Single-Family and Low-Rise Multifamily Residential New Construction Baseline Study (MA23R60)

September 30, 2024

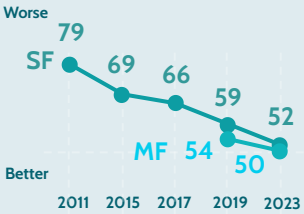
The Massachusetts Electric and Gas Program Administrators

SUBMITTED BY:
NMR Group, Inc.

2023 MA Single-Family and Multifamily Residential New Construction Baseline (RNC) and Code Compliance Study

Overview

Unlike previous RNC studies that relied on on-site inspections, this study used the official database of HERS rating data from RESNET to describe energy-efficiency practices and code compliance for new homes in Massachusetts. The report separately describes single-family (SF, 1-4 units) and low-rise multifamily (MF, 5+ units, <4 stories) homes that received HERS ratings. The RESNET data described over 14,000 SF and over 5,700 MF units, nearly half of homes permitted in MA from Nov. 2020 - Dec. 2022. The study covered Base Code and Stretch Code homes permitted under the 2018 IECC. Unless noted, the results below describe homes that did *not* participate in the PAs' RNC program.

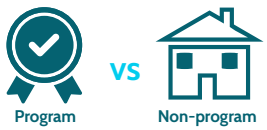


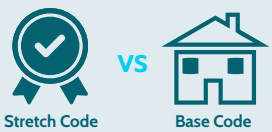
HERS scores continue to improve (lower scores are better).

Average HERS scores improved since the previous studies (SF: from 59 to 52, MF: 54 to 50). Interestingly, these scores improved even though the the maximum HERS score allowable under code did not change during that time (HERS 55).

SF program and non-program HERS scores are similar (1 point difference). The gap is wider for MF, with program homes nearly 3 points better.

The average SF HERS score of program homes is only 1 point (2%) better than than non-program homes (P: 51, NP: 52) - the spread was 4 points in the previous study.
For MF, program units are nearly 3 points (5%) better than non-program (P: 50, NP: 47), on average.





Stretch Code homes outperform HERS-rated Base Code homes on average, particularly among MF.

Code sets the same maximum HERS score for Base and Stretch Code homes,
but SF Stretch Code scores are about 1 point better than HERS-rated Base Code scores (53 vs 52),
For MF, Stretch Code homes substantially outperform HERS-rated Base Code homes (55 vs 49).

All-electric homes are rare - 4% of SF, 14% of MF.

Electric heating is more common in MF than SF (SF: 9%, MF: 29%).
Fossil-fuel forced air heating systems are extremely common (SF: 85%, MF: 69%).
Gas tankless water heaters are also quite popular (SF: 61%, MF: 53%).
HPWHs have started to gain traction, even in MF homes (SF: 24%, MF: 13%)

Air and duct leakage rates have improved.

SF air leakage is 29% lower than the previous baseline; MF is 15% lower.
Far more homes have ducts in conditioned space, which has dramatically reduced problematic leakage: SF: 47% of homes have supply ducts fully in conditioned space; MF: 87%.
As a result of this (and potentially better sealing practices), average duct leakage rates have fallen (improved) by more than 50% for SF and 65% for MF.

Based on RESNET data, code compliance under 2018 IECC is high for SF (95%) but middling for MF (59%). Across the board, few homes built under the 2018 IECC would satisfy the new, stricter 2021 IECC requirements.

Code compliance was assessed based on homes' HERS score and if the values in the RESNET data satisfied other key requirements, such as code's air leakage requirements.

Recommendations

Develop a program theory and logic model (PTLM) that reflects the new design of the RNC program, which now includes an explicit market transformation goal. Based on the new design, work with stakeholders to reconsider how the program should calculate savings, including what an appropriate baseline should be in such a complex market.

Use guidance from the recent MA21R41 RNC Energy Optimization Code Compliance and Electrification studies to develop training and marketing materials to help builders comply with the new 10th Edition building code.
Include materials specifically targeted at Base Code communities.

The following graphic provides mean efficiency values for the SF and low-rise MF non-program homes included in the study. Insulation values include the nominal R-value of the insulation; the associated U-value incorporates framing and installation quality.

Single-Family

HERS Score: non-program 52.0

Base Code 53.0
Stretch Code 51.5
Program 51.0

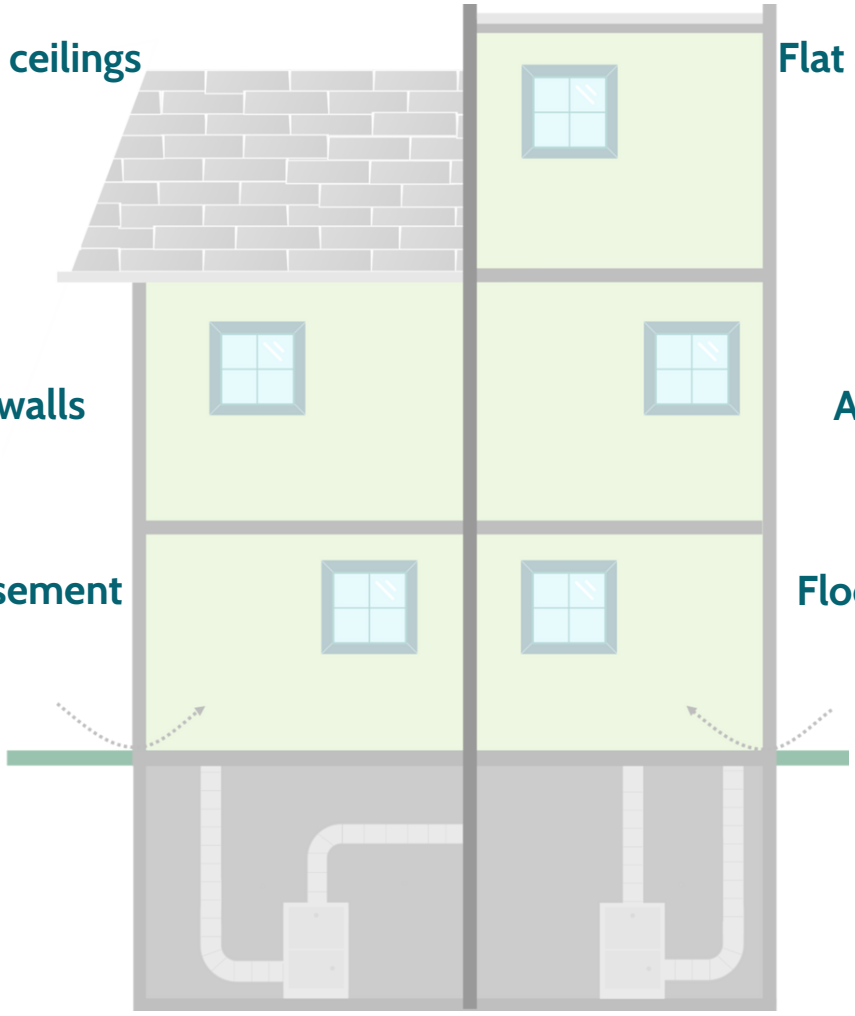
Flat & vaulted ceilings
R-42.7
U-0.024

Windows
U-0.28

Above-grade walls
R-22.1
U-0.048

Floor over basement
R-33.3

Air leakage
2.2 ACH50



Heating COP 1.15
Heat Pump HSPF 10.3
Fossil Fuel AFUE 95.4

Cooling SEER 14.3
CAC 13.8
Ducted ASHP 17.5
Ductless ASHP 19.6
GSHP (n=2) 21.1

Water heater EF 1.56
Electric 3.33
Fossil Fuel 0.92

Duct leakage CFM25/100 ft2 CFA
Total leakage 5.7
Leakage to outside 1.9

Multifamily

HERS Score: non-program 49.6

Base Code 54.7
Stretch Code 48.6
Program 47.0

Flat & vaulted ceilings
R-41.2
U-0.025

Windows
U-0.28

Above-grade walls
R-23.9
U-0.044

Floor over basement
R-33.4

Air leakage
2.9 ACH50

Heating COP 1.51
Heat Pump HSPF 10.4
Fossil Fuel AFUE 94.7

Cooling SEER 15.0
CAC 13.9
Ducted ASHP 17.4
Ductless ASHP 19.1
GSHP (n=1) 20.9

Water heater EF 1.29
Electric 2.29
Fossil Fuel 0.93

Duct leakage CFM25/100 ft2 CFA
Total leakage 5.4
Leakage to outside 1.9

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Glossary

Term	Definition
ACH_{50}	Air Changes per Hour with a 50-Pascal pressure gradient
ASHP	Air-Source Heat Pump
BTU	British Thermal Unit; a unit of energy. 1,000,000 BTU = 293 kWh
BTUh	British Thermal Units per Hour; a rate of energy consumption
CAC	Central Air Conditioner
CFA	Conditioned Floor Area
CFM25	Cubic Feet per Minute with a 25 Pascal pressure gradient
COP	Coefficient of Performance; a measure of equipment efficiency, usually heating; higher is better
DHW	Domestic Hot Water
EF	Energy Factor (including CEF, IMEF, MEF and UEF) measures equipment efficiency; higher is better
E/HRV	An amalgam of ERV and HRV, given their similarities
ERV	Energy Recovery Ventilation; higher performance option to an HRV
DOER	Massachusetts Department of Energy Resources
GSHP	Ground-Source Heat Pump
HERS	Home Energy Rating System; summarizes a home's efficiency; lower is better
HPWH	Heat Pump Water Heater
HRV	Heat Recovery Ventilation provides fresh air to a home while reducing energy lost in exhausted air
HSPF(2)	Heating Season Performance Factor (v. 2); a measure of electric heating efficiency; higher is better
HVAC	Heating, Ventilation and Air Conditioning
ICF	A consulting firm that implements the PAs' RNC program
IECC	International Energy Conservation Code
ISP	Industry standard practice; the RNC program UDRH has typically been based on ISP for non-program homes
kWh	Kilowatt-Hour; a unit of energy typically used for electricity. 1 kWh = 3,412 BTU
LTO	(Duct) Leakage to Outside; lower is better
MF	Multifamily homes (per program definitions, includes units in buildings with 5+ units
MSHP	Mini or Multi-Split Heat Pump; a variable speed air source heat pump, usually ductless
Mixed-fuel	A home with combustion-powered equipment e.g., furnace, boiler, water heater, dryer and/or stove
NP	Non-participant; a home that did not participate in the PAs' RNC program
P	Participant in the PAs' RNC program
PAs	Massachusetts Gas and Electric Program Administrators
PTLM	Program theory and logic model; a description of a program's design and anticipated outcomes
PV	Photovoltaics, also known as solar panels
R-value	Measure of a material's resistance to the flow of heat, higher is better
RESNET	Residential Energy Services Network (oversees the HERS rating industry)
RNC	Residential New Construction
SEER(2)	Seasonal Energy Efficiency Ratio (v. 2); a measure of cooling system efficiency; higher is better
SF	Single-family homes (per RNC program definitions, includes homes in 1–4-unit buildings)
SHGC	Solar Heat Gain Coefficient; a measure of how much infrared light passes through a window
SRE	Sensible Recovery Efficiency; heat exchanged between fresh air and exhaust ventilation flows
TDL	Total Duct Leakage; lower is better
U-factor	Measure of heat flow through a material, lower is better, inverse of R-value
UCB	Unconditioned Basement
UDRH	User-Defined Reference home; the hypothetical "typical" home against which program savings are calculated

Executive Summary

The Massachusetts PAs offer incentives for building energy-efficient homes. The PAs use energy models to compare the efficiency of program homes to that of hypothetical versions built to baseline efficiency levels, which are typically informed by industry standard practices. **This is the most recent in a series of studies for the PAs and EEAC describing ISP among new homes**.

The report leverages the **official database of HERS rating data from RESNET** to separately describe energy-efficiency practices and code compliance for program and non-program **new single-family (one to four units)** and **low-rise multifamily homes (5+ units, less than four stories)**. The study covers homes built under the Ninth Edition Massachusetts State Building Code, based on the **2018 IECC**, which includes Base and Stretch Code. The study also compares these homes to the Tenth Edition Building Code, based on the **2021 IECC**, that started coming into effect in 2023 to see how far the 2018 IECC homes are from meeting the significant changes under the new code.

METHODOLOGY

Using RESNET's HERS rating data instead of data collected during on-site visits allowed for broader market coverage than previous studies, but it does not cover homes built without the benefit of HERS ratings, such as homes built in Base Code communities under the prescriptive code compliance path. HERS ratings are increasingly common in Massachusetts. Stretch Code (covering 91% of the state) promotes HERS ratings,[1] the RNC program requires them, and Base Code accepts them as a compliance option. The new Tenth Edition code requires them for Stretch and Specialized Codes. RESNET's official HERS rating database included energy model data for nearly 37,000 single- and multifamily units. The team cleaned this dataset down to 14,513 single- and 5,733 multifamily units, yielding usable data for approximately 46% of the 43,762 homes permitted from November 2020 – December 2022. The study assessed single- *and* multifamily homes, require no field work, and expanded the sample from a select number of on-site visits to thousands of records created by HERS raters prior to home occupancy. In contrast, the most recent single-family baseline (MA19X02) relied on on-site visits at 100 occupied homes. The most recent multifamily study (MA20R30) also relied on RESNET data. For simplicity, MA19X02 and MA20R30 results are presented in this report as the 2019 baseline studies. These and other relevant reports can be found here.

