38.0	38.0	38.0
Std. Dev.	1.5	5.2	4.3

Table 39. Vented Attic Ceiling R-values for Combined Onsites and Permit Reviews

	Statewide
n	65
Mean	39.0
Min	28.9
Max	60.0
Median	38.0
Std. Dev.	4.4

Table 40. Vented Attic Ceiling Insulation Type

	Custom	Spec	Statewide
n	10	21	31
Fiberglass batts	77%	76%	76%
Cellulose, loose fill	17%	10%	12%
Fiberglass, loose fill	5%	8%	7%
Fiberglass batts and cellulose, loose fill	NA	7%	4%
None	NA	<1%	<1%

Table 41. Vented Attic Ceiling Insulation Grade

	Custom	Spec	Statewide
n	10	21	31
1	54%	31%	39%
2	13%	56%	41%
3	32%	14%	20%

Table 42. Vaulted Ceiling R-values

	Custom	Spec	Statewide
n	12	4	16
Mean	38.3	31.8	36.6
Min	30.0	20.0	20.0
Max	51.0	39.0	51.0
Median	38.0	34.0	38.0
Std. Dev.	5.7	8.8	6.9

Table 43. Vaulted Ceiling R-values for Both Onsites and Permit Reviews

	Statewide
n	24
Mean	36.9
Min	20.0

	Statewide
Max	51.0
Median	38.0
Std. Dev.	6.4

Table 44. Vaulted Ceiling Insulation Type

	Custom	Spec	Statewide
n	12	4	16
Open cell spray foam (low density)	43%	-	37%
Closed cell spray foam (high density)	30%	77%	36%
Fiberglass batts	27%	23%	27%

Table 45. Vaulted Ceiling Insulation Grade

	Custom	Spec	Statewide
n	12	4	16
1	65%	89%	68%
2	23%	11%	21%
3	12%	NA	11%

B.2.4 Floors

Table 46. Conditioned/Unconditioned Basement Floor R-values

	Custom	Spec	Statewide
n	13	16	29
Mean	27.5	27.6	27.6
Min	0.0	0.0	0.0
Max	38.0	31.1	38.0
Median	30.0	30.0	30.0
Std. Dev.	9.1	7.7	8.2

Table 47. Conditioned/Unconditioned Basement Floor R-values for Both Onsites and Permit Reviews

	Statewide

n	57
Mean	28.1
Min	0.0
Max	42
Median	30.0
Std. Dev.	6.1

Table 48. Conditioned/Unconditioned Basement Insulation Type

	Custom	Spec	Statewide
n	13	16	29
Fiberglass Batts	92%	90%	91%
None	8%	10%	9%

Table 49. Conditioned/Unconditioned Basement Insulation Grade

	Custom	Spec	Statewide
n	13	16	29
1	43%	12%	27%
2	21%	47%	35%
3	35%	41%	38%

Table 50. Conditioned/Garage Floor R-values

	Custom	Spec	Statewide
n	6	9	15
Mean	30.0	30.0	30.0
Min	30.0	30.0	30.0
Max	30.0	30.0	30.0
Median	30.0	30.0	30.0
Std. Dev.	0.0	0.0	0.0

B.2.5 Foundation Walls

Table 51. Primary Insulation in Foundation Walls
(Onsites: Conditioned Foundation Walls)

	Custom	Spec	Statewide
n	7	14	21
CCF spray foam (high density)	100%	0%	33%
Fiberglass batt	0%	36%	24%
Rock Wool Board	0%	36%	24%
None	0%	29%	19%

Table 52. Foundation Wall Insulation Grade
(Onsites: Conditioned Foundation Walls)

	Custom	Spec	Statewide
n	7	14	21
1 (Best)	100%[a]	50%	67%
2 (Typical)	0%	36%	24%
3 (Poor)	0%	0%	0%
N/A	0%	14%	10%

Table 53. Average R-Value of Conditioned Foundation Wall Insulation
(Onsites: Conditioned Foundation Walls)

	Custom	Spec	Statewide
n	7	14	21
Mean	29.6[a]	12.6	18.2
Min	21.0	0.0	0.0
Max	33.0	21.0	33.0
Median	33.0	15.0	19.0
Std. Dev.	5.9	8.6	11.2

None of the unconditioned foundation walls observed in this study were insulated.

B.2.6 Rim Joists

Table 54. Average R-Value of Conditioned Rim Joists

(Onsites: Conditioned to Ambient Rim Joists)

	Custom	Spec	Statewide
n	4	5	9
Mean	27.1	17.8	22.0
Min	12.6	15.0	12.6
Max	33.0	21.0	33.0
Median	31.5	19.0	19.0
Std. Dev.	9.8	2.7	8.0

Table 55. Average R-Value of Unconditioned Rim Joists

(Onsites: Unconditioned to Ambient Rim Joists)

	Custom	Spec	Statewide
n	19	25	44
Mean	24.7	23.7	24.2
Min	15.0	0.0	0.0
Max	38.0	30.0	38.0
Median	21.0	27.2	24.1
Std. Dev.	6.9	8.0	7.5

Table 56. Rim Joist Insulation Grade

(Onsites: All Rim Joists)

	Custom	Spec	Statewide
n	23	30	53
1	70%[a]	33%	49%
2	17%[a]	50%	36%
3	13%	13%	13%
N/A	0%	3%	2%

Table 57. Rim Joist Insulation Type
(Onsites: All Rim Joists)

	Custom	Spec	Statewide
n	23	30	53
Fiberglass batt	56%[a]	83%	72%
CCF spray foam (high density)	39%[a]	3%	19%
OCF spray foam (low density)	4%	3%	4%
Rock wood board	0%	7%	4%
None	0%	3%	2%

B.2.7 Slabs

Table 58. Insulation Type for Slabs
(Onsites: Perimeter Insulation of Conditioned Slabs)

	Custom	Spec	Statewide
n	6	11	17
None	100%	82%	88%
XPS (pink/blue/green)	0%	18%	12%

B.2.8 Windows

Table 59. Average Window U-factors
(Onsites: Confirmed Values Only)

	Custom	Spec	Statewide
n	28	50	78
Mean	0.30	0.30	0.30
Min	0.27	0.28	0.27
Max	0.34	0.31	0.34
Median	0.29	0.30	0.29
Std. Dev.	0.02	0.01	0.01

Table 60. Glazing Type

(Onsites: Percentage of Total Window Area)

	Custom	Spec	Statewide
n (Window Square Footage)	5847	5404	11251
Double pane, low-e coating	71%	63%	67%
Double pane, low-e coating, argon	21%	23%	22%
Triple pane, low-e coating, argon	6%	14%	10%
Double Pane	2%	0%	1%

B.3 Mechanical Equipment

B.3.1 Heating

Table 61. Primary Heating Systems

(Onsites: All Homes)

Type	Custom	Spec	Statewide
n	18	22	40
Furnace	61%	86%	75%
Boiler (hydro-air)	22%	5%	12%
Mini-split	11%	--	5%
ASHP	6%	--	2%
Electric baseboard	--	5%	2%
Furnace, dual-fuel[1]	--	5%	2%

1Dual fuel furnaces refers to the usage of an electric heat pump with a fossil fuel furnace as a backup heating source.

Table 62. Primary Heating System Fuel

(Onsites: All Homes)

	Custom	Spec	Statewide
n	18	22	40
Propane	61%	63%	62%
Natural gas	22%	32%	28%
Electricity	17%	5%	10%

Table 63. Primary Heating System Location

(Onsites: All Homes)

	Custom	Spec	Statewide
n	18	22	40
Unconditioned basement/enclosed crawlspace	72%	60%	65%
Vented attic	6%	23%	15%
Conditioned space	6%	14%	10%
Ambient	11%	--	5%
Garage	--	5%	2%
Sealed attic	6%	0%	2%

Table 64. Primary Heating System Efficiency (AFUE)

(Onsites: Primary Heating Systems with AFUE Rating)

	Custom	Spec	Statewide
n	15	21	36
Mean	93.6	90.6	91.6
Min	80.0	80.0	80.0
Max	97.0	96.5	97.0
Median	95.0	92.1	95.0
Std. Dev	4.0	6.3	5.6

Table 65. Primary Heating ENERGY STAR Status

(Onsites: All Homes)

	Custom	Spec	Statewide
n	18	22	40
Yes	89%	41%	62%
No	11%	59%	38%

Table 66. All Heating System Efficiency (AFUE)

(Onsites: All Heating Systems with AFUE Rating)

	Custom	Spec	Statewide
n	19	28	47
Mean	93.0	90.4	91.4
Min	80.0	80.0	80.0
Max	97.0	96.5	97.0
Median	95.0	92.1	93.0
Std. Dev	4.8	6.3	5.8

Table 67. Secondary Heating Equipment Type

(Onsites: Secondary Heating Systems)

	Custom	Spec	Statewide
n	11	11	22
Furnace	36%	64%	50%
Mini-split	45%	9%	27%
ASHP	9%	9%	9%
Electric baseboard	--	18%	9%
Fireplace insert/wood stove	9%	--	5%