Base Code information from code officials. The study included a brief survey with code officials in 17 of the 50 Base Code towns, where homes can follow the prescriptive compliance path. This provided feedback about trends in those communities where RESNET data offer limited visibility.

Qualitative feedback from market actors to complement the baseline data analysis. The study interviewed with seven builders and three HERS raters about market and program trends.

[1] In 2020, BBRS clarified that homes could comply with ERIs rather than HERS ratings, but it is unclear if this was common. https://www.mass.gov/doc/780-cmr-ninth-edition-residential-chapter-11-energy-efficiency-bbrs-advisory-as-of-10132020-0/download

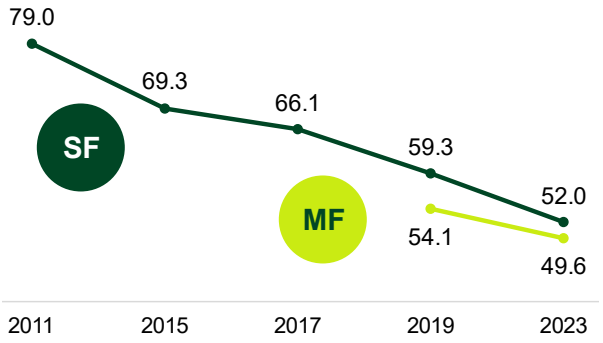
In the findings below, quantitative results specific to single- or multifamily homes are introduced with a relevant icon, as shown at left.

Energy Efficiency Findings

These findings describe HERS-rated homes. They do not cover homes that followed Base Code's prescriptive compliance path or otherwise avoided a HERS rating. Based on code officials' comments, it is possible that homes with HERS ratings outperform those without (Section 12).

HERS Scores

Non-program HERS scores continue to improve. Single-family HERS scores improved by 12% since the previous study, while multifamily scores improved by 8%.

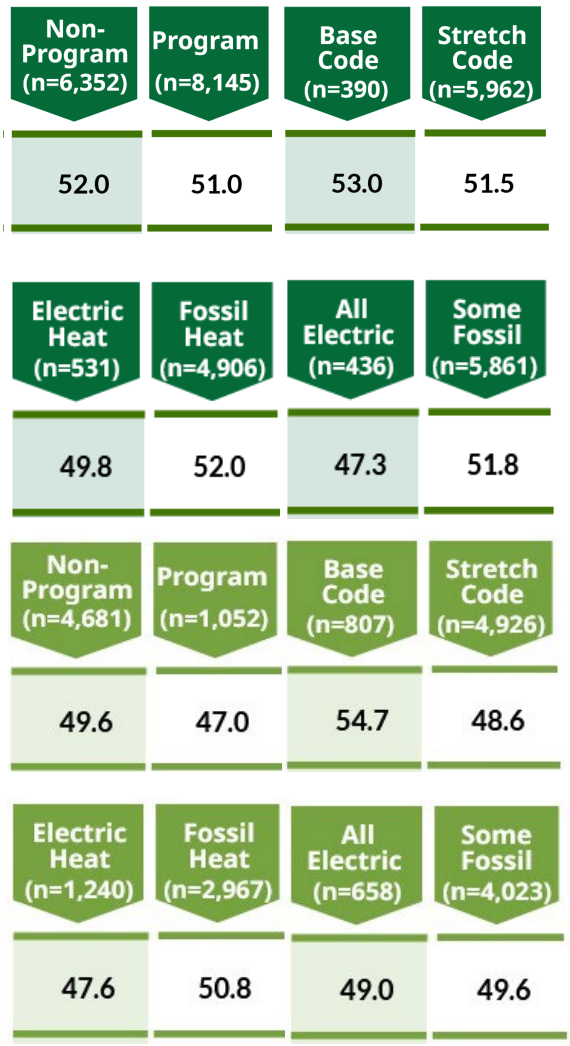


Converging HERS scores. The gap between SF program and non-program homes is only 1 point on average. Similarly, Stretch Code homes outpace their HERS-rated, Base Code counterparts by 1.5 points. On average, HERS-rated homes under Base and Stretch Code perform better than required, as a score of 55 would have satisfied Base or Stretch Code.

Electrically heated SF homes have lower HERS scores, mostly due to higher mechanical system efficiencies, but on average, all-electric homes do tend to have slightly better building envelopes than other homes (see Section 7).

Improvements under Stretch Code. Multifamily Stretch Code homes have become more efficient since the previous study (HERS 51.1 down to 48.6); HERS-rated Base Code homes have gotten slightly worse (from 54.2 up to 54.7). Program homes outperform non-program by 2.6 points, on average.

Among multifamily homes, electrically-heated homes have the lowest HERS scores, but on average, mixed-fuel homes that heat with electricity actually scored better than the smaller group of all-electric homes. Simply going all-electric does not guarantee the best HERS score.

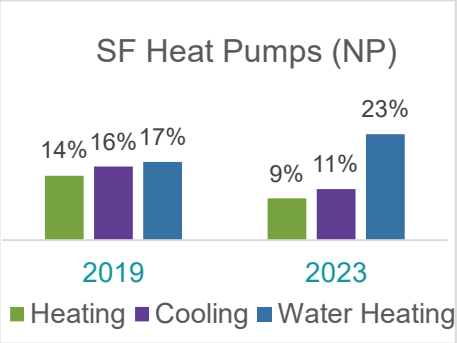


Electrification and Mechanical Systems

Most new homes still rely on fossil-fuel heating and water heating systems.

All-electric SF homes are rare (P: 8%, NP: 4%).

Fossil-fuel forced air systems (mainly furnaces) are nearly ubiquitous (P: 85%, NP: 85%, including natural gas and propane), particularly in HERS-rated Base Code homes. Propane is used to heat 43% of non-program homes, and 26% of program homes. Heat pumps are relatively uncommon (P: 13%, NP: 9%).



Tankless gas water heaters (P: 56%, NP: 61%) and HPWHs (P: 30%, NP: 24%) have both gained market share at the expense of conventional, tank units.

Interestingly, RESNET data show that HVAC heat pumps are less common among non-participants than in the on-site sample from 2019. The market may have shifted, but sampling bias and/or sampling error in the 19X02 study could also contribute to this result.[2]

Overall, average mechanical system efficiencies are relatively flat compared to 2019 and tend to be comparable or identical across market segments.

Ducts have improved substantially. Far more homes have supply ducts in conditioned space (47% vs 15% in 2019), resulting in less duct leakage (1.9 CFM_{25}/100 ft^2 CFA of LTO vs. 4.3 in 2019), and insulation is slightly up (R-7.7 vs R-6.6 in 2019 for unconditioned supply ducts).

All-electric is more common in MF, but still a minority of units (P: 32%, NP: 14%). Most multifamily homes use furnaces (P: 45%, NP: 69%), and ducted and ductless ASHPs make up most of the remainder (P: 52%, NP: 27%). Around half of multifamily homes use fossil-fuel tankless water heaters (P:39%, NP: 53%). Notably, HPWHs in program homes are almost as common (P: 34%, NP: 13%), despite some resistance to HPWHs in multifamily projects.[3] Unlike in single-family, heating with propane is extremely rare in multifamily, found in less than 3% of units.

As with SF, MF ducts have improved since 2019 – 87% had supply ducts completely in conditioned space, and average duct leakage to outside was down 65% from 2019.

[2] The New Construction Non-Program Model Review study (MA19R19) may also support the RESNET results shown here. MA19R19 explored Ekotrope data for non-program homes from the same time frame as 19X02. There, NMR found a significantly smaller proportion of electric heating than in 19X02. 19X02: 12% of base code homes and 22% of stretch relied on electric heat; MA19R19's results were 0% and 5% of stretch codes, respectively.

[3] https://ma-eeac.org/wp-content/uploads/MA21R44-RNC-Electrification-Barriers-Study-Final-Report.pdf; see P. 6.

Air Infiltration

Homes are getting tighter; HERS-rated Base and Stretch homes have similar air leakage.

SF air leakage continues to improve among HERS-rated homes. Non-program homes improved from 3.1 ACH_{50} in 2019 to 2.2 in 2023, well below the code requirement of 3 ACH_{50} that has not changed for multiple code cycles. Non-program, HERS-rated Base Code homes are only slightly worse than Stretch (2.4 vs 2.2 ACH_{50}). Program homes had the same average performance as their non-program counterparts, but this is only a tiny improvement from the 2.3 ACH_{50} seen in 2019 program homes.

MF air leakage has improved. Air infiltration continues to improve in multifamily homes as well (P: 2.5 ACH_{50}, NP: 2.9 ACH_{50}), down from 3.4 ACH_{50} in the previous 2022 study.

Mechanical Ventilation

E/HRVs are uncommon – something that will likely change due to the new Stretch Code.

E/HRVs are rare in SF. Approximately 80% of homes – program and non-program – rely on exhaust-only ventilation fans, e.g., bathroom fans on timers. Homes rarely included E/HRVs that recover energy from expelled air (P: 3%, NP: 6%). Some have no dedicated mechanical ventilation systems (P: 15%, NP: 13%). Due to new Stretch Code requirements that require E/HRVs, homes built under the next code cycle may look quite different for this metric.

E/HRVs are even less common in MF. Multifamily homes routinely lack a dedicated ventilation system (P: 36%, NP 27%), and E/HRVs are extremely rare (P: 1%, NP: 5%).

Insulation

Average insulation levels have generally improved, particularly for MF. Insulation values tend to be similar across code variants and between program and non-program homes.

SF insulation has improved slightly. Non-program walls improved from R-19.7 in 2019 to R-22.1 in this study. Non-program ceiling insulation (R-42.7) is comparable to 2019 results. Framed floors (R-33.3) and foundation walls (R-19.9) also increased relative to 2019 values. These R-values represent nominal values for the insulation only.

MF insulation has improved substantially. Average U-values in non-program walls, ceilings, and floors improved by at least 31% over 2019 results. For comparability to 2019 results, these U-values incorporate framing and installation quality.

Windows

RESNET data yield more reliable results, but values are similar to previous studies.

Consistent trends. Average non-program U-factors did not change much from 2019 (0.29 vs. 0.28 now), but this study includes window data for over 6,000 non-program homes, compared to only 25 in 2019, because HERS raters have access to window specifications – occupants or builders normally remove specification labels.

Window U-factors in MF follow similar trends as for SF – 0.28 on average, unchanged since 2020.

CODE COMPLIANCE FINDINGS

HERS-rated homes built under the 2018 IECC have improved on past baseline results and have high compliance rates, but significant improvements will be needed to meet the 2021 IECC. The new Stretch and Specialized Codes (2021 IECC) are much stricter than the previous Stretch Code (2018 IECC). A HERS score of 55 complied with the old code, but the new Stretch Code and Specialized Code require HERS 45 for all-electric homes and 42 for homes with fossil fuels, among other new requirements. The upcoming Base Code (2021 IECC) represents a more modest increase, from HERS 55 to 52 for fossil-fuel homes. See Table 2 for more details.

SF compliance under 2018 IECC appears high, with compliance rates between the high 80s and mid-90s for different home categories. These estimates incorporate homes' HERS scores and if they meet other mandatory requirements, such as maximum air leakage values. Stretch Code compliance would be nearly 100% based on HERS scores (55 or better), but some homes fail code's air leakage requirements (3 ACH_{50} or better), reducing compliance by a few points. Most homes did extremely poorly against code's 90% high-efficiency lighting requirement, but this may be due to HERS raters recording conservative values to hit target HERS scores regardless of final lighting choices.

Because the new Stretch Code (2021 IECC) is so much stricter than the previous version (2018 IECC), almost all homes built under the previous Stretch Code would not meet the new version. Even with average HERS scores in the low 50s, only a small handful of homes (P: 1%, NP: 4%) look like they would satisfy most of the new Stretch Code's requirements (HERS 45 all-electric and 42 mixed-fuel, as of July 2024).

Nine out of ten interviewed market actors agreed builders would have difficulties meeting the new requirements. One summarized the issue as follows.

> ***The current energy Stretch Code, very simply, is this: you're in a gym, you lift a 20-lb dumbbell, that's a piece of cake. Then 30, that's OK. Now I want you to lift an 80-lb dumbbell. And you're saying, "How in God's name am I gonna do that?"***

Base code homes: closer to meeting the new code. In contrast, about 43% of non-program, HERS-rated homes built under the old Base Code (2018 IECC) would meet the new Base Code (2021 IECC), because the Base Code is not changing as much.