Table 68. All Heating System Fuel

(Onsites: All Heating Systems)

	Custom	Spec	Statewide
n	32	40	72
Propane	44%	55%	50%
Electricity	38%	16%	25%
Natural gas	19%	30%	25%

Table 69. All Heating System Type

(Onsites: All Heating Systems)

	Custom	Spec	Statewide
n	32	40	72
Furnace	47%	65%	57%
Fireplace insert/wood stove	9%	18%	14%
Mini-split	22%	2%	11%
Boiler (hydro-air)	12%	2%	7%
ASHP	6%	2%	4%
Electric baseboard	--	8%	4%
Furnace, dual-fuel	--	2%	1%
Portable space heater	3%	--	1%

Table 3570. Furnace Fuel

(Onsites: Furnaces)

	Custom	Spec	Statewide
n	15	26	41
Propane	60%	62%	61%
Natural Gas	40%	38%	39%

Table 36 71. Furnace ENERGY STAR Status

(Onsites: Furnaces)

	Custom	Spec	Statewide
n	15	26	41
Yes	80%	35%	51%
No	20%	65%	49%

Table 72. Furnace Efficiency (AFUE)
(Onsites: All Furnaces with AFUE Rating)

	Custom	Spec	Statewide
n	15	26	41
Mean	92.4	90.0	90.9
Min	80.0	80.0	80.0
Max	97.0	96.5	97.0
Median	95.0	92.1	92.1
Std. Dev	5.3	6.4	6.0

Table 73. Heat Pump Efficiency (HSPF)
(Onsites: MSHPs and ASHPs with HSPF Rating)

	Custom	Spec	Statewide
n	9	2	11
Mean	10.7	8.6	10.3
Min	9.0	8.2	8.2
Max	12.5	9.0	12.5
Median	10.6	8.6	10.5
Std. Dev	1.2	0.6	1.4

There were five boilers found during onsite visits; all used propane as their fuel, all were ENERGY STAR certified, and all had an AFUE of 95.

B.3.2 Cooling

Table 74. Primary Cooling System Type
(Onsites: All Homes)

	Custom	Spec	Statewide
N	18	22	40
Central air-split	83%	91%	88%
Mini-split	11%	--	5%
ASHP	6%	5%	5%
Room air conditioner	--	5%	2%

Table 75. Primary Cooling System Location
(Onsites: All Homes)

	Custom	Spec	Statewide
n	18	22	40
Unconditioned basement	67%	50%	58%
Vented attic	11%	36%	25%
Ambient	11%	--	5%
Conditioned area	6%	5%	2%
Sealed attic	6%	--	2%
Garage	--	5%	2%

Table 76. Primary Cooling System ENERGY STAR Status
(Onsites: All Homes)

	Custom	Spec	Statewide
n	18	22	40
Yes	39%	45%	42%
No	61%	55%	57%

Table 77. Primary Cooling System Efficiency (SEER)
(Onsites: Primary Cooling Systems with SEER Value)

	Custom	Spec	Statewide
n	18	21	39
Mean	14.6	13.8	14.2
Min	13.0	13.0	12.0
Max	20.0	16.5	20.0
Median	13.8	13.5	13.5
Std. Dev	2.2	0.9	1.7

Table 78. All Cooling System Efficiency (SEER)

(Onsites: All Cooling Systems with SEER Value)

	Custom	Spec	Statewide
n	30	29	59
Mean	15.6	13.9	14.8
Min	13.0	13.0	13.0
Max	26.1	16.5	26.1
Median	14.0	14.0	14.0
Std. Dev	3.4	0.9	2.6

Table 79. Central Air Conditioner Efficiency (SEER)

(Onsites: Central ACs with SEER Value)

	Custom	Spec	Statewide
n	21	27	48
Mean	13.8	13.8	13.8
Min	13.0	13.0	13.0
Max	18.0	16.5	18.0
Median	13.5	14.0	13.8
Std. Dev.	1.1	0.8	1.0

Table 80. Central Air Conditioner ENERGY STAR Status

(Onsites: Central ACs)

	Custom	Spec	Statewide
n	21	27	48
Yes	24%	33%	29%
No	76%	67%	71%

Table 81. Heat Pump Cooling Efficiency (SEER)

(Onsites: MSHPs and ASHPs with SEER Rating)

	Custom	Spec	Statewide
n	9	2	11
Mean	20.0	15.5	19.2
Min	16.0	15.0	15.0
Max	26.1	16.0	26.1
Median	20.0	15.5	19.5
Std. Dev.	2.9	0.7	3.2

Table 82. Heat Pump ENERGY STAR Status

(Onsites: MSHPs and ASHPs)

	Custom	Spec	Statewide
n	9	2	11
Yes	100%	50%	90%
No	--	50%	10%

Table 83. MSHP Cooling Efficiency (SEER)

(Onsites: MSHPs with SEER Rating)

	Custom	Spec	Statewide
n	7	1	8
Mean	21.0	16.0	20.4
Min	19.0	16.0	16.0
Max	26.1	16.0	26.1
Median	20.0	16.0	20.0
Std. Dev	2.4	NA	2.9

Table 84. ASHP Cooling Efficiency (SEER)

(Onsites: ASHPs with SEER Rating)

	Custom	Spec	Statewide
n	2	1	3
Mean	16.5	15.0	16.0
Min	16.0	15.0	15.0
Max	17.0	15.0	17.0
Median	16.5	15.0	16.0
Std. Dev.	0.7	NA	1.0

There were three room air conditioners found during on-site visits, they were all ENERGY STAR certified and had a CEER of 12.

B.3.3 Thermostats

Table 85. Thermostat Type

(Onsites: Thermostats)

	Custom	Spec	Statewide
n	33	35	68
Programmable	48%	63%	56%
Programmable + Wi-Fi	18%	17%	18%
Manual	15%	11%	13%
Smart	18%	9%	13%

Table 86. Summer Set Point

(Onsites: Thermostats with Verified Set Points)

	Custom	Spec	Statewide
n	29	35	64
Mean	72.4	71.0	71.6
Min	64.0	65.0	64.0
Max	76.0	79.0	79.0
Median	74.0	74.0	74.0
Std. Dev	3.1	12.7	9.6

Table 87. Winter Set Point

(Onsites: Thermostats with Verified Set Points)

	Custom	Spec	Statewide
n	29	35	64
Mean	67.9	68.3	68.1
Min	65.0	60.0	60.0
Max	75.0	76.0	76.0
Median	68.0	68.0	68.0
Std. Dev	2.8	3.4	3.1

B.3.4 Ducts

Table 88. Duct Location Penetration

(Onsites: Homes with Various Duct Locations Present)

	Custom	Spec	Statewide
n	56	59	115
Unconditioned basement	40%	29%	34%
Vented attic	18%	41%	30%
Conditioned space	18%	12%	15%
Sealed attic	15%	2%	8%
Conditioned basement	2%	12%	7%
Enclosed crawlspace	7%	3%	5%
Garage	0%	2%	1%

Table 89. Duct Insulation Type Penetration

(Onsites: Homes with Various Duct Locations Present)

	Custom	Spec	Statewide
n	56	59	115
Fiberglass wrap	54%	66%	60%
Bubble wrap	43%	31%	37%
Internal	0%	3%	2%
Uninsulated	4%	0%	2%

Table 90. Duct Leakage to the Outside (CFM25/100 sq. ft.)*
(Onsites: Duct Systems)

	Custom	Spec	Statewide
n	23	22	45
Mean	5.2	11.5	8.3
Min	0.0	0.0	0.0
Max	18.7	33.2	33.2
Median	3.8	7.4	4.6
St. Dev.	5.3	11.1	9.1

*Removed 2 outliers

Table 91. Total Duct Leakage (CFM25/100 sq. ft.)*
(Onsites: Duct Systems)

	Custom	Spec	Statewide
n	20	23	43
Mean	21.7	27.0	24.6
Min	5.7	3.5	3.5
Max	46.8	80.6	80.6
Median	18.2	21.7	21.7
St. Dev.	12.5	20.5	17.2

*Removed 3 outliers

B.3.5 Domestic Hot Water

Table 92. Water Heater Type
(Onsites: Water Heaters)

	Custom	Spec	Statewide
n	19	22	41
Instantaneous	47%	50%	49%
Storage, stand-alone	21%	45%	34%
Instantaneous, combi boiler	11%	5%	7%
Storage, heat pump	11%	0%	5%
Storage, indirect heat	11%	0%	5%

Table 93. Water Heater Fuel
(Onsites: Water Heaters)

	Custom	Spec	Statewide
n	19	22	41
Propane	58%	59%	59%
Electric	26%	32%	29%
Natural gas	16%	9%	12%

Table 94. Water Heater ENERGY STAR Status
(Onsites: Water Heaters)

	Custom	Spec	Statewide
n	19	22	41
Yes	78%	50%	62%
No	22%	50%	38%

Table 95. Water Heater Location
(Onsites: Water Heaters)

	Custom	Spec	Statewide
n	19	22	41
Unconditioned basement/enclosed crawlspace	78%	77%	78%
Conditioned basement	11%	14%	12%
Conditioned 1-3 floor	11%	0%	5%
Garage	0%	9%	5%