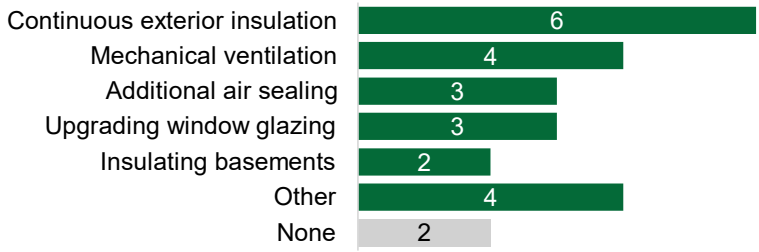
MF compliance rates are lower, but trends are similar. Program homes appear to be 67% compliant based on RESNET data, with non-program, HERS-rated homes at 59%. Using current practices, only 1% of multifamily program homes and 8% of non-participants would meet the new Stretch Code requirements; again, non-program Base Code compliance fares much better (66%) given the limited Base Code changes.

Qualitative Feedback from Market Actors

Officials in Base Code communities reported that prescriptive compliance is extremely common. They said on average, 80% of single-family and 95% of multifamily construction in their communities followed the prescriptive compliance path (i.e., no HERS rating). HERS-rated Base Code single-family homes have an average HERS score of 53 – two points better than required – suggesting they might outperform their non-HERS rated counterparts. For multifamily, that average falls right around 55, suggesting limited difference between prescriptive and HERS-rated Base Code homes.

During interviews, market actors described the changes they had made to keep up with recent code updates (Figure 1). Also, five out of ten thought program participation was likely to increase as a means of more successfully complying with the more stringent requirements.

Figure 1: Changes to Building Practices Because of New Codes



Almost all market actors expected builders to have a difficult time complying with the new Stretch and Specialized Codes. In contrast, code officials in Base Code towns predicted builders would not have a particularly challenging time complying with the new Base Code since it is not a dramatic upgrade over the 2018 IECC version.

Market actors were also rather concerned about a potential program shift to all-electric, primarily citing construction costs and customer preference for gas cooktops. Most said they would have no choice but to adapt if the program shifted to all-electric, but some predicted a decrease in program participation or some builders dropping out of the market.

Key Limitations and Sources of Uncertainty

Key limitations of the study include the RESNET data's focus on HERS-rated homes (excluding the small number of non-program homes built in Base Code communities that were allowed to follow the prescriptive compliance path), several sources of uncertainty within the RESNET data, and methodological differences between this and previous studies that limit some longitudinal comparisons. See Key Limitations and Sources of Uncertainty for detail.

RECOMMENDATIONS

1 **Move forward with the PAs' plan to develop a program theory and logic model (PTLM) for the RNC program that reflects the new program design. Based on the updated program theory, work with stakeholders to reconsider how the program calculates savings.** The Massachusetts RNC market is undergoing substantial change, creating an opportunity to reconsider the program's approach to calculating savings. For instance, the PAs have redesigned the RNC offering to have an all-electric focus and have decided to treat it as a market transformation initiative. Additionally, there are now three code versions in effect in different municipalities, Base, Stretch, and Specialized Code, each with their own requirements and on their own implementation schedule. Furthermore, as the RNC program has aligned its performance requirements with those of Stretch Code and the vast majority of the state has moved to a HERS-based compliance path, the gap between program and HERS-rated non-program homes continue to decrease.

Given all these changes, we recommend that the PAs move forward with their plan to formally develop and document the program theory underlying the new program design.[4] In line with best practices for measuring market effects,[5] this program theory should clearly document how the program's activities are expected to change market actors' practices and how that will ultimately yield changes to the market. While evaluators can help facilitate this process, the theory should originate from the PAs' implementation team, who have the clearest vision of how the program works and what it is designed to achieve.

From there, evaluators, EEAC consultants, PAs, and other stakeholders can work together to develop an appropriate framework for estimating savings, informed by the documented program theory, market research, and any policy guidance. Informed by the new program theory, this group should consider questions such as if the baseline for the program should continue to be ISP for non-program homes. Specifically, stakeholders should consider if the ISP described in this study, based on HERS-rated homes primarily built under Stretch Code, represents an appropriate baseline for Base Code homes that were built to prescriptive compliance standards without the benefit of a HERS rater. Alternative baseline scenarios could incorporate code minimums, might be based on ISP for some measures and not others, or might have different values for homes in Base, Stretch, or Specialized Code communities, given that the PAs have contributed to adoption of and compliance with those more advanced codes. Ideally, policymakers will also provide feedback on such topics.

Table 1 provides context to inform future decisions about program baselines. The table summarizes the HERS requirements under different code versions in Massachusetts (2015, 2018, and 2021 IECC), the current single-family and low-rise multifamily UDRH values (based on homes built under the 2015 IECC), and the ISP values described in this study (homes built under 2018 IECC). It also shows the new 2021 IECC-based requirements, which have recently come into effect for Stretch and Specialized communities but have not yet been phased in for Base Code.

[4] The PAs included a Stage 1 Plan for a study that would develop a PTLM in the SEP filed in 2024.
[5] https://ma-eeac.org/wp-content/uploads/Action_Plan_Measuring_Market_Effects_FINAL_2019.02.15.pdf

Table 1: Key HERS Scores Values to Inform Baseline Decisions

Base Code (Previous)	Current UDRH (ISP)	Base & Stretch (Applicable to MA23R60)	MA23R60 ISP	Stretch & Special. (Current)	Base Code (Upcoming)
2015 IECC		*2018 IECC*		*2021 IECC*	
55	SF: 55.7 MF: 54.1	55	SF: 52.0 MF: 49.6	Electric: 45 Mixed fuel: 42	Electric: 55 Mixed-fuel: 52

2 **Use guidance from the MA21R41 RNC Energy Optimization Code Compliance and Electrification Study to develop training and marketing materials to help builders meet the Tenth Edition building code. Consider efforts targeted at improving outcomes in Base Code communities, as well.** Program and non-program homes built late in the previous code cycle generally would not meet the new Stretch Code requirements, and interviewed market actors confirmed it would be challenging for many builders to do so. The optimized packages of the MA21R41 study may help builders meet those new requirements, from identifying cost-effective ways to add insulation to what efficiency E/HRV they should choose. Without clear support for how to build high-performance all-electric homes cost-effectively, the program – now moving toward an all-electric focus – could anticipate some amount of attrition among builders less inclined to build all-electric. Additionally, given concerns about new code requirements, builders may need substantial support from the program just to comply with code. As code officials noted, building to above-code standards may be uncommon in Base Code towns where HERS ratings are optional. The program may be well suited to improve outcomes in those communities, either in terms of overall performance or code compliance.

CONSIDERATIONS FOR FUTURE RESEARCH

1 **The PAs should continue to regularly obtain RESNET data describing HERS-rated homes in Massachusetts.** Regardless of the specific savings approach the PAs and stakeholders develop for the RNC program, we encourage the PAs to continue to obtain RESNET data to keep track of progress in the market. This information provides valuable insights about market trends, and may be useful for quantifying market effects in the future.

2 **For any high-priority variables of interest not included in RESNET data, conduct additional research or leverage other research efforts to inform those values.** RESNET does not identify, for example, whether an electric stove is an electric resistance or induction model. It also does not identify the recovery efficiency of ventilation equipment, the presence of faucet aerators, or include believable information about the efficiency of installed lighting or many appliances. Field-work or surveys could likely inform such data points, should the PAs identify them as problematic information gaps or program opportunities to improve energy-efficiency practices or promote electrification measures with high rates of consumer satisfaction (e.g., induction stoves).[6] RESNET may be able to offer some additional data fields not available for this study, such as the area of a given assembly or output of installed PV systems.

[6] https://ma-eeac.org/wp-content/uploads/MA21R44-RNC-Electrification-Barriers-Study-Final-Report.pdf

Section 1 Introduction, Background, and Methodology

This report represents the most recent in a series of periodic residential new construction (RNC) baseline studies conducted for the Massachusetts Program Administrators (PAs) and the Energy Efficiency Advisory Council (EEAC). Historically, RNC baseline studies in Massachusetts have focused on either single-family or multifamily homes. This study uses a new approach that allows it to cover both home types, as described below.

1.1 GOALS

This study has the following primary goals, focused on gathering information about industry standard practices (ISP) in the RNC market.

- Using RESNET data, develop updated specifications describing RNC ISP for single-family and multifamily homes, that can be coded into the program's User Defined Reference Home (UDRH) – the baseline against which the program calculates savings.
- Compare program and non-program homes built at the same timeframe against 1) each other, and 2) against the results of previous baseline studies.
- Compare homes built under the 2018 IECC-based code to the requirements of that code *and* of the 2021 IECC-based code being phased in between 2023 and 2025, to see how homes fare against the applicable code and to upcoming code requirements.
- Via a small number of market actor interviews, provide qualitative feedback about the RNC market to inform program design and future evaluations, specifically regarding
    - anticipated code compliance early in the 2021 IECC code cycle,
    - potential adjustments to the program's baseline approach, and
    - feedback about anticipated responses to program changes in 2024 and beyond.

1.2 BACKGROUND

Follow-up from previous RNC baseline studies. The PAs' low-rise RNC program incentivizes the construction of energy-efficient homes. The PAs periodically conduct baseline studies to determine how new single-family homes are built outside of the program, so that program homes are compared to an accurate and current baseline. These studies typically involve detailed on-site data collection to identify real-world practices at the measure level. In 2020, NMR completed the most recent single-family baseline study under the Cross-Cutting contract (MA19X02), relying on on-site data collection, and in 2021, NMR completed the most recent multifamily baseline study (MA20R30), which relied primarily on RESNET data.

HERS ratings are increasingly common in Massachusetts. For years, Massachusetts has favored a performance-based energy code, such that most new homes in Massachusetts have HERS ratings conducted as a matter of course. Most of the municipalities in the state have adopted the Stretch Code (67% in 2018, 86% in 2020, and 91% at the time this report was finalized – including the 45 municipalities that had adopted the Specialized code – which requires HERS ratings for code compliance. [7] Homes built in the few Base Code communities can also comply with code by obtaining a HERS score.

Code trends. In 2017, Massachusetts adopted a code based on the 2015 IECC. The current RNC program uses a UDRH based on homes built under that code. In 2020, the Base and Stretch Codes were updated to reflect the 2018 IECC. Homes described in *this* study were subject to the 2018 IECC-based code. Since then, Massachusetts has moved to a 2021 IECC-based energy code, including Base, Stretch, and Specialized code variants, being phased in at various times between 2023 and 2025. The 2021 IECC-based code is much stricter as shown in Table 1. A score of 55 generally met code under the previous code, but to satisfy the 2021 IECC, homes would need to exceed that score by roughly 10 to 13 points, depending on their fuel. (Including solar also provides an additional three-point buffer.) At the time this report was written, 45 municipalities had adopted the Specialized Code, though it is not yet in effect in all of them. This represents a significant departure from previous code versions, as municipalities can now adopt one of three code versions; each of which represents a substantial increase in energy efficiency over the previous code.

Table 2 provides a high-level summary of the recent residential energy code requirements in Massachusetts. This report provides comparisons to the applicable 2018 IECC-based requirements, along with the upcoming 2021 IECC-based requirements.

[7] Massachusetts Department of Energy Resources Green Communities Division (August 23, 2024). Stretch Code Adoption, by Community. https://www.mass.gov/doc/building-energy-code-adoption-by-municipality/download

Table 2: New Construction Code Compliance Criteria Summary

Building Code	Effective Date	Path	Fuel(s)	Maximum HERS
Stretch (2018 IECC)	Nov. 8. 2020	ERI	Any	55
Base (2018 IECC)	Nov. 8. 2020	Prescriptive	Any	–
		ERI	Any	55
Specialized (2021 IECC)	July 1, 2023	ERI	All-electric	45†
			Mixed-fuel	42†
Stretch (2021 IECC)	July 1, 2024	ERI	All-electric	45
			Mixed-fuel	42
Base (2021 IECC)	2025 (planned)	Prescriptive	Any	‡
		ERI	All-electric	55
			Mixed-fuel	52

† Specialized code requires other provisions, such as Passive House compliance for large multifamily buildings.
‡ Prescriptive path mandates certain features in lieu of an ERI. Key changes from the previous code include:

Attics	*Walls*	*Windows*	*Slabs*	*Lighting*
R-60	*0.045 U / R-20+5 / R-30*	*0.40 SHGC*	*4 feet of R-10*	*100% LEDs*

Leveraging a new source of baseline data. RESNET maintains the registry of official HERS ratings produced with approved modeling tools such as Ekotrope, which the PAs use to calculate savings for low-rise RNC participants. RESNET provided NMR with this information for the PAs' use in baseline studies. (The MA20R30 study used this data as the basis of the multifamily baseline study.) This database provided insight into how homes are built at reduced cost relative to typical baseline studies. Because the analysis relies on a pool of data that could be updated every year, making decisions about baseline updates based on reanalyzing a new batch of RESNET data could allow the PAs to always have baselines that are prudent and up-to-date.