Table 96. All Water Heater Efficiency (EF)

(Onsites: Water Heaters, Converted from UEF)

	Custom	Spec	Statewide
n	19	22	41
Mean	1.17	0.89	1.02
Min	0.68	0.66	0.66
Max	3.45	0.96	3.45
Median	0.93	0.93	0.93
Std. Dev.	0.80	0.09	0.56

Table 97. Fossil Fuel Water Heater Efficiency (EF)

(Onsites: Fossil Fuel Water Heaters, Converted from UEF)

	Custom	Spec	Statewide
n	14	15	29
Mean	0.90	0.87	0.89
Min	0.68	0.66	0.66
Max	0.96	0.96	0.96
Median	0.93	0.93	0.93
Std. Dev.	0.08	0.10	0.09

Table 98. Electric Heater Efficiency (EF)

(Onsites: Electric Water Heaters, Converted from UEF)

	Custom	Spec	Statewide
n	5	7	12
Mean	1.94a	0.92	1.35
Min	0.92	0.92	0.92
Max	3.45	0.93	3.45
Median	0.93	0.92	0.93
Std. Dev.	1.38	0.01	0.98

Table 99. Instantaneous Water Heater Efficiency (EF)
(Onsites: Water Heaters)

	Custom	Spec	Statewide
n	9	11	20
Mean	0.92	0.91	0.92
Min	0.81	0.81	0.81
Max	0.96	0.96	0.96
Median	0.93	0.93	0.93
Std. Dev.	0.04	0.05	0.05

Table 100. Combi Water Heater Efficiency (EF)
(Onsites: Water Heaters)

	Custom	Spec	Statewide
n	2	1	3
Mean	0.95	0.95	0.95
Min	0.95	0.95	0.95
Max	0.95	0.95	0.95
Median	0.95	0.95	0.95
Std. Dev.	0.00	NA	0.00

Table 101. Electric Resistance Storage Water Heater Efficiency (EF)
(Onsites: Water Heaters)

	Custom	Spec	Statewide
n	3	7	10
Mean	0.93	0.92	0.92
Min	0.92	0.92	0.92
Max	0.93	0.93	0.93
Median	0.93	0.92	0.92
Std. Dev.	0.01	0.01	0.01

Table 102. Natural Gas and Propane Storage Water Heater Efficiency (EF)
(Onsites: Water Heaters)

	Custom	Spec	Statewide
n	1	3	4
Mean	0.68	0.69	0.69
Min	0.68	0.66	0.66
Max	0.68	0.72	0.72
Median	0.68	0.70	0.69
Std. Dev.	NA	0.03	0.03

B.3.6 Water Fixtures

Table 103. Presence of Aerator

	Custom	Spec	Statewide
n	73	86	159
Yes	97%	96%	97%
No	3%	3%	3%

Table 104. Flow Rate

	Custom	Spec	Statewide
n	54	70	124
Mean	1.7	1.6	1.7
Min	1.2	1.2	1.2
Max	2.5	2.5	2.5
Median	1.8	1.5	1.6
Std. Dev	0.4	0.4	0.4

B.3.7 Renewables and Electric Vehicles

Table 105. Penetration of Renewables and Electrification Measures

	Custom	Spec	Statewide
n	18	22	40
Solar PV	22%	4.5%	12%

Electric Vehicle	11%	-	5%
Battery Storage	5%	-	2%

Table 106. PV Capacity (kW)

	Custom	Spec	Statewide
n	6	1	7
Mean	10.5	5.7	9.8
Min	5.7	5.7	5.7
Max	17.0	5.7	17.0
Median	9.9	5.7	9.9
Std. Dev	4.3	-	4.4

B.3.8 Electrification Potential

Table 107. Wiring Orientation

	Custom	Spec	Statewide
n	18	22	40
Top	61%	55%	57%
Side	33%	32%	32%
Bottom	6%	14%	10%

Table 108. Wiring Phase

	Custom	Spec	Statewide
n	18	22	40
3W	100%	100%	100%

Table 109. Dryer Fuel

	Custom	Spec	Statewide
n	17	19	36
Electric (208 / 240v)	70%	74%	72%
Electric (110V)	6%	26%	17%

Propane	24%	--	11%

Table 110. Washer Configuration

	Custom	Spec	Statewide
n	17	19	36
Front Load	47%	61%	54%
Top Load	53%	39%	46%

Table 111. Range Fuel

	Custom	Spec	Statewide
n	20	21	41
Propane	55%	76%	66%
Electric	35%	10%	22%
Natural Gas	10%	14%	12%

B.4 Building Department Data

The following section details average efficiency values only from data collected at building departments.

Table 112. Type of Documentation Available at Building Departments

Type	Statewide
n	120
Permit	98%
Blueprints	72%
Blower Door Results	61%
Duct Leakage Results	41%
Inspection Checklist	12%
IECC Energy Certificate	11%
Compliance Certificate	8%
HERS Certificate	7%
ENERGY STAR Home Certification	1%

B.4.1 Heating

Table 113. Availability of Heating Data

Metric	Statewide
n	120
System Type	59%
Fuel	33%
Efficiency	18%

Table 114. Heating System Type

Type	Statewide
n	127
Furnace	48%
Fireplace insert/Wood stove	22%
Boiler (hydro-air)	10%
Mini-split	6%
GSHP	5%
ASHP	3%
Boiler (forced hot water)	3%
DHW as boiler	2%
Open hearth/fireplace	1%

Table 115. Heating System Fuel

Fuel	Statewide
n	127
Propane	67%
Electricity	28%
Natural Gas	4%
Wood	1%

Table 116. All Heating System Efficiency (AFUE)

	Statewide
n	22
Mean	92.1
Min	80.0
Max	98.0
Median	94.0
Std. Dev.	4.8

Table 117. Heat Pump Efficiency (COP)

	Statewide
n	4
Mean	3.4
Min	3.1
Max	3.8
Median	3.4
Std. Dev.	0.4

Table 118. Boiler Efficiency (AFUE)

	Statewide
n	6
Mean	93.5
Min	90.0
Max	98.0
Median	94.0
Std. Dev.	3.1

Table 119. Furnace Efficiency (AFUE)

	Statewide

n	15
Mean	91.3
Min	80.0
Max	96.5
Median	90.0
Std. Dev.	5.4

B.4.2 Cooling

Table 120. Availability of Cooling Data

Metric	Statewide
n	120
System Type	43%
Efficiency	11%

Table 121. Primary Cooling System Type

Type	Statewide
n	80
Central Air-split	76%
Mini-split	10%
GSHP	8%
ASHP	6%

Table 122. All Cooling System Efficiency (SEER)

	Statewide
n	17
Mean	16.1
Min	12.8
Max	30.0
Median	16.0
Std. Dev.	4.1

Table 123. Central Air Conditioner Cooling Efficiency (SEER)

	Statewide
n	12
Mean	14.7
Min	12.8
Max	20.0
Median	14.2
Std. Dev.	2.1

Table 124. Mini-Split Cooling Efficiency (SEER)

	Statewide
n	2
Mean	24.5
Min	19.0
Max	30.0
Median	24.5
Std. Dev.	7.8

B.4.3 Domestic Hot Water

Table 125. Availability of Water Heater Data

Metric	Statewide
n	127
System Type	14%
Fuel	14%
Efficiency	10%

Table 126. Water Heater Type

Type	Statewide
n	31
Instantaneous	56%
Storage, Indirect heat	22%
Storage, Stand-alone	17%

Instantaneous, Combi boiler	6%

Table 127. Water Heater Fuel

Fuel	Statewide
n	31
Propane	61%
Natural Gas	22%
Electric	17%

Table 128. All Water Heater Efficiency (UEF)

	Statewide
n	7
Mean	0.9
Min	0.9
Max	1.0
Median	0.9
Std. Dev.	0.0

B.4.4 Above-Grade Walls

Table 129. Availability of Wall Data

Metric	Statewide
n	120
Insulation Type	62%
R-Value	59%

Table 130. Primary Wall Cavity Insulation Type

	Statewide
n	81
Fiberglass batt	49%
Unknown	37%
CCF spray foam (high density)	5%

OCF spray foam (low density)	5%
Cellulose, dense pack	1%
None	1%
OCF spray foam (low density) and CCF spray foam (high density)	1%

Table 131. Average Wall R-Value for Cavity Insulation

	Statewide
n	76
Mean	20.8
Min	13.0
Max	30.0
Median	21.0
Std. Dev.	1.7

Table 132. Average Wall R-Value for Continuous Insulation

	Statewide
n	58
Mean	0.3
Min	0.0
Max	18.0
Median	0.0
Std. Dev.	2.4

Table 133. Average Wall Total R-Value

	Statewide
n	56
Mean	20.9
Min	15.0
Max	30.0

Median	21.0
Std. Dev.	1.7

B.4.5 Ceilings

Table 134. Availability of Ceiling Data

Metric	Statewide
n	120
Insulation Type	62%
R-Value	61%

Table 135. Primary Ceiling Cavity Insulation Type

	Statewide
n	83
Unknown	48%
Fiberglass batt	28%
CCF spray foam (high density)	12%
OCF spray foam (low density)	4%
OCF spray foam (low density); CCF spray foam (high density)	3%
Blown	1%
Cellulose, loose fill	1%
FGB, cathedral	1%
Fiberglass, loose fill	1%