How homes compare against the applicable and upcoming codes. The study used RESNET data to understand how homes perform against the code that was in effect when they were built (2018 IECC) and against the upcoming code (2021 IECC), to learn about how far the 2018 IECC homes are from meeting the significant changes coming into effect under the new code.

SF and MF. The study includes single- and low-rise multifamily homes, as RESNET's data covers both. Historically, Massachusetts has not conducted low-rise multifamily baseline studies; on-site inspections have always been challenging in terms of recruiting and data quality. The 20R30 multifamily study also made clear that the RESNET data outperforms the data available from building departments, in terms of quantity and quality of usable data.

Qualitative research to inform program design and NTG updates. As requested by the PAs and EEAC consultants, the study included limited interviews with market actors to provide qualitative information about the Massachusetts RNC market, including their feedback about program baselines, code compliance, and free-ridership and spillover in light of changing codes, program requirements, and state-level policies. The last RNC NTG study was completed in 2021.[8] This study will provide feedback about the market that could inform the next such study.

[8] https://ma-eeac.org/wp-content/uploads/MA20X05-B-RNCNTG_Low-rise-RNC-NTG_FinalDraft-07272021.pdf

1.3 Relevant Previous Baseline Studies

For reference, we provide links to relevant historical Massachusetts RNC baseline studies in Table 3. Longitudinal results described in Section 2 and Section 7 rely on findings from many of these reports.

Table 3: Relevant Previous MA RNC Baseline Studies

Nominal Study Year	Home Type		Study #	Report Date	On-sites	Link
	SF	*MF*				
2019	-	Low & Mid-rise	20R30	3/2/2022	N/A (RESNET)	Report
2019	✓	-	19X02	4/1/2020	100	Report
2017	✓	-	17-2	1/3/2018	50	Report
2015	✓	-	-	2/13/2017	194	Report
2012	✓	-	-	7/17/2012	50	Report
2011	✓	-	-	8/16/2012	100	Report

1.4 Summary of Evaluation Activities

The study included the following key tasks:

- Code official survey to inform market trends in Base Code communities (n=17)
- Interviews with builders and HERS raters (n=10)
- Requesting and analyzing HERS data from RESNET
- Requesting and analyzing program tracking and energy model data from the PAs

1.5 Methodology

1.5.1 Code Official Survey

Base code homes are not required to have HERS ratings and represent less than 10% of the state's population. Given the study's reliance on RESNET's HERS rating data, which by definition focuses on Stretch Code communities where HERS ratings are required, the study had limited information about building practices in Base Code towns. The study team conducted a brief survey with Massachusetts code officials to learn about trends in Base Code communities.

Code officials were asked to provide quick responses on the following topics:

- what portion of new homes in their jurisdictions comply with energy code via the prescriptive vs. HERS rating path,
- what portion of new homes in their jurisdictions are approximately code compliant vs. built to above-code standards, and
- how they expect either of those estimates to change under the new, more stringent Base Code coming into effect in 2024 or 2025.

This feedback was designed to gather information on Base Code practices without spending undue effort to learn about a small portion of the new multifamily and single-family homes built in the state.

The team reached out to all 50 municipalities in Massachusetts that follow the Base Code, via phone and email, and 38% (n=19) responded to the survey, with 17 (33%) providing usable data. We contacted each code official up to three times; no incentives were offered. See D.1 for the survey instrument, showing the questions asked of code officials in Base Code communities.

1.5.2 Follow-up with DOER Officials

As requested by the PAs, the study team had conversations with DOER officials who use the RESNET data as a part of their Green Communities work to ensure that the team was aware of any potential data issues DOER had encountered in its use of the RESNET data. This feedback was designed to dovetail with the goals of code official outreach described above.

1.5.3 Market Actor Interviews

The study included ten interviews with builders (n=7) and HERS raters (n=3) in Massachusetts to gather qualitative insights about RNC trends. Interviews focused on the following topics:

- **Activity level:** How many new homes did respondents work on in the past year? What portion went through the program? What portion were in Base vs. Stretch Code?
- **Baselines and code compliance:** The new 2021 IECC-based energy code represents a big jump relative to the previous code cycle – what will code compliance be like early in the new, 2021 IECC-based code cycle? What HERS values do builders normally target?
- **Representativeness of RESNET data:** What compliance paths are used in Base Code communities? Why do builders get HERS ratings in Base Code communities, where it is not required?
- **Net-to-Gross issues:** What do market actors think about all-electric homes? How is the program affecting decisions about energy efficiency or fuel choice?

The team recruited respondents from program tracking data, intake form data, and energy model results provided by ICF. To gather a variety of perspectives, respondents were targeted based on geography and activity level, i.e., how many projects they worked on in a given year. See Appendix A for more detail about the sample design.

The team contacted a limited pool of the program participants, slightly widening the outreach with each contact wave in order to avoid contacting the same people too many times for evaluation research. The outreach used PA-approved recruitment language and Mass Save branding in email outreach and included a PA contact person to provide legitimacy. To avoid overburdening program participants, respondents were contacted via email and phone, only up to three times (plus any additional coordinating emails/calls that were necessary to schedule conversations). Respondents were provided with $125 incentives in the form of digital gift cards, and conversations took between 30 and 45 minutes.

1.5.4 Processing and Analyzing RESNET and Program Data

1.5.4.1 Acquire RESNET Data

RESNET data. RESNET maintains a registry of all official HERS ratings. The study team obtained HERS rating data from RESNET, targeting homes permitted under the 2018 IECC-based code (November 8, 2020, through the end of 2022). The data were non-anonymized and included addresses to allow the team to identify program homes in the dataset.

1.5.4.2 Cleaning RESNET Data

Properly classifying homes. The team performed extensive data cleaning to limit the analysis to new homes built under the 2018 IECC-based energy code. This included identifying any homes that were not recently built (HERS ratings can be conducted on existing homes), that homes were properly identified as single- vs. multifamily, that addresses were formatted correctly to ensure reliable cross-checks between this and program tracking data, and so forth. See Appendix A for more detail. **The team received 36,700 records from RESNET with construction dates since the previous baseline, and ultimately winnowed the list down to 19,369 homes built in the relevant timeframe, 47% of which were participants in the PAs' RNC program.**

Preparing data for analysis. Data cleaning focused on preparing data for analysis, rather than performing a record-level data check, as would be typical with an on-site based study, where individual data points contribute more directly to overall results. That said, the team performed reasonableness checks on values, removing those that appeared to be data transcription errors. In that process, analysts found questionable values for some measures, particularly insulation R-values and U-values, resulting in additional data cleaning, discussions with RESNET, and limiting the number of records that we analyzed for any measures with unreliable values. Additionally, efficient lighting rates appear to be artificially low, and for appliances, the study team excluded efficiency values that appeared to be default values that RESENET directs HERS raters to use when they do not have actual specifications. See A.2.2.1 for additional discussion of the data cleaning process.

RESNET data vs. previous baseline study data. The data provided by RESNET do not align with every data point gathered by on-site technicians for previous RNC baseline studies. That said, the study includes direct comparisons whenever possible. See A.2 for additional discussion of differences between RESNET data and values traditionally included in RNC baseline studies.

1.5.4.3 Acquire and Process Program Data

The study team requested program tracking data, intake form data (contact information collected by the program at the point of the project's entry into the program), and energy model data exported from Ekotrope for program homes built since November 8, 2020. The study team reviewed and cleaned program home records sufficiently to cross-check records against the RESNET data. For more description of that iterative process, see A.2.

1.5.4.4 Analysis Sample Frame

Table 4 quantifies the RESNET and program data received from RESNET and the PAs/ICF, respectively, plus the number of permitted units with the study timeframe. The "original" columns describe the data as it was supplied to NMR, while the "usable" columns relate to the records remaining after cleaning. The primary factor contributing to the diminished count of both RESNET and program records are permit or construction dates before November 2020, some homes were also excluded on the basis of not appearing to be new construction based on further investigation of unusual values, and mid-rise multifamily homes were also removed (which were roughly 20% of the initial multifamily records received).

Table 4: Primary Data Sources

	Original			Usable		
Source	SF	MF	Total	SF	MF	Total
Census Permits	18,741	25,021	43,762	18,741	25,021	43,762
RESNET	21,311	15,388	36,629	14,456	4,739	19,195
Program†	18,701	4,265	22,966	8,216	913	9,129

† Usable counts includes 181 additional records from a previous data request for 22R48.

Table 5 shows the results of dividing the final, usable RESNET and program records by the number of permits. However, in the previous multifamily baseline study (20R30) the team discovered that the "5+ Family" Census Bureau permit data can include townhouses, which would be classified as single-family by the residential new construction program, as well as mid-rise construction. It is not possible to identify these from the permit counts without extensive review of building department records outside the purview of this study. Consequently, the true population of single-family homes is likely larger than that for one-to-four-unit buildings shown in Table 4, and conversely the multifamily population is smaller. These changes would reduce the single-family penetration rates while increasing those for multifamily.

Additionally, there has been uncertainty regarding whether or not Stretch Code requires official HERS ratings. HERS scores are referenced in code, but they are referenced as a mechanism to satisfy the *ERI* compliance path, and ERIs can be generated without a HERS rating. BBRS issued a clarification in late 2020 that non-HERS rated homes could satisfy code with a qualifying ERI, but it is unclear if it was common practice to bypass HERS ratings in favor of ERI calculations.[9] Interviewed market actors could not speak to this issue, unfortunately. The new/upcoming Tenth Edition code will specifically require HERS ratings for Stretch and Specialized Codes. If bypassing the HERS process has been common, any future analysis of RESNET data for homes built under the Tenth Edition code may have greater coverage than for this study.

Table 5: Market Coverage

	Single-Family	Multifamily
RESNET	78%	19%
Program	44%	4%

[9] https://www.mass.gov/doc/780-cmr-ninth-edition-residential-chapter-11-energy-efficiency-bbrs-advisory-as-of-10132020-0/download

1.5.4.5 No Weighting or Significance Testing

***No* weighting or significance testing.** Past baselines studies compared program homes to a sample of non-program homes. Accordingly, they used weighting to ensure that sampled homes reflected the population appropriately and tested results for statistically significant differences between key groups of homes. Given the large sample sizes available to this study RESNET data were neither weighted nor tested for statistically significant differences. The large sample sizes reduce sampling error compared to a small sample of on-site inspections. With these large sample sizes, confidence intervals around mean values are generally quite narrow, such that even potentially inconsequential differences between groups of homes would be flagged as significantly different in many cases. For example, there is only a small, one-point difference between program and non-program single-family average HERS scores. This difference is statistically significant using the 90% confidence, 10% precision tests used in previous Massachusetts baseline studies, even though the more important takeaway is their general similarity.

1.6 KEY LIMITATIONS AND SOURCES OF UNCERTAINTY

Stretch code focus. RESNET data include HERS-rated homes, but HERS ratings are not required in Base Code communities (and as noted, there has even been confusion about whether HERS scores were even required in Stretch Code communities). RESNET data only capture homes where the builders choose to obtain an official HERS rating or participate in the RNC program. That said, RESNET data cover far more homes than could ever be included in a study leveraging on-sites at a modest sample of homes. On the one hand, if non-program Base Code homes perform substantially worse than their HERS-rated counterparts, the ISP values here could slightly overstate the performance of non-program Base Code homes described here. On the other hand, in some cases, raters appear to log inefficient values for measures that might change post-occupancy, leading to conservative ratings that may *under*estimate actual performance.

Data uncertainty. The team identified sources of uncertainty in the RESNET data, such as:

- RESNET data are not limited to new homes, and limited data make it challenging to identify permit dates. The team used checks to exclude them, but some high-performing existing homes or renovations could be included. Without non-program home permit dates, estimating program penetration becomes challenging.
- RESNET provided over 36,000 records, while the PAs provided nearly 23,000 via program tracking data. After cleaning, the number of usable records in the RESNET data represent 78% of the Census' single-family permits (nearly 19,000 units) and 19% of multifamily permits (over 25,000). However, NMR has confirmed that the "5+ Family" classification the Census uses includes homes that the program would call single-family, casting doubt on attempts to calculate market coverage or program penetration. The relevant program records appear to represent 44% of single-family permits and 4% of multifamily permits, using the problematic classification used by the Census. Overall, the primary reason for excluding RESNET and program records was permit or construction dates before November 2020.
- Some measure values were blank or exceeded reasonable ranges, such as walls that appeared uninsulated. The team applied reasonableness checks to remove such values

or in some cases backfilled values from program tracking data and worked with RESNET to develop protocols to identify values to exclude from analysis. These values generally appeared to be data transcription errors.

- HERS scores are affected by solar PV. For the 1% of RESNET records with solar panels, the RESNET-provided HERS scores *did* take the solar into account, leaving NMR to backfill the non-solar scores (e.g., via program tracking data or estimating scores based on typical impacts from solar). This increases the uncertainty around the HERS scores for a very small portion of homes included in the analysis.
- For various reasons, RESNET data may differ from the as-built conditions. As one example, the RESNET data might incorrectly reflect an interim HERS rating, not the final energy model. As another example, some measure entries are extremely inefficient, particularly for lighting and appliances, suggesting that raters might be logging inefficient values to build in a compliance buffer. NMR reached out to DOER staff who had worked with RESNET data before, who confirmed that they had seen minor discrepancies between the as-built home and the energy model, often reflecting minor administrative issues rather than systematic issues with code compliance.

Code compliance. The above issues with data uncertainty contribute to questions about code compliance rates. For example, very few energy models demonstrated compliance with code's requirement of efficient lighting in 90% of fixtures, even though the market has overwhelmingly moved toward LED lighting. For this reason, lighting was ignored in code compliance rates.

Comparisons with previous studies. Given the methodological differences between this and previous baseline studies, some longitudinal comparisons may not be possible.

- **Different data points.** RESNET data do not include every variable from previous baseline studies. For example, insulation material is not a mandatory input for HERS energy models, so RESNET lacks this information. This study included as many comparable analyses as the data permit.
- **Occupied vs. unoccupied homes.** Some comparisons may not be appropriate because RESNET data generally describe homes prior to occupancy, while most previous studies visited occupied homes. HERS raters may have entered data for measures that were not yet installed, such as appliances or lighting. As noted above, raters may log conservative (inefficient) values to ensure that a home would achieve its target HERS score regardless of equipment choices made later by the occupant. The fact that so few homes in this study complied with code's efficient lighting requirements (no more than 15% for *any* of the home types considered in this study) suggests this may be common, and this could change the HERS score for a given home by several points. Similarly, the low rates of solar PV use should be viewed with skepticism. While builders can include solar panels on their homes, these are often installed by the homeowner. Accordingly, rates of solar PV use in the RESNET data likely far underpredict how many of these homes are likely to have solar panels installed by their occupants.

1.7 Report Organization

This overall report structure is as follows:

Report Body

- Executive Summary: summary of high-level findings and recommendations
- Introduction, Background, and Methodology: summary of study goals, program background, and methodology used
- Single-Family Comparisons: key comparisons (longitudinal and by market segments)
- Single-Family Building Shell: high-level building shell findings
- Single-Family Mechanical Equipment: high-level mechanical equipment findings
- Single-Family Appliances: high-level lighting and appliances findings
- Single-Family Code Compliance: summary of code compliance results
- Multifamily Comparisons: key comparisons (longitudinal and by market segments)
- Multifamily Building Shell: high-level building shell findings
- Multifamily Mechanical Equipment: high-level mechanical equipment findings
- Multifamily Appliances: high-level lighting and appliances findings
- Multifamily Code Compliance: summary of code compliance results
- Insights from Code Officials & Market Actors: findings from the code official survey and market actor interviews

Appendices

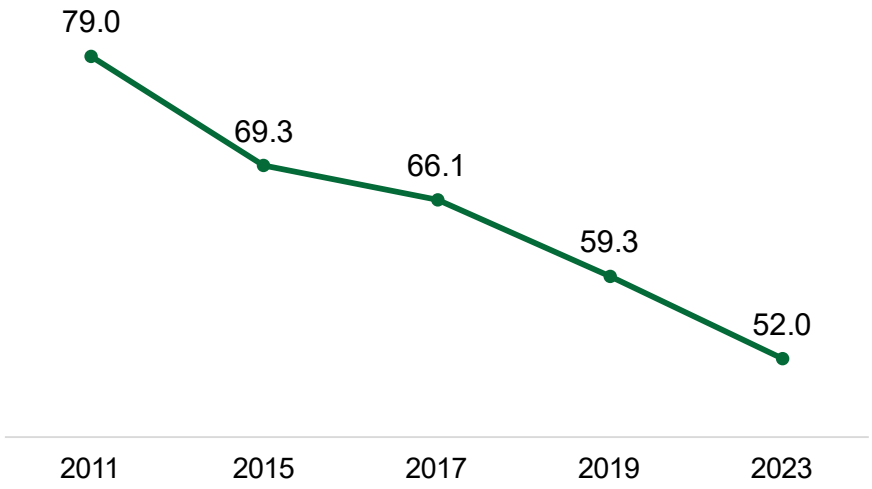
- Detailed Methodology
- Detailed Data: Single-Family
- Detailed Data: Multifamily
- Data Collection Instruments

Section 2 Single-Family Comparisons

This section contains comparisons for key measures across groups and over time, limited to homes that received HERS ratings.

Change over time in non-program homes. The continually decreasing average HERS index scores in Figure 2 show that the efficiency of new, single-family homes has increased steadily over time. The reduction in the average HERS index score from 79.0 to 52.0 represents a 34% improvement since 2011. The reduction in the average HERS index score from 59.3 to 52.0 represents a 12% improvement since the last baseline study in 2019.

Figure 2: Single-Family Non-Program Average HERS Index Scores Over Time



Program homes and Stretch Code homes are more efficient than their non-program and Base Code counterparts, but the gap is narrowing. Program homes are 2% more efficient than non-program homes, with average HERS index scores of 51.0 and 52.0, respectively (Figure 3). Homes in Stretch Code communities are 3% more efficient than homes in Base Code communities, with average HERS index scores of 51.5 and 53.0, respectively.

Figure 3: SF Average HERS Scores – Program/Non-Program, Base/Stretch

	Non-Program (n=6,352)	Program (n=8,145)
HERS Index Score	52.0	51.0

	Base Code (n=390)	Stretch Code (n=5,962)
HERS Index Score	53.0	51.5

The more electric, the more efficient. Homes that heat with electricity are 4% more efficient than homes that heat with fossil fuel, with average HERS index scores of 49.8 and 52.0, respectively (Figure 4). The figure below separately describes results for 1) all-electric homes, 2) mixed-fuel homes that heat with electricity but use fossil fuels for water heating, cooking, and/or drying clothes ("electric heat"), and 3) homes that heat with fossil fuels ("fossil heat"). On average, all-electric homes are 5% more efficient (average HERS index score of 47.3) than the larger group of homes that heat with electricity but still use fossil fuels for other end uses (average HERS index score of 49.8). The all-electric HERS scores are driven lower by the much higher heating, cooling, and water heating efficiency values, but for most measures, the all-electric homes do also slightly outperform the other home categories at the measure-level.

Figure 4: SF Non-Program Average HERS Index Scores by Degree of Electrification

	All Electric (n=436)	Electric Heat (n=531)	Fossil Heat (n=4,906)
HERS Index Score	47.3	49.8	52.0
ACH50	1.9	2.0	2.3
Duct LTO CFM25/100 ft^2	1.7	1.9	2.0
Exterior Wall R-value	23.1	22.8	22.3
Ceiling R-value	42.8	42.7	43.1
Floor to Bsmt R-Value	34.4	34.5	33.7
Heating COP	3.42	3.43	0.95
Cooling SEER	18.6	18.5	13.9
Water Heater EF	2.90	2.21	1.45

Table 6 provides measure-level comparisons across time for single-family homes. Heat pump heating efficiency (HSPF/COP) are omitted due to the small number of heat pumps seen in previous studies, and because the substantial variation in system type seen in those past studies yields misleading trends. For example, the 2017 study had only eight ductless MSHPs and 1 GSHP, while 2019 had only about 30 heat pumps (with a very different equipment mix), while this study had over 500 ducted and nearly 400 ductless heat pumps, and over 20 GSHPs. Additional single-family measure-level findings and discussion are provided in Section 3 through Section 5.

Table 6: Key Measure Comparison Across Baseline Studies in SF Non-Program Homes

	2011 (n=100)	2015 (n=146)	2017 (n=50)	2019 (n=100)	2023 (n=6,352)
HERS Index Score	79.0	69.3	66.1	59.3	52.0
ACH50	4.8	3.6	3.6	3.1	2.2
Duct LTO CFM25/100 ft^2	12.4	4.6	4.2	4.3	1.9
Exterior Wall R-value	19.4	20.6	NA	21.8	22.1
Flat Ceiling R-value	36.8	40.0	NA	43.8	42.7*
Vaulted Ceiling R-Value	35.5	32.8	NA	41.6	42.7*
Floor to Bsmt R-Value	26.7	30.2	NA	30.1	33.3
Fossil Fuel AFUE	90.9	93.3	92.9	94.0	95.4
Cooling SEER	13.7	13.8	14.8	14.9	14.3
Water Heater EF	0.75	1.05	1.05	1.29	1.56
Efficient Bulb Saturation	20%	50%	75%	89%	NA

*Flat and vaulted ceilings combined.

Section 3 Single-Family Building Shell

This section provides high-level findings regarding the thermal envelope/building shell of single-family homes included in the RESNET data. For additional detail, see B.4.

3.1 Air Infiltration and Ventilation

The average ACH50 value is consistent across codes and is better than previous baselines. The average ACH50 is 2.2, versus 3.1 in 2019. Base code (2.4) and Stretch Code (2.2) have comparable values (Table 31).

Recovery ventilation remains rare. HRVs and ERVs were installed in only 6% of homes, compared to 15% in 2019 (Table 32).

3.2 Insulation R-values

Below we provide nominal R-values, which represent the thermal resistance of the insulation material itself. For the corresponding U-values that account for insulation installation quality (grade) and framing factors, see Appendix B. Nominal R-values are provided for reference; a UDRH would rely on the more holistic U-value metric.

3.2.1 Above Grade Walls

The average R-value of wall insulation is consistent across codes and is better than the previous baseline. Program homes have an average nominal R-value of R-23.3, while non-program homes achieve an average of R-22.1. This represents an improvement compared to the 2019 average of R-19.7 for non-program homes. The R-values are similar between the Base Code (R-22.6) and Stretch Code (R-21.7).

3.2.2 Ceilings (Flat and Vaulted Combined)

Note that the previous baselines categorized ceilings as either flat or vaulted, however, the data for the current baseline does not include this level of detail. As a result, the R-values for flat and vaulted ceilings are combined, providing a single average value for all ceiling types.

The average R-value is consistent across codes and is similar to previous baselines. In 2019, vaulted ceilings had an average R-value of R-43.8, while flat ceilings averaged R-41.6. The current average R-value for all ceilings is R-42.7, indicating a relatively unchanged average R-value compared to previous baseline. The R-values are similar between the Base Code (R-42.3) and Stretch Code (R-42.7).

3.2.3 Floors Over Unconditioned Basements

The average R-value is slightly less for Stretch Code homes compared to Base Code homes and is better than previous baselines. The average R-value for floors has slightly improved since the previous baseline, with current averages of R-33.3 for non-program homes and R-34.4 for program homes, an increase from R-30.1 in 2019. While there is some inconsistency across codes, Base Code homes have a slightly higher average R-value of R-35.7 compared to Stretch Code homes at R-33.3.

3.2.4 Foundation Walls

The average R-value is similar across codes and has improved since the previous baseline. The average R-value for non-program homes has increased by 31%, from R-15.2 in 2019 to R-19.9 for this baseline.

3.3 WINDOWS

Window U-factors remained consistent. The average window U-factor is 0.28, virtually the same as in 2019 (0.29) and 2015 (0.30) (Table 45). As a reminder, window data for this study includes far more verified data than have previously been available from on-site based studies, because window specification stickers are commonly discarded post-occupancy.

Window SHGCs have decreased slightly. The average window SHGC is 0.29, down slightly from 0.35 in 2019 (Table 46).

Section 4 Single-Family Mechanical Equipment and Electrification

This section summarizes the mechanical systems seen in the RESNET homes, including the extent to which homes were heated by electricity or were all-electric. For more details, see B.5.

4.1 Electrification

All-electric single-family homes are relatively rare, across the board. Only 8% of program homes and 4% of non-program homes are all-electric (Table 7), due to low adoption of electric heating equipment. Electric cooking and water heating are reasonably common – between one-quarter and one-third of homes depending on the market segment, and almost all homes use electric clothes dryers.

The sample sizes in Table 7 vary per measure due to missing data for some homes; exact counts can be found in the corresponding section of Appendix B.

Table 7: Single-Family Electrification by End Use

End Use	Program	NP: Base Code	NP: Stretch	NP: Overall
Heating	13%	4%	10%	9%
Hot Water	32%	31%	26%	27%
Cooking	26%	33%	28%	28%
Clothes Dryer	99%	95%	96%	96%
All-electric				
n	8,217	353	5,137	5,490
Penetration	8%	1%	5%	4%

4.2 Heating Equipment

Electric heating is still uncommon. Fewer than one in ten non-program homes (9%) heat with electricity, notably, lower than the 14% seen in the 2019 study. Program homes are slightly more likely to heat with electricity (13%) than non-program homes (9%). Only 4% of non-program homes in Base Code communities heat with electricity, compared to 10% in Stretch Code (Table 47).