Table 136. Primary Ceiling Continuous Insulation Type

	Statewide
n	83
None	86%
Unknown	8%

Blown, unknown	2%
Cellulose, loose fill	2%
Fiberglass, loose fill	2%

Table 137. Average Ceiling R-Value for Cavity Insulation

	Statewide
n	73
Mean	37.9
Min	8
Max	60
Median	38
Std. Dev.	6.9

Table 138. Average Ceiling Total R-Value

	Statewide
n	73
Mean	38.6
Min	28.8
Max	49.0
Median	38.0
Std. Dev.	4.0

B.4.6 Floors

Table 139. Availability of Floor Data

Metric	Statewide
n	120
Insulation Type	48%
R-Value	47%

Table 140. Primary Floor Cavity Insulation Type

	Statewide
n	67
Fiberglass batt	47%
Unknown	43%
Batt, unknown	3%
CCF spray foam (high density)	3%
Rock wool board	3%

Table 141. Average Floor R-Value for Cavity Insulation

	Statewide
n	58
Mean	28.8
Min	15.0
Max	42.0
Median	30.0
Std. Dev.	4.6

B.4.7 Windows

Table 142. Availability of Window Data

Metric	Statewide
n	120
U-Factor	26%
SHGC	21%

Table 143. Average Window U-factor (Confirmed Values Only)

	Statewide
n	31
Mean	0.30
Min	0.19
Max	0.35
Median	0.30

Std. Dev.	0.03

Table 144. Average Window SHGC (Confirmed Values Only)

	Statewide
n	25
Mean	0.30
Min	0.19
Max	0.49
Median	0.30
Std. Dev.	0.07

B.4.8 Air Leakage

Table 145. Availability of Air Leakage Data

Metric	Statewide
n	120
ACH50	63%

Table 146. Average Air Infiltration (ACH50)

	Statewide
n	76
Mean	3.8
Min	0.4
Max	7.4
Median	3.6
Std. Dev.	1.5

B.4.9 Duct Leakage

Table 147. Availability of Duct Leakage Data

Metric	Statewide
n	120
Total Leakage (CFM25 per 100 sq. ft.)	43%

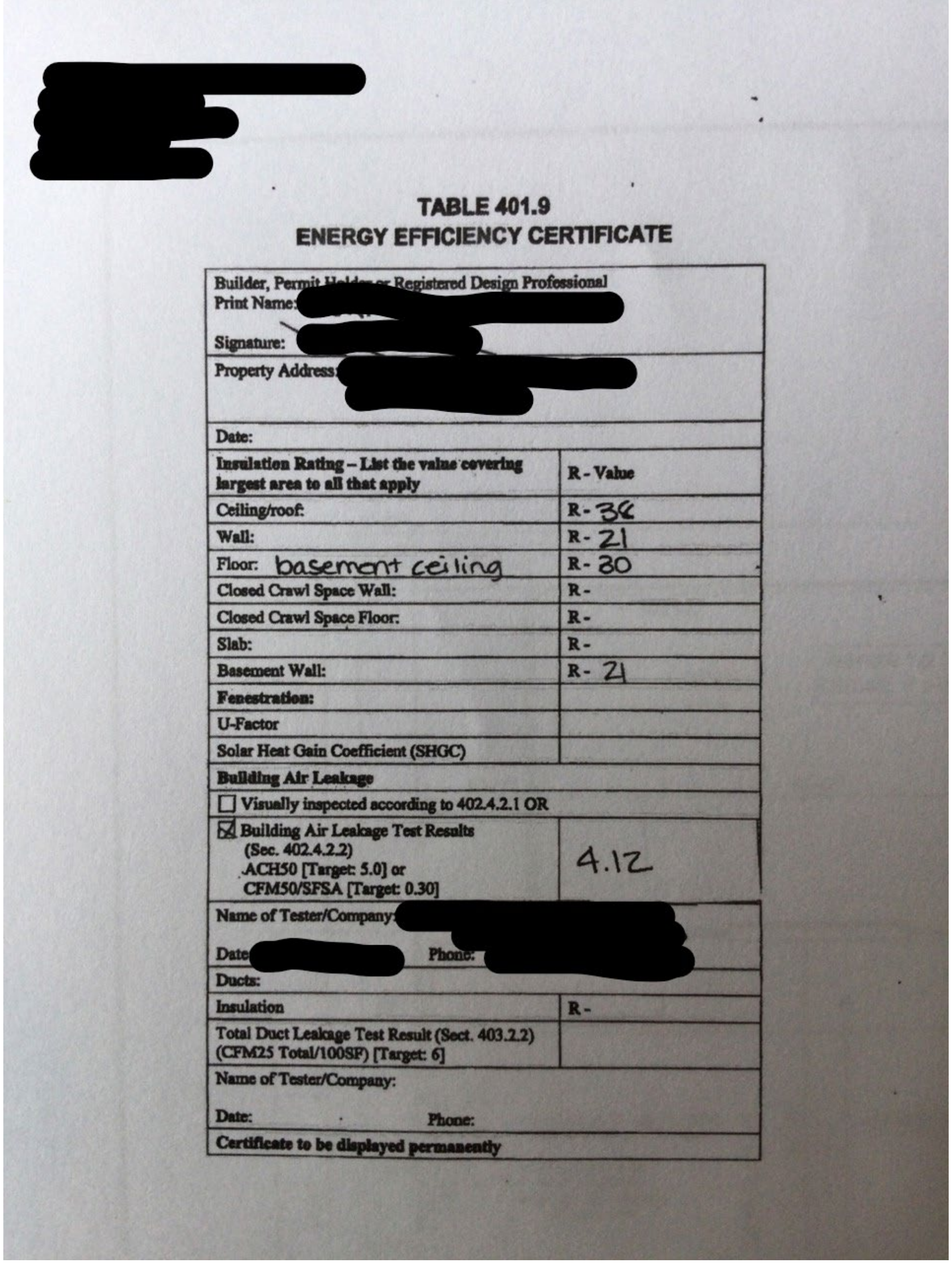
Table 148. Average Total Duct Leakage per 100 Square Feet (CFM25)

	Statewide
n	75
Mean	5.8
Min	0.8
Max	27.9
Median	5.3
Std. Dev.	3.3

Appendix C Building Department Forms

The following section provides examples of types of documentation obtained at building departments including energy certificates, IECC compliance checklists, blower door results, and duct blaster results.

C.1 Energy Certificates



[redacted]

TABLE 401.9
ENERGY EFFICIENCY CERTIFICATE

Builder, Permit Holder or Registered Design Professional
Print Name: [redacted]
Signature: [redacted]

Property Address: [redacted]

Date:

Insulation Rating – List the value covering largest area to all that apply	**R - Value**
Ceiling/roof:	R - 38
Wall:	R - 21
Floor: basement ceiling	R - 30
Closed Crawl Space Wall:	R -
Closed Crawl Space Floor:	R -
Slab:	R -
Basement Wall:	R - 21
Fenestration:	
U-Factor	
Solar Heat Gain Coefficient (SHGC)	

Building Air Leakage

☐ Visually inspected according to 402.4.2.1 OR

☒ Building Air Leakage Test Results (Sec. 402.4.2.2) ACH50 [Target: 5.0] or CFM50/SFSA [Target: 0.30]: 4.12