Fuel-fired air distribution continues to dominate, particularly in Base Code communities. A large majority (85%) of program and non-program homes alike heat with fuel-fired air distribution systems i.e., furnaces or hydro-air boilers. The proportion of homes heating with fuel-fired air distribution systems in non-program Base Code communities is higher at 95% (Table 48). Propane is used to heat 43% of non-program homes (including forced air and boilers), but only 26% of program homes.

Table 8: Single-Family Heating Equipment by Type and Fuel

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*7,325*	*354*	*5,072*	*5,426*
Fuel-fired air distribution	85%	95%	85%	85%
Natural Gas	60%	54%	46%	46%
Propane	25%	41%	39%	39%
Ducted ASHP (Electric)	7%	3%	6%	6%
Ductless ASHP (Electric)	5%	1%	3%	3%
Boiler	2%	1%	6%	5%
Natural Gas	1%	1%	1%	1%
Propane	1%	<1%	4%	4%
GSHP (Electric)	<1%	0%	<1%	<1%
Other*	<1%	<1%	<1%	<1%

*Includes electric baseboard or radiant and electric air distribution.
**Values may not sum due to rounding.

Fossil fuel heating system efficiency inched up, but overall heating equipment efficiency did not, largely due to the relatively low use of heat pumps. Table 9 displays the average AFUE for major system types. The fossil fuel systems include forced air and hydronic distribution. The heat pump systems include ducted and ductless ASHPs as well as GSHPs. To create an all-system average COP, efficiencies were converted to COP using RESNET protocols, which yields an approximate estimate, not a result aligned with manufacturer/AHRI specifications.[10] Average AFUE among fossil fuel systems is 95.4, slightly better than 94.0 in 2019. However, average HSPF for heat pumps is 10.3, slightly lower than 10.5 in 2019. Despite the improvement in fossil fuel system efficiency, the small reduction in heat pump efficiency combined with the lower proportion of homes with heat pumps (which are more efficient than fossil fuel systems) pulled the overall COP down slightly, from 1.28 in 2019 to 1.15.

Table 9: Average Efficiency for all Single-Family Fossil Fuel Systems, Electric Heat Pumps, and All Systems

	All Fossil Fuel (AFUE)	All Heat Pump (HSPF)	All Heat Pump (COP)	All Systems (COP)
n	*4,927*	*472*	*472*	*5,399*
Min	80.0	7.2	2.11	0.80
Mean	95.4	10.3	3.00	1.15
Median	96.0	10.0	2.99	0.96
Max	98.1	17.7	5.20	5.20
SD	1.3	1.5	0.43	0.61

[10] To convert to COP, AFUE values were divided by 100, HSPF values were divided by 3.413.

4.3 COOLING EQUIPMENT

Central air conditioning continues to dominate, particularly in Base Code communities. Most homes with permanent cooling systems rely on traditional central AC systems (89%). This proportion in Base Code communities is higher at 95% (Table 53). While the proportion of homes cooling with ducted heat pumps increased slightly from 6% in 2019 to 8% in 2023, the proportion of homes cooling with ductless heat pumps declined during the same timeframe: from 8% to 3%. RESNET data did not allow for determining the percentage of homes with cooling systems, but this was 99% of homes in the 2019 study.

Overall cooling equipment efficiency plateaued. The average SEER across all cooling systems is 14.3, comparable to 14.9 in 2019 (Table 10).

Table 10: Average Efficiency for all Single-Family Cooling Systems

Efficiency (SEER)	CAC	Ducted ASHP	Ductless ASHP	GSHP	Combined
n	*4,421 (89%)*	*374 (8%)*	*153 (3%)*	*2 (<1%)*	*4,969 (100%)*
Min	12.0	12.2	14.3	14.0	12.0
Mean	13.8	17.5	19.6	21.1	14.3
Median	13.5	17.8	19.7	20.3	14.0
Max	22.5	23.1	26.1	26.2	26.2
SD	1.1	2.2	2.1	3.2	1.9

4.4 DOMESTIC HOT WATER

Adoption of gas instantaneous and HPWH systems in new homes continues to erode the share of conventional water heaters. Conventional (standalone storage) water heaters represented 29% of water heating equipment in 2019 and just 13% in 2023, while instantaneous systems have increased from 43% to 61% over the same time period. HPWHs have also increased in prevalence over time, and now represent 24% of water heating systems in new, non-program homes (versus 17% in 2019). HPWHs are similarly common in homes that heat with propane and those that heat with natural gas (27% and 21%, respectively).

Table 11: Single-Family Water Heater Prevalence & Efficiency (EF) by Type and Fuel

	Program	NP: Base Code	NP: Stretch Code	NP: Overall Prevalence	NP: Overall EF
n	*7,383*	*370*	*5,314*	*5,684*	*5,684*
Instantaneous	57%	53%	62%	61%	0.94
Natural gas	39%	28%	31%	31%	0.95
Propane	17%	24%	30%	30%	0.94
Electric	<1%	1%	<1%	<1%	0.94
Heat pump (electric)	30%	28%	24%	24%	3.57
Conventional	13%	19%	13%	13%	0.80
Natural gas	9%	14%	6%	6%	0.76
Propane	2%	3%	5%	5%	0.80
Electric	1%	2%	2%	2%	0.92
Integrated	<1%	<1%	1%	1%	0.86
Natural gas	<1%	<1%	1%	1%	0.86
Propane	<1%	<1%	<1%	<1%	0.87

*Values may not sum due to rounding.

Overall water heater efficiency is trending upward. Overall water heater efficiency is 1.56, up from 1.29 in 2019. This increase is due to 1) higher proportions of instantaneous and HPWHs, and 2) improvements in HPWH efficiency. The average efficiency of HPWHs has increased steadily, from 2.66 in 2015 to 3.34 in 2019 and 3.57 in 2023.

Table 12: Overall Single-Family DHW Equipment Efficiency

Efficiency (EF)	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*7,383*	*370*	*5,314*	*5,684*
Min	0.59	0.59	0.59	0.59
Mean	1.72	1.62	1.56	1.56
Median	0.95	0.95	0.95	0.95
Max	4.69	4.05	5.00	5.00
SD	1.23	1.19	1.14	1.15

4.5 DUCT SYSTEMS

Ducts are increasingly being installed in conditioned space. All supply ducts were located completely within conditioned space in 47% of homes, up from approximately 15%[11] in 2019 (Table 68). When ducts are installed in conditioned space, any leakage happens within the thermal envelope, reducing the energy penalty from duct leakage.

Duct leakage to the outside is dramatically improved, due to the shift toward installing ducts in conditioned space. Average duct leakage to the outside is 1.9 CFM25/100 ft^2 CFA, a decrease of over 50% from 4.3 in 2019 (Table 66). Similarly, average total duct leakage is down over 50% since 2019: from 13.6 to 5.7 CFM25/100 ft^2 CFA (Table 67). Average duct leakage to outside is slightly higher in Base Code communities (2.4 CFM25/100 ft^2 CFA) than in Stretch Code communities (1.9 CFM25/100 ft^2 CFA). In contrast, there is no difference in average total duct leakage between Base Code communities and Stretch Code communities.

Supply ducts are better insulated. The average R-value for supply ducts located in unconditioned space is 7.7. In comparison, the 2019 averages were 6.6 for attic supply ducts and 5.6 for ducts located in unconditioned basements (Table 69).

4.6 RENEWABLES

PV penetration is much lower than in 2019, likely due to methodological differences between studies. PV penetration is extremely low in the RESNET data, down from 12% in 2019 to only 1%. Previous RNC baseline studies sampled occupied homes, but the homes in the RESNET data were rated prior to occupancy and panels are generally installed by the owner/occupant. PV penetration did not vary significantly between program (1.4%) and non-program (0.9%) homes (Table 70). Among the relatively few homes with PV, on-site power production was around 11,200 kwh (Table 71).

[11] The 2019 study reported the percentage of homes for which all ducts (supply and return) were located within conditioned space. The RESNET dataset used for this study contains this information for supply ducts only. It is possible for a home to have all supply ducts, but not all return ducts, located within conditioned space; however, this is an uncommon arrangement. Therefore, 15% is a reasonable (albeit conservative) estimate for the percentage of homes with all supply ducts located within conditioned space.

Section 5 Single-Family Appliances

The share of electric dryers continued to rise. The share of electric dryers continued its upward trajectory, from 78% in 2015, to 81% in 2019, resting at a robust 96% in 2023.

Electric ranges remain unpopular. The share of electric ranges is 28%; little higher than in 2015 at 25%.

Energy consumption of most appliances has remained steady. The average energy consumption of refrigerators and dishwashers changed little since 2015. Clothes washers are an exception: average energy consumption of clothes washers more than doubled between 2019 and 2023. As described in A.2.2.3, readers should view appliance efficiency figures with some skepticism, as HERS raters might have made their energy models before appliances were installed. HERS raters would likely have been able to correctly assess the fuel that would be used for a dryer or range, but they may have recorded placeholder efficiency values otherwise. The team attempted to remove obvious default values provided in the absence of better information, but some placeholders likely remain in the data.

Section 6 Single-Family Code Compliance

This section summarizes how single-family homes included in the study compare to the applicable code version, and how well prepared they are to meet the upcoming code version.

6.1 Overall Results

Single-family homes compare favorably to the code version under which they were built, but most are far below the current code.

Homes were compared to the applicable code, the Ninth Edition of the Massachusetts State Building Code based on the 2018 IECC (Table 13). They were also compared to the Tenth Edition (Table 14, 2021 IECC), which entered full effect in July of 2024.[12] The projected poor performance of existing building practices against the Tenth Edition indicates that substantial changes will be necessary for homes to meet the new code.

6.2 Compliance with Relevant Code: Ninth Edition

Code compliance under the later stages of the 2018 code cycle appears to be quite high: approximately 88% for non-program Base Code homes, and in the mid-90s for program homes and non-program homes in Stretch Code communities.

Table 13 estimates the portion of homes that comply with the Ninth Edition code.

- The **HERS only** row counts homes which satisfy the HERS requirement of 55 or less, with renewable energy credits.[13]
- The **Prescriptive R** row includes Base Code homes with HERS scores above 55 that meet the minimum prescriptive R-values for each measure[14] *and* satisfy one of the R407 Additional Efficiency Package options, thereby demonstrating compliance with the prescriptive path of the Base Code.[15]
- The **Program** column compares homes to the codes adopted by municipalities where they are located.

Additional contributors to compliance. Beyond the HERS score and the basic prescriptive requirements, building code includes numerous other requirements that affect compliance rates. Table 13 shows compliance rates with additional key requirements concerning air infiltration (3 ACH_{50}), duct leakage or placement (total duct leakage of 4 CFM_{25}/100 ft^2 CFA or in conditioned space [Base Code only]), and lighting efficiency (90% efficient fixtures). The RESNET data indicates remarkably low levels of compliance with the efficient lighting requirement compared to

[12] Stretch code was updated in 2023 but HERS requirements did not change until July 2024, when the target changed from 55 to 42 for fossil-fuel and 45 for all-electric. Base code is not set to change until at least 2025.
[13] We do not have precise photovoltaic array sizing, and therefore assume that any builder installing PV will have installed a large enough array (2.5 kW) to receive the five-point credit available in the Ninth Edition.
[14] Except conditioned slab insulation, whose requirements are not readily verified with the available information.
[15] This should be considered an underestimate; it does not account for the prescriptive code's UA trade-off option as RESNET data did not include measure area. Similarly, the 90% UA option of R407 is not assessed.

the average MA-REC rating of 98.5% for lighting in 19X02. This disparity could arise if it is common practice to complete final ratings without permanent lighting fixture information, such that raters can ensure homes comply regardless of final lighting choices. Given the low compliance rates for this measure in the data, it is excluded from the combined ratings at the bottom of the table. The 19X02 MA-REC ratings are also listed for comparison, although this metric affords partial credit for non-compliant measures, unlike the rest of this analysis. Both MA-REC and Table 13 omit numerous other requirements like hot water pipe insulation that would need to be inspected by a code official but are not identified in the RESNET data.

Table 13: Massachusetts Ninth Edition (2018 IECC) Single-Family Compliance

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	8,218	391	5,969	6,361
Core Requirements				
HERS only	95%	85%	99%	98%
Prescriptive R	–	5%	–	–
Additional Mandatory Requirements				
ACH_{50} (A)	98%	97%	96%	96%
Ducts (D)†	80%	77%	*82%*	*82%*
Lighting	10%	10%	15%	14%
Overall Compliance (Core + Additional)				
HERS & A	93%	84%	96%	95%
Prescriptive & A & D	–	4%	–	–
TOTAL	**93%**	**88%**	**96%**	**95%**
19X02 MA-REC	**99%**	**89%**	**91%**	**90%**

† Duct leakage requirements only apply to prescriptive path Base Code, but all homes with unconditioned duct work must be tested.