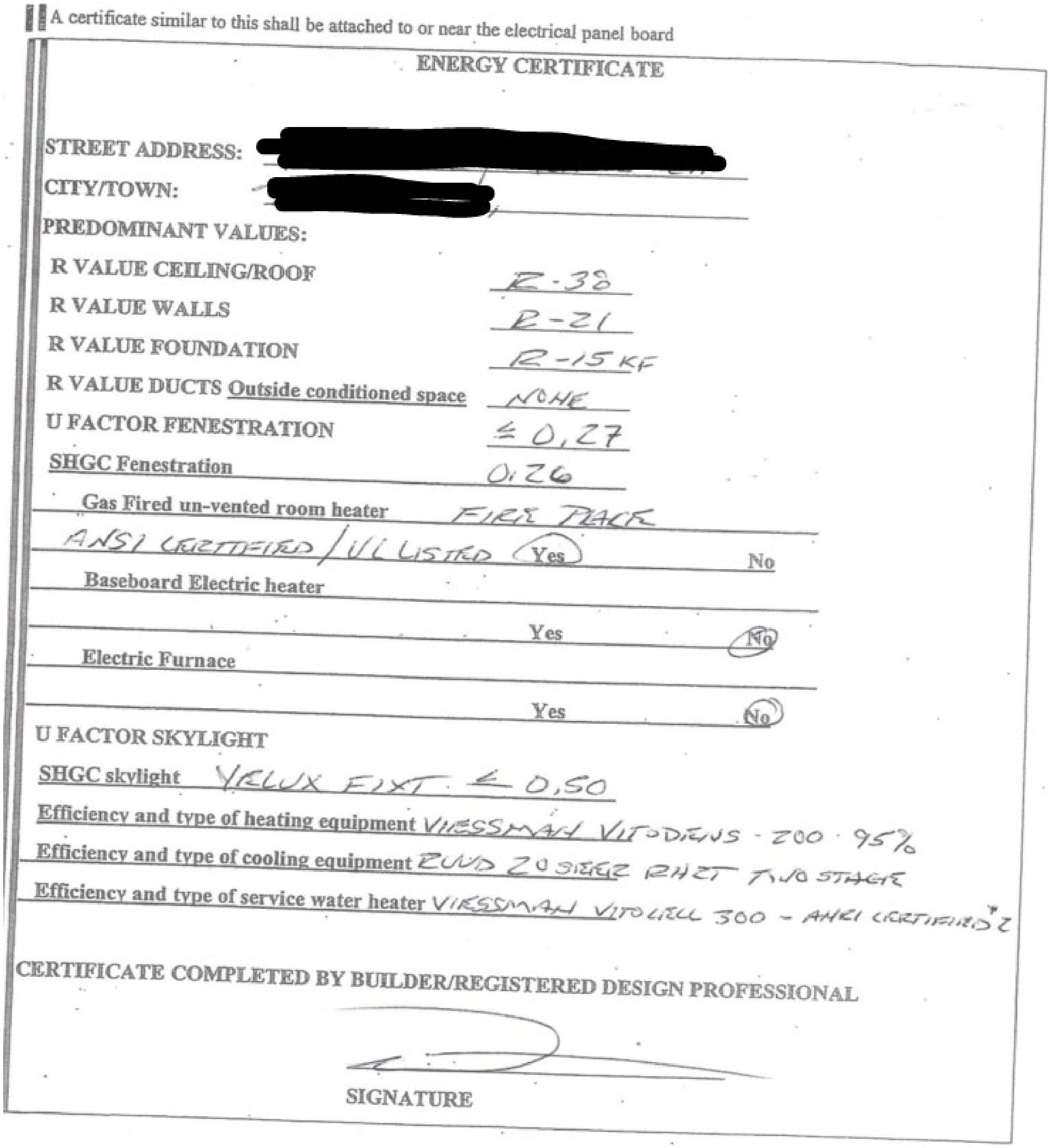
Name of Tester/Company: [redacted]
Date: [redacted] Phone: [redacted]

Ducts:

Insulation	R -
Total Duct Leakage Test Result (Sect. 403.2.2) (CFM25 Total/100SF) [Target: 6]	

Name of Tester/Company:
Date: Phone:

Certificate to be displayed permanently



A certificate similar to this shall be attached to or near the electrical panel board

ENERGY CERTIFICATE

STREET ADDRESS: [redacted]
CITY/TOWN: [redacted]

PREDOMINANT VALUES:

R VALUE CEILING/ROOF R-38
R VALUE WALLS R-21
R VALUE FOUNDATION R-15 KF
R VALUE DUCTS Outside conditioned space NONE
U FACTOR FENESTRATION ≤ 0,27
SHGC Fenestration 0,26

Gas Fired un-vented room heater FIRE PLACE
ANSI CERTIFIED / UL LISTED [✓ Yes] No

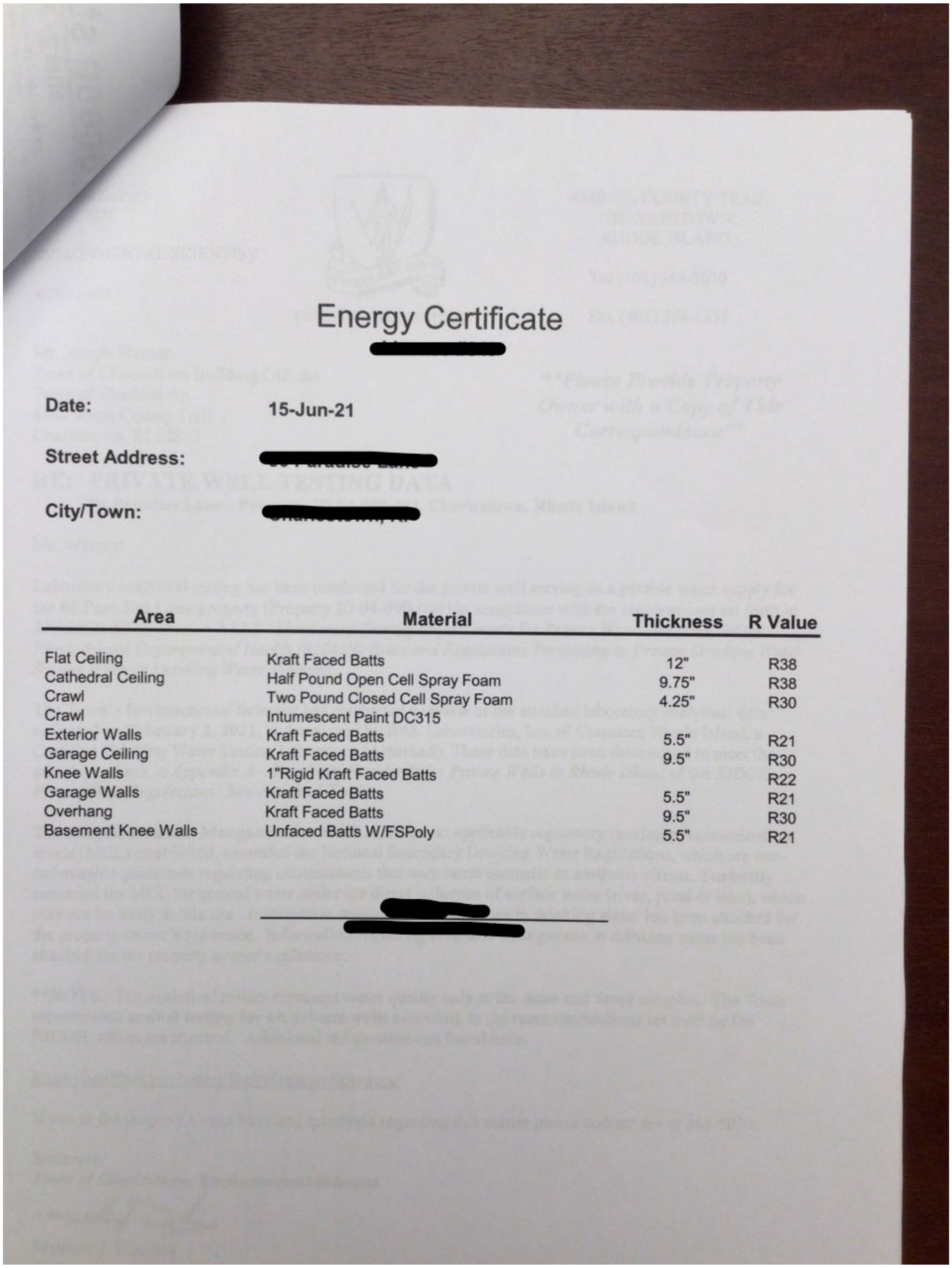
Baseboard Electric heater
Yes [✓ No]

Electric Furnace
Yes [✓ No]

U FACTOR SKYLIGHT
SHGC skylight VELUX FIXT. ≤ 0,50
Efficiency and type of heating equipment VIESSMAN VITODENS - 200 - 95%
Efficiency and type of cooling equipment RUUD 20 SEER RAZT TWO STAGE
Efficiency and type of service water heater VIESSMAN VITOCELL 300 - AHRI CERTIFIED

CERTIFICATE COMPLETED BY BUILDER/REGISTERED DESIGN PROFESSIONAL

SIGNATURE



Energy Certificate

[redacted]

Date: 15-Jun-21

Street Address: [redacted]