6.3 COMPLIANCE WITH THE NEW/UPCOMING CODE: TENTH EDITION

Homes are compared to the code variety listed in DOER's Massachusetts Building Energy Code Adoption by Municipality from June 2024.

Single-family homes built to program and/or Stretch Code requirements under the Ninth Edition Code fare extremely poorly against the Tenth Edition requirements – only about 1% appear ready to comply with the new requirements (Table 14). For Stretch and Specialized communities, [16] the new code requirements that came into effect in July 2024 include substantially stricter fuel-specific HERS scores (45 all-electric, 42 mixed-fuel) and new recovery ventilation requirements.[17] The new Base Code (not yet finalized) will require slightly lower HERS scores (52) or higher levels of prescriptive insulation.

In contrast, non-program Base Code homes fare much better under the Tenth Edition Code: approximately two-fifths would comply (43%). Therefore, less effort will be necessary to lift Base Code homes up to the forthcoming Base Code requirements. This is because the Base Code HERS requirements only changed marginally (from 55 to 52), compared to the starker reduction of the Stretch and Specialized code.

Table 14: Estimated Massachusetts Tenth Edition (2021 IECC) SF Compliance

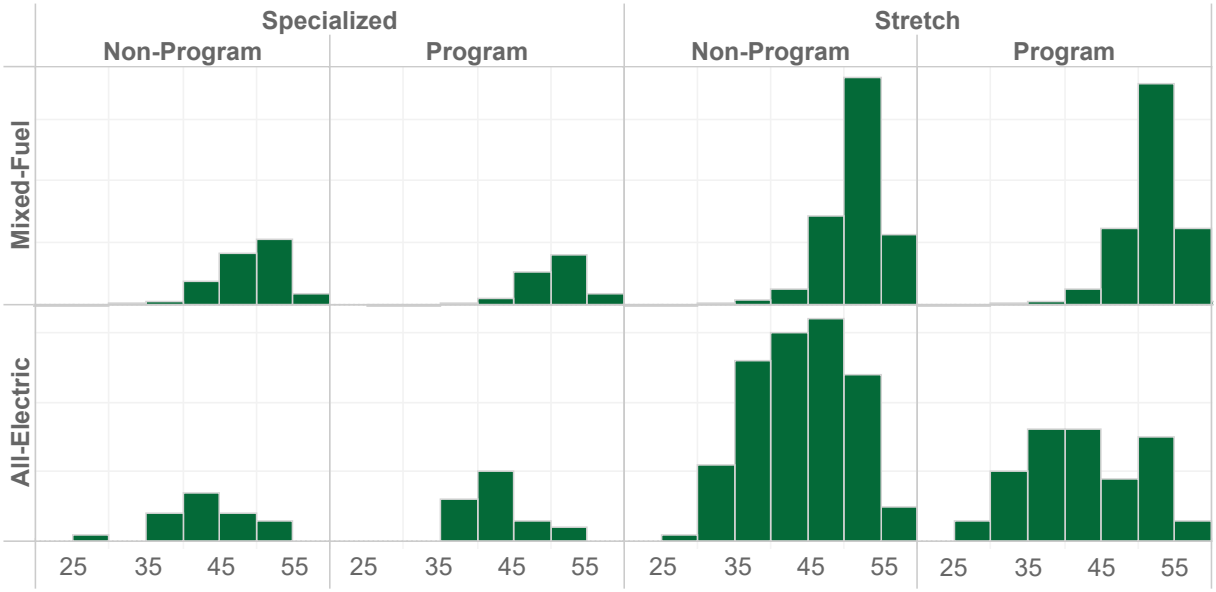
	Program	NP: Base Code	NP: Stretch or Specialized	NP: Overall
n[18]	*8,217*	*422*	*5,937*	*6,359*
HERS only	8%	43%	3%	6%
Prescriptive R	–	2%	–	–
Additional Mandatory Requirements				
ACH50 (A)	98%	97%	96%	96%
Ducts (D)†	80%	78%	*82%*	*82%*
Ventilation (V)	3%	6%	6%	6%
Combined				
HERS + A + V	1%	*42%*‡	1%	4%
Prescriptive + A + D	–	1%	–	–
TOTAL	**1%**	**43%**	**1%**	**4%**

† Duct requirements applicable to Base Code only.
‡ The draft Base Code does not appear to require recovery ventilation for the ERI (performance) path.

[16] The requirement of 4 kW of solar panels for SF, mixed-fuel Specialized homes is excluded from this analysis since there was no comparable requirement in the Ninth Edition and builders could bypass this by building all-electric.
[17] Recovery ventilation efficiency was not included in RESNET data. Since 16 of 17 recovery ventilation systems in 19X02 satisfied code requirements, we assume here that all such installations also satisfy the 65% SRE requirement.
[18] Counts in Table 14 differ from Table 13 because two municipalities switched from Stretch Code under the Ninth Edition to Base Code in the Tenth. This analysis assumes the higher levels of rigor will persist in these communities for some time.

As shown by the narrow mixed-fuel peaks in Figure 5, the low levels of compliance in Stretch and Specialized code communities are largely an artifact of builders targeting the existing code requirement rather than stretching beyond it. Even program homes fall into this category, and rarely have HERS scores low (good) enough to meet the substantially stricter HERS requirements of the new Stretch and Specialized Codes. Nevertheless, it appears to be possible to meet the new code with relative ease as outlined in the recent RNC Energy Optimization Code Compliance and Electrification Study (21R41: Phase 1–Code Compliance, Phase 2–Electrification).

Figure 5: Distribution of HERS Scores by Tenth Edition Code and Program Status[19]



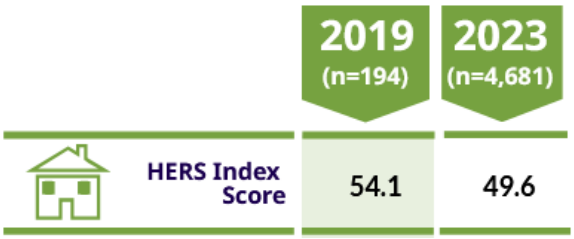
[19] Y-axis scales are not included in Figure 5 since each cell would have its own scale, and the shape and position of the distributions relative to the x-axis are more important that the absolute magnitudes of the bars.

Section 7 Multifamily Comparisons

This section contains comparisons for key measures across groups and over time, limited to homes that received HERS ratings.

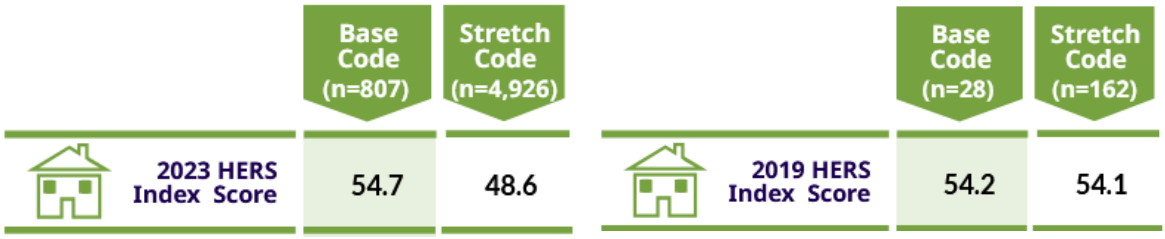
Change over time in non-program homes. The reduction in average HERS scores between 2019 and 2023 indicates an improvement in the efficiency of new, low-rise multifamily homes. With an average score of 49.6, multifamily homes are 8% more efficient than in 2019 (Figure 6).

Figure 6: Multifamily Non-Program Average HERS Index Scores Over Time



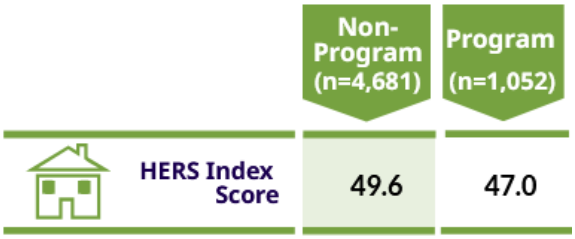
MF Stretch Code homes have become more efficient since 2019, but HERS-rated Base Code homes have not. Stretch Code homes are 11% more efficient than their HERS-rated Base Code counterparts, with an average HERS score of 48.6 compared to 54.7 (Figure 7). Moreover, Stretch Code homes have improved in efficiency since 2019, when the average HERS score was 54.1. In contrast, HERS-rated Base Code homes have not improved in efficiency relative to the 2019 results. In fact, the average HERS score has increased slightly, from 54.2 to 54.7.

Figure 7: Multifamily Non-Program Average HERS Index Scores by Code



Multifamily program homes are 5% more efficient than non-program homes, with an average HERS score of 47.0 and 49.6, respectively (Figure 8).

Figure 8: Multifamily Program and Non-Program Average HERS Index Scores



Surprisingly, all-electric multifamily homes have worse HERS scores than mixed-fuel homes that heat with electricity but use fossil fuels for other end-uses. Homes that heat with electricity are 8% more efficient than homes that heat with fossil fuel, with average HERS index scores of 47.6 and 50.8, respectively (Figure 9). The figure below separately describes results for 1) all-electric homes, (2) mixed-fuel homes that heat with electricity but use fossil fuels for water heating, cooking, and/or drying clothes ("electric heat"), and 3) homes that heat with fossil fuels ("fossil heat"). On average, all-electric homes actually have higher (worse) average HERS index scores (49.0) than the larger group of homes that heat with electricity but are not fully all-electric (average HERS index score of 47.6).

Figure 9: MF Non-Program Average HERS Index Scores by Home Heating Fuel

	All Electric (n=658)	Electric Heat (n=1,240)	Fossil Heat (n=2,967)
HERS Index Score	49.0	47.6	50.8
ACH50	2.7	3.0	2.9
Duct LTO CFM25/100 ft^2	1.9	1.9	2.0
Exterior Wall R-value	24.0	23.8	21.9
Ceiling R-value	42.3	41.7	40.9
Floor to Bsmt R-Value	33.2	33.1	33.5
Heating COP	3.48	3.53	0.95
Cooling SEER	17.2	17.7	14.0
Water Heater EF	2.29	1.60	1.16

Table 15 provides measure-level comparisons across time for multifamily homes. Additional multifamily measure-level findings and discussion are provided in Section 8 through Section 10.

Table 15: Key Measure Comparison Across Baseline Studies in Multifamily Non-Program Homes

	2019 (n=194)	2023 (n=4,681)
HERS Index Score	54.1	49.6
ACH50	3.4	2.9
Duct LTO CFM25/100 ft^2	5.5	1.9
Exterior Wall U-value	0.064	0.044
Flat Ceiling U-value	0.034	0.025
Vaulted Ceiling U-Value	0.039	0.025
Floor to Bsmt U-Value	0.067	0.032
Fossil Fuel AFUE	94.7	94.7
Heat Pump HSPF	8.3	10.4
Cooling SEER	13.8	15.0
Water Heater EF	1.21	1.29

Section 8 Multifamily Building Shell

8.1 Air Infiltration and Ventilation

The average ACH50 value is better than previous baselines. The average ACH50 is 2.9, down from 3.4 in 2019 (Table 83).

Penetration of HRVs and ERVs is low. HRVs and ERVs were installed in only 5% of non-program homes and 1% of program homes (Table 84).

8.2 Insulation R-values

Below we provide U-values that account for insulation installation quality (grade) and framing factor. For the corresponding R-values that represent the thermal resistance of the insulation material itself, see Appendix C. Nominal R-values are provided for reference; the UDRH relies on the more holistic U-value metric.

8.2.1 Above Grade Walls

The average U-value is lower (better) for Base Code homes and is better than previous baselines. The average U-value is 0.044, substantially better than U-0.064 in the previous baseline. The Base Code homes exhibit a lower average U-value of 0.038 compared to Stretch Code homes at U-0.045.

8.2.2 Ceilings (Flat and Vaulted Combined)

The average U-value is consistent across codes and is better than previous baselines. The average U-value for flat and vaulted ceilings is 0.025, down from U-0.034 for flat and U-0.039 for vaulted ceilings in the previous baseline. The average U-values do not vary between Base Code (0.024) and Stretch Code (0.025).

8.2.3 Floors Over Unconditioned Basements

The average U-value is consistent across codes and is better than previous baselines. The average U-value for floors above unconditioned space is U-0.032, which is lower than the previous baselines average U-value of 0.067. The average U-values are similar and only slightly vary between Base Code (0.029) and Stretch Code (0.032).

8.2.4 Foundation Walls

The average U-value for this baseline is U-0.045, with Base Code homes exhibiting lower values. No comparable data exists for foundation walls in multifamily buildings from the previous baseline, as most buildings in both baselines lacked conditioned basements with foundation walls.