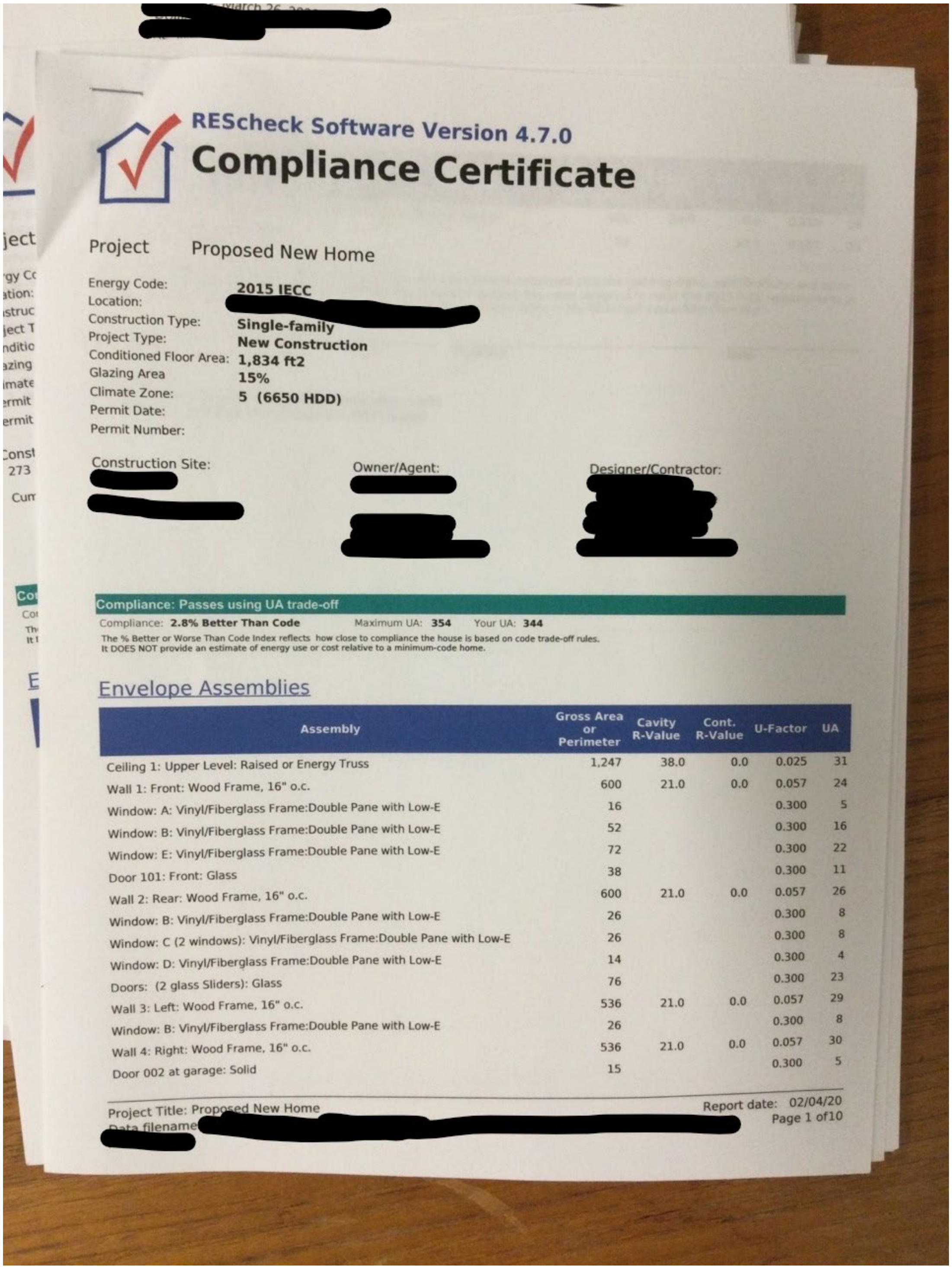
City/Town: [redacted]

Area	Material	Thickness	R Value
Flat Ceiling	Kraft Faced Batts	12"	R38
Cathedral Ceiling	Half Pound Open Cell Spray Foam	9.75"	R38
Crawl	Two Pound Closed Cell Spray Foam	4.25"	R30
Crawl	Intumescent Paint DC315		
Exterior Walls	Kraft Faced Batts	5.5"	R21
Garage Ceiling	Kraft Faced Batts	9.5"	R30
Knee Walls	1"Rigid Kraft Faced Batts		R22
Garage Walls	Kraft Faced Batts	5.5"	R21
Overhang	Kraft Faced Batts	9.5"	R30
Basement Knee Walls	Unfaced Batts W/FSPoly	5.5"	R21

[redacted]

[redacted]

C.2 IECC Compliance and REScheck



[redacted]

REScheck Software Version 4.7.0

Compliance Certificate

Project Proposed New Home

Energy Code:	**2015 IECC**
Location:	[redacted]
Construction Type:	**Single-family**
Project Type:	**New Construction**
Conditioned Floor Area:	**1,834 ft2**
Glazing Area	**15%**
Climate Zone:	**5 (6650 HDD)**
Permit Date:	
Permit Number:	

Construction Site:	Owner/Agent:	Designer/Contractor:
[redacted]	[redacted]	[redacted]

Compliance: Passes using UA trade-off

Compliance: **2.8% Better Than Code** Maximum UA: **354** Your UA: **344**

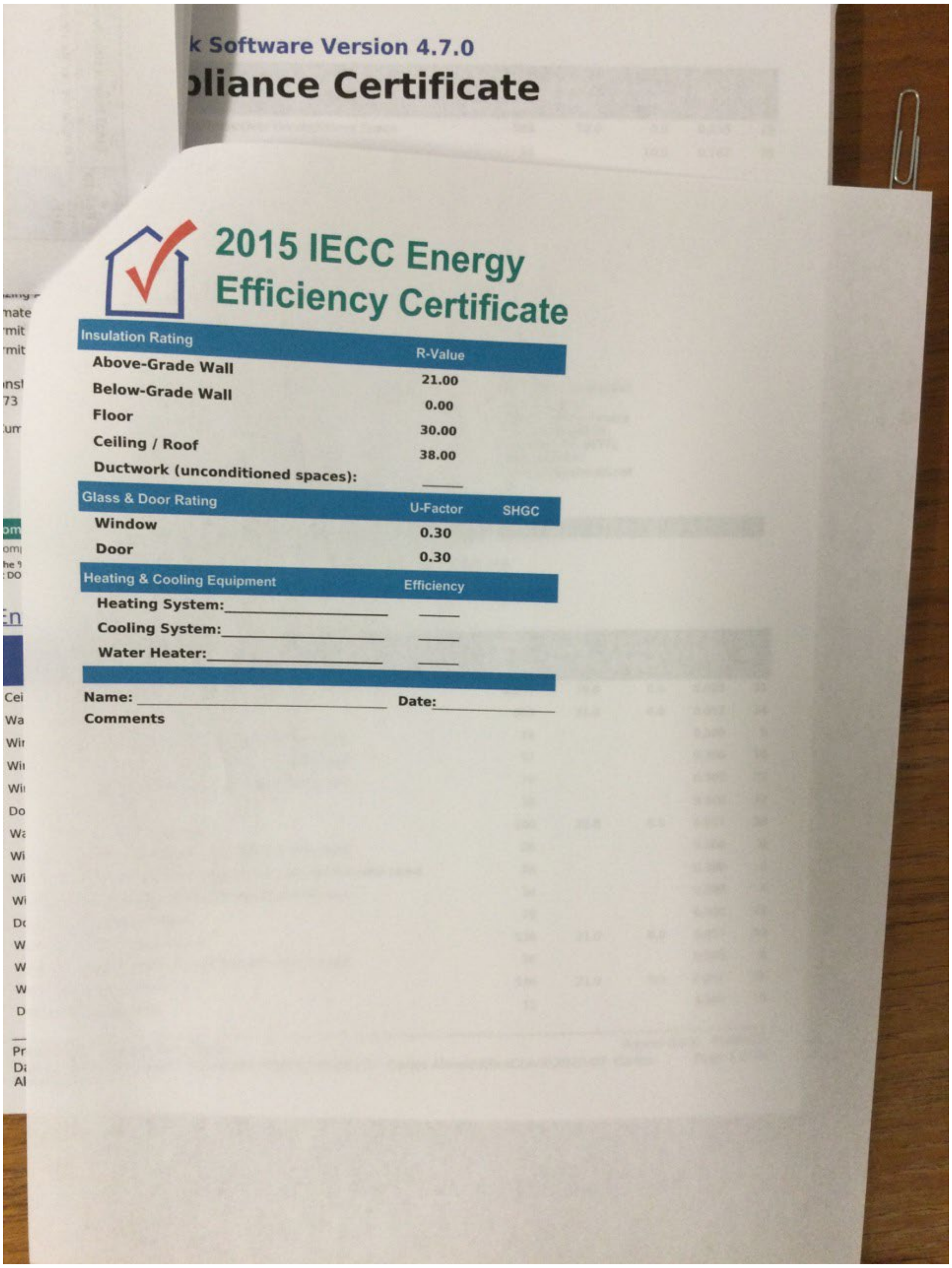
The % Better or Worse Than Code Index reflects how close to compliance the house is based on code trade-off rules. It DOES NOT provide an estimate of energy use or cost relative to a minimum-code home.