8.3 WINDOWS

Window U-factors have remained consistent. The average window U-factor is 0.28, the same as in 2019 (Table 97). Unlike single-family, the previous multifamily baseline relied on RESNET data, making this longitudinal comparison quite reliable.

Window SHGCs have decreased slightly. The average window SHGC is 0.28, down slightly from 0.30 in 2019 (Table 98).

Section 9 Multifamily Mechanical Equipment and Electrification

9.1 Electrification

All-electric multifamily homes are substantially more common than all-electric single-family homes, but they still represent a minority of the multifamily market, ranging from 14% of non-program units to 32% of program units (Table 16). Across the board, space and water heating end uses drive this result, because most units use electric cooking and nearly all use electric clothes dryers.

The sample sizes in Table 16 vary per measure due to missing data for some homes; exact counts can be found in the corresponding section of Appendix C.

Table 16: Multifamily Electrification by End Use

End Use	Program	NP: Base Code	NP: Stretch or Specialized	NP: Overall
Heating	52%	13%	33%	29%
Hot Water	42%	44%	23%	26%
Cooking	72%	79%	60%	63%
Clothes Dryer	99%	100%	99%	99%
All-electric				
n	1,052	717	3,964	4,681
Penetration	32%	8%	15%	14%

9.2 Heating Equipment

Electric heating is more common in multifamily homes than single-family homes. Over one-quarter (29%) of multifamily homes are heated with electricity, compared to only 9% of single-family homes. Over twice as many non-program multifamily homes in Stretch Code communities (33%) heat with electricity than in Base Code communities (13%). Program multifamily homes lead non-program multifamily homes with 52% heating with electricity (Table 99).

Fossil fuel-fired equipment efficiency held steady. Fossil fuel-fired heating equipment efficiency held steady from 2019 at 94.7 AFUE. Fuel-fired equipment efficiency is notably higher in Stretch Code communities (95.5 AFUE) than in Base Code communities (91.4 AFUE) (Table 101).

Table 17: Multifamily Heating Equipment by Type and Fuel

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,025*	*676*	*3,468*	*4,144*
Furnace	45%	87%	65%	69%
Natural Gas	45%	85%	64%	67%
Propane	<1%	2%	2%	2%
Ducted ASHP (Electric)	20%	2%	19%	16%
Ductless ASHP (Electric)	32%	6%	12%	11%
Boiler	3%	0%	3%	2%
Natural Gas	3%	0%	3%	2%
Propane	0%	0%	<1%	<1%
GSHP (Electric)	0%	0%	<1%	<1%
Other*	0%	6%	1%	2%

*Includes electric baseboard or radiant and electric air distribution.
**Values may not sum due to rounding.

The average overall heating COP of heating systems in new homes is higher than achievable by fossil fuel systems alone due to the contribution of heat pumps. Table 18 displays the average efficiency values for major system types. The fossil fuel systems include both air and hydronic distribution. The heat pump systems include both ducted and ductless air source heat pumps as well as a ground source heat pump. To create an all-system average COP, efficiencies were converted to COP using RESNET protocols, which yields an approximate estimate, not a result derived from manufacturer/AHRI specifications.[20]

Table 18: Average Efficiency for all Multifamily Fossil Fuel Systems, Electric Heat Pumps, and All Systems

	All Fossil Fuel (AFUE)	All Heat Pump (HSPF)	All Heat Pump (COP)	All Systems (COP)
n	*2,961*	*1,099*	*1,099*	*4,061*
Min	80.0	7.2	2.12	0.80
Mean	94.7	10.4	3.03	1.51
Median	95.0	10.2	3.00	0.96
Max	98.0	15.4	4.50	4.50
SD	3.5	1.2	0.34	0.94

[20] To convert to COP, AFUE values were divided by 100, HSPF values were divided by 3.413.

9.3 Cooling Equipment

Overall cooling equipment efficiency has improved. The average SEER across all cooling systems is 15.0, an improvement upon the 13.8 of the previous baseline.

Table 19: Average Efficiency for all Multifamily Cooling Systems

Efficiency (SEER)	CAC	Ducted ASHP	Ductless ASHP	GSHP	Combined
n	*2,951*	*681*	*371*	*1*	*4,004*
Min	12.0	11.1	11.9	20.9	11.1
Mean	13.9	17.4	19.1	20.9	15.0
Median	14.0	18.0	19.2	20.9	14.0
Max	20.0	25.5	33.1	20.9	33.1
SD	1.3	2.9	3.9	n/a	2.7

9.4 Domestic Hot Water

HPWHs have gained a foothold in program homes. Instantaneous water heaters are the most common type of water heating equipment, installed in over one-half (53%) of non-program homes and two-fifths (40%) of program homes. HPWHs are relatively common in program homes (34%) but are still uncommon in non-program homes (13%), particularly those in Base Code communities (2%).

Conventional (standalone storage) water heaters are still commonly installed in non-program homes. Conventional water heaters account for around one-third (33%) of water heaters installed in non-program homes. They are especially prevalent in Base Code communities where they account for over two-fifths (43%) of water heaters installed in non-program homes.

Table 20: Multifamily Water Heaters by Type and Fuel

	Program	NP: Base Code	NP: Stretch Code	NP: Overall	NP: Overall EF
n	*1,034*	*676*	*3,725*	*4,401*	*4,401*
Instantaneous	40%	55%	52%	53%	0.95
Natural gas	38%	55%	51%	51%	0.95
Propane	<1%	0%	2%	1%	0.95
Electric	1%	1%	<1%	<1%	0.95
Conventional	26%	43%	31%	33%	0.90
Natural gas	14%	1%	22%	19%	0.89
Electric	7%	42%	8%	13%	0.92
Propane	5%	0%	1%	1%	0.91
Heat pump (electric)	34%	2%	15%	13%	3.69
Integrated (natural gas)	0%	0%	1%	1%	0.94

*Values may not sum due to rounding.

Table 21: Overall Multifamily DHW Equipment Efficiency

Efficiency (EF)	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,034*	*676*	*3,725*	*4,401*
Min	0.83	0.90	0.61	0.61
Mean	1.85	1.00	1.34	1.29
Median	0.96	0.95	0.95	0.95
Max	3.88	3.75	4.09	4.09
SD	1.28	0.41	0.99	0.93

9.5 Duct Systems

Most ducts are located within conditioned space. Supply ducts were located entirely within conditioned space for 87% of homes (Table 118). Homes in Base Code communities were slightly more likely to have all supply ducts located within conditioned space (93%) than homes in Stretch Code communities (86%).

Ducts leakage is down due to the shift towards installing ducts in conditioned space. Average duct leakage to the outside is 1.9 CFM_{25}/100 ft^2 CFA, a 65% reduction from 5.5 in 2019 (Table 116).

9.6 Renewables

PV penetration is low. PV penetration is only 2.0% (Table 120). Among the relatively few multifamily homes with PV, on-site power production was around 3,024 kwh per unit (Table 121).

Section 10 Multifamily Appliances

Virtually all dryers are electric. Ninety-nine percent of clothes dryers are electric.

Electric ranges are more common in multifamily than single-family homes. The share of electric ranges in multifamily homes is 63%, compared to only 28% in single-family homes.

See C.8 for additional information about the efficiency of appliances included in the RESNET data. As described in A.2.2.3, readers should view appliance efficiency figures with some skepticism, as HERS raters might have made their energy models before appliances were installed. HERS raters would likely have been able to correctly assess the fuel that would be used for a dryer or range, but they may have recorded placeholder efficiency values otherwise. The team attempted to remove obvious default values provided in the absence of better information, but some placeholders likely remain in the data.

Section 11 Multifamily Code Compliance

This section summarizes how multifamily homes included in the study compare to the applicable code version, and how well prepared they are to meet the upcoming code version.

11.1 Overall Results

Multifamily homes compare favorably to the code version under which they were built, but most are far below the current code. Also, the RESNET data confirms the feedback from code officials (12.1.1) that a significant proportion of multifamily Base Code construction appears to rely on the prescriptive path. One-fourth of low-rise multifamily Base Code homes within the sample have sufficient shell insulation to not require a HERS rating. In contrast, only 5% of single-family Base Code homes complied with the code based on their prescriptive R-value performance.

Homes were compared to the applicable code, the Ninth Edition of the Massachusetts State Building Code based on the 2018 IECC (Table 22). They were also compared to the Tenth Edition (Table 23, 2021 IECC), which entered full effect in July of 2024.[21] The projected poor performance of existing building practices against the Tenth Edition indicates that substantial changes will be necessary for homes to meet the new code.

11.2 Compliance with Relevant Code: Ninth Edition

Code compliance under the later stages of the 2018 code cycle is relatively high: 82% for non-program Base Code homes, 67% for program homes and 62% for non-program homes in Stretch Code communities.

Table 22 estimates the portion of homes that comply with the Ninth Edition code.

- The **HERS only** row counts homes which satisfy the HERS requirement of 55 or less, with renewable energy credits.[22]
- The **Prescriptive R** row includes Base Code homes with HERS scores above 55 that meet the minimum prescriptive R-values for each measure[23] *and* satisfy one of the R407 Additional Efficiency Package options, thereby demonstrating compliance with the prescriptive path of the Base Code.[24]

[21] Stretch code was updated in 2023 but HERS requirements did not change until July 2024, when the target changed from 55 to 42 for fossil-fuel and 45 for all-electric. Base code is not set to change until at least 2025.
[22] We do not have precise photovoltaic array sizing, and therefore assume that any builder installing PV will have installed a large enough array (2.5 kW) to receive the five-point credit available in the Ninth Edition.
[23] Except conditioned slab insulation, whose requirements are not readily verified with the available information.
[24] This should be considered an underestimate; it does not account for the prescriptive code's UA trade-off option as RESNET data did not include measure area. Similarly, the 90% UA option of R407 is not assessed.

Additional contributors to compliance. Beyond the HERS score and the basic prescriptive requirements, building code includes numerous other requirements that affect compliance rates. Table 22 shows compliance rates with additional key requirements concerning air infiltration (3 ACH_{50}), duct leakage or placement (total duct leakage of 4 CFM_{25}/100 ft^2 CFA or in conditioned space [Base Code only]), and lighting efficiency (90% efficient fixtures). The RESNET data indicates remarkably low levels of compliance with the efficient lighting requirement compared to the average MA-REC rating of 98.5% for lighting in 19X02. This disparity could arise if it is common practice to complete final ratings without permanent lighting fixture information, such that raters can ensure homes comply regardless of final lighting choices. Given the low compliance rates for this measure in the data, it is excluded from the combined ratings at the bottom of the table. Table 22 also omits numerous other requirements like hot water pipe insulation that would need to be inspected by a code official but are not identified in the RESNET data. Unfortunately, the UDRH-focused 20R30 report includes no suitable code compliance metrics to use as a point of comparison for these results.

Table 22: Massachusetts Ninth Edition (2018 IECC) Multifamily Compliance

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	913	717	3,109	3,826
HERS only	80%	59%	72%	70%
Prescriptive R	–	26%	–	–
Additional Mandatory Requirements				
ACH_{50} (A)	75%	89%	64%	69%
Ducts (D)†	78%	91%	71%	75%
Lighting	1%	0%	2%	1%
Combined				
HERS + A	67%	56%	62%	59%
Prescriptive + A + D	–	26%	–	–
TOTAL	**67%**	**82%**	**62%**	**59%**

† Duct requirements applicable to Base Code only.

11.3 COMPLIANCE WITH NEW/UPCOMING CODE: TENTH EDITION

As with single-family, multifamily homes built to program and/or Stretch Code requirements under the Ninth Edition Code fare extremely poorly against the Tenth Edition requirements (Table 23). For Stretch and Specialized communities,[25] the new requirements that came into effect in July 2024 include fuel-specific HERS scores (45 all-electric, 42 mixed-fuel) and new recovery ventilation requirements.[26] The new Base Code will require slightly lower HERS scores (52) or higher levels of prescriptive insulation.[27] The Specialized R405 Passive House Certification requirement for buildings larger than 12,000 square feet is also excluded from this analysis given the complexity of this provision and the near-zero projected compliance rate of multifamily Specialized Code homes under the Tenth Edition without this additional filter.

Prescriptive path Base Code homes are projected to have a significantly higher level of compliance under the Tenth Edition (35%, Table 23) than the Ninth (26%, Table 22) because of Additional Efficiency Package option R408.2.4. This gives credit for fully conditioned ductwork, a common feature in large low-rise multifamily construction featuring decentralized heating and cooling systems. Nevertheless, overall compliance rates are expected to be lower (66% versus 82%) given the lower permissible HERS rating. Consequently, without additional interventions the prescriptive path may become even more prominent in multifamily Base Code construction.

Table 23: Estimated Massachusetts Tenth Edition (2021 IECC) MF Compliance

	Program	NP