Envelope Assemblies

Assembly	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	U-Factor	UA
Ceiling 1: Upper Level: Raised or Energy Truss	1,247	38.0	0.0	0.025	31
Wall 1: Front: Wood Frame, 16" o.c.	600	21.0	0.0	0.057	24
Window: A: Vinyl/Fiberglass Frame:Double Pane with Low-E	16			0.300	5
Window: B: Vinyl/Fiberglass Frame:Double Pane with Low-E	52			0.300	16
Window: E: Vinyl/Fiberglass Frame:Double Pane with Low-E	72			0.300	22
Door 101: Front: Glass	38			0.300	11
Wall 2: Rear: Wood Frame, 16" o.c.	600	21.0	0.0	0.057	26
Window: B: Vinyl/Fiberglass Frame:Double Pane with Low-E	26			0.300	8
Window: C (2 windows): Vinyl/Fiberglass Frame:Double Pane with Low-E	26			0.300	8
Window: D: Vinyl/Fiberglass Frame:Double Pane with Low-E	14			0.300	4
Doors: (2 glass Sliders): Glass	76			0.300	23
Wall 3: Left: Wood Frame, 16" o.c.	536	21.0	0.0	0.057	29
Window: B: Vinyl/Fiberglass Frame:Double Pane with Low-E	26			0.300	8
Wall 4: Right: Wood Frame, 16" o.c.	536	21.0	0.0	0.057	30
Door 002 at garage: Solid	15			0.300	5

Project Title: Proposed New Home
Data filename [redacted]

Report date: 02/04/20
Page 1 of10



k Software Version 4.7.0

pliance Certificate

2015 IECC Energy Efficiency Certificate

Insulation Rating	R-Value
Above-Grade Wall	21.00
Below-Grade Wall	0.00
Floor	30.00
Ceiling / Roof	38.00
Ductwork (unconditioned spaces):	____

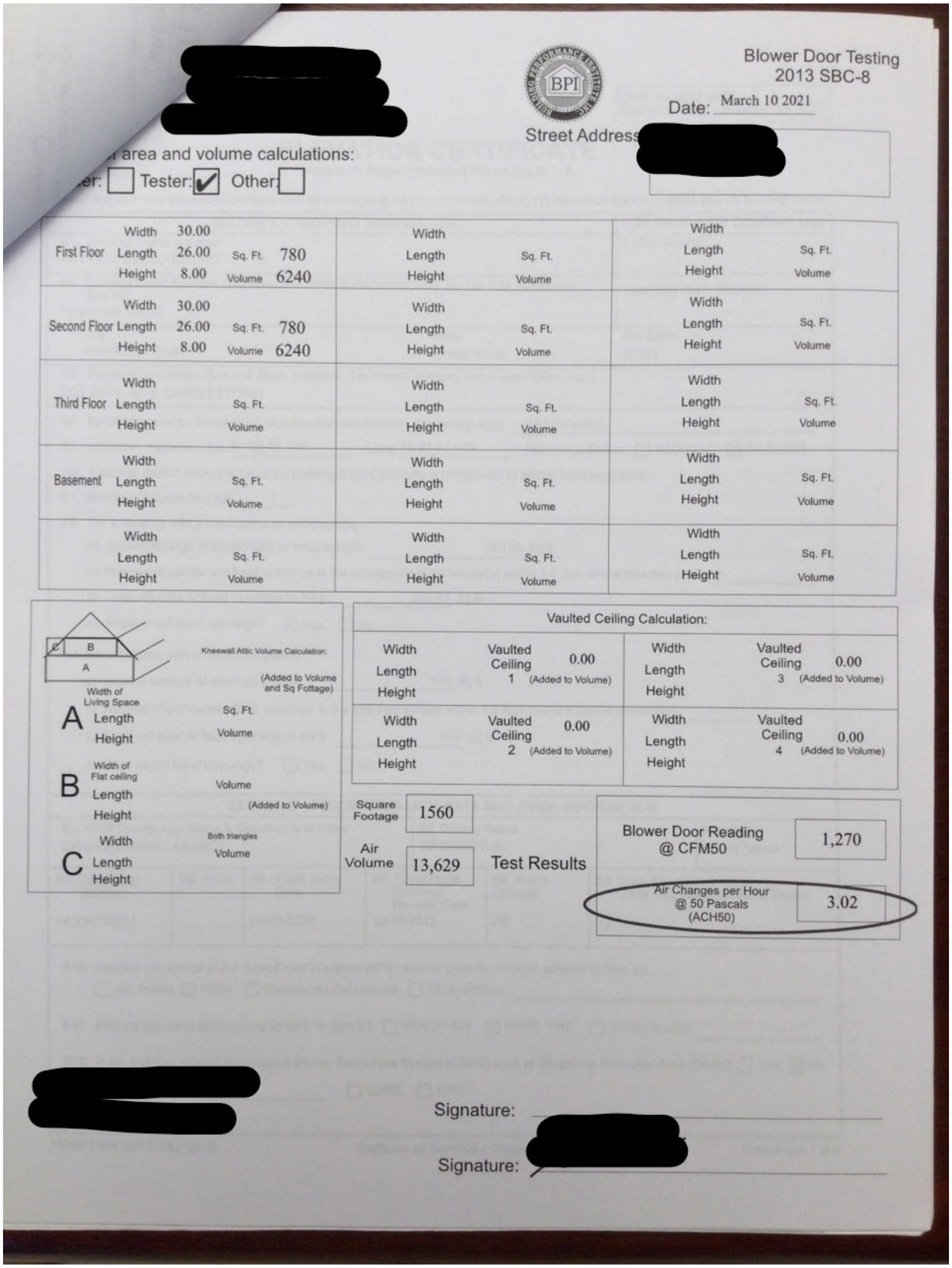
Glass & Door Rating	U-Factor	SHGC
Window	0.30	
Door	0.30	

Heating & Cooling Equipment	Efficiency
Heating System:____________________	____
Cooling System:____________________	____
Water Heater:____________________	____

Name: ______________________________ Date:____________

Comments

C.3 Blower Door and Duct Blaster Results



[redacted]

Blower Door Testing
2013 SBC-8

Date: March 10 2021

Street Address: [redacted]

r area and volume calculations:

er: ☐ Tester: ☑ Other: ☐

First Floor Width 30.00 Length 26.00 Sq. Ft. 780 Height 8.00 Volume 6240	Width Length Sq. Ft. Height Volume	Width Length Sq. Ft. Height Volume
Second Floor Width 30.00 Length 26.00 Sq. Ft. 780 Height 8.00 Volume 6240	Width Length Sq. Ft. Height Volume	Width Length Sq. Ft. Height Volume
Third Floor Width Length Sq. Ft. Height Volume	Width Length Sq. Ft. Height Volume	Width Length Sq. Ft. Height Volume
Basement Width Length Sq. Ft. Height Volume	Width Length Sq. Ft. Height Volume	Width Length Sq. Ft. Height Volume
Width Length Sq. Ft. Height Volume	Width Length Sq. Ft. Height Volume	Width Length Sq. Ft. Height Volume

Kneewall Attic Volume Calculation:

A Width of Living Space
Length Sq. Ft.
Height Volume
(Added to Volume and Sq Fottage)

B Width of Flat ceiling
Length Volume
Height (Added to Volume)

C Width
Length Both triangles Volume
Height

Vaulted Ceiling Calculation:

Width Length Height Vaulted Ceiling 1 0.00 (Added to Volume)	Width Length Height Vaulted Ceiling 3 0.00 (Added to Volume)
Width Length Height Vaulted Ceiling 2 0.00 (Added to Volume)	Width Length Height Vaulted Ceiling 4 0.00 (Added to Volume)

Square Footage: 1560

Air Volume: 13,629

Test Results

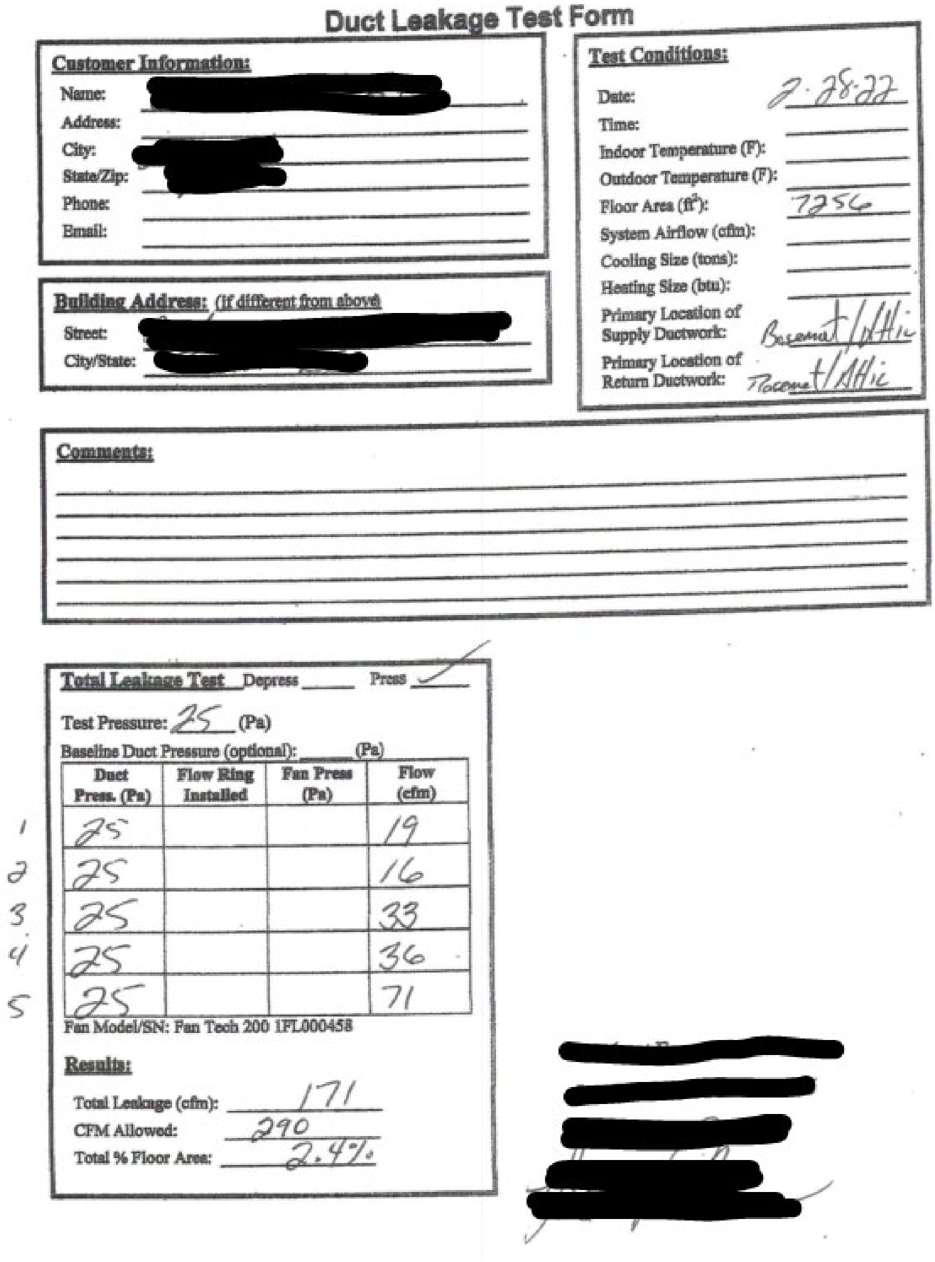
Blower Door Reading @ CFM50: 1,270

Air Changes per Hour @ 50 Pascals (ACH50): 3.02

[redacted]

Signature:

Signature: [redacted]



Duct Leakage Test Form

Customer Information:

Name: [redacted]
Address:
City: [redacted]
State/Zip:
Phone:
Email:

Test Conditions:

Date: 2-28-22
Time:
Indoor Temperature (F):
Outdoor Temperature (F):
Floor Area (ft²): 7256
System Airflow (cfm):
Cooling Size (tons):
Heating Size (btu):
Primary Location of Supply Ductwork: Basement/Attic
Primary Location of Return Ductwork: Basement/Attic

Building Address: (if different from above)

Street: [redacted]
City/State: [redacted]

Comments:

Total Leakage Test Depress ____ Press ✓

Test Pressure: 25 (Pa)
Baseline Duct Pressure (optional): ____ (Pa)

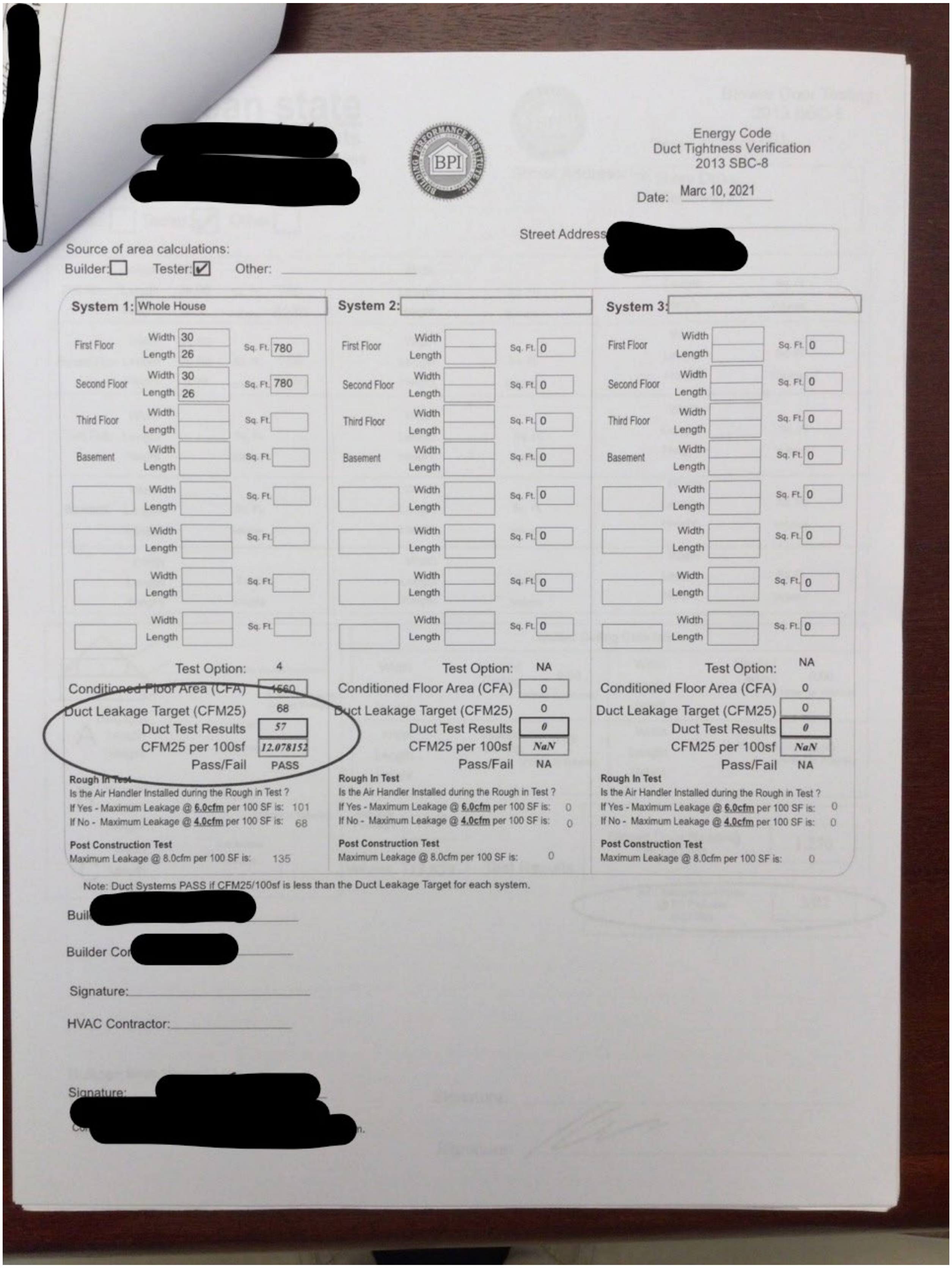
	Duct Press. (Pa)	Flow Ring Installed	Fan Press (Pa)	Flow (cfm)
1	25			19
2	25			16
3	25			33
4	25			36
5	25			71

Fan Model/SN: Fan Tech 200 1FL000458

Results:

Total Leakage (cfm): 171
CFM Allowed: 290
Total % Floor Area: 2.4%

[redacted]



[redacted]

[redacted]

Energy Code
Duct Tightness Verification
2013 SBC-8

Date: Marc 10, 2021

Street Address [redacted]

Source of area calculations:
Builder: ☐ Tester: ☑ Other: ____________

System 1: Whole House			**System 2:**			**System 3:**		
First Floor	Width 30 Length 26	Sq. Ft. 780	First Floor	Width Length	Sq. Ft. 0	First Floor	Width Length	Sq. Ft. 0
Second Floor	Width 30 Length 26	Sq. Ft. 780	Second Floor	Width Length	Sq. Ft. 0	Second Floor	Width Length	Sq. Ft. 0
Third Floor	Width Length	Sq. Ft.	Third Floor	Width Length	Sq. Ft. 0	Third Floor	Width Length	Sq. Ft. 0
Basement	Width Length	Sq. Ft.	Basement	Width Length	Sq. Ft. 0	Basement	Width Length	Sq. Ft. 0
	Width Length	Sq. Ft.		Width Length	Sq. Ft. 0		Width Length	Sq. Ft. 0
	Width Length	Sq. Ft.		Width Length	Sq. Ft. 0		Width Length	Sq. Ft. 0
	Width Length	Sq. Ft.		Width Length	Sq. Ft. 0		Width Length	Sq. Ft. 0
	Width Length	Sq. Ft.		Width Length	Sq. Ft. 0		Width Length	Sq. Ft. 0

Test Option:	4	NA	NA
Conditioned Floor Area (CFA)	1560	0	0
Duct Leakage Target (CFM25)	68	0	0
Duct Test Results	57	0	0
CFM25 per 100sf	12.078152	NaN	NaN
Pass/Fail	PASS	NA	NA
Rough In Test Is the Air Handler Installed during the Rough in Test ?			
If Yes - Maximum Leakage @ **6.0cfm** per 100 SF is:	101	0	0
If No - Maximum Leakage @ **4.0cfm** per 100 SF is:	68	0	0
Post Construction Test Maximum Leakage @ 8.0cfm per 100 SF is:	135	0	0

Note: Duct Systems PASS if CFM25/100sf is less than the Duct Leakage Target for each system.

Buil[redacted]

Builder Co[redacted]

Signature: ____________

HVAC Contractor: ____________

Signature: [redacted]

Co[redacted]n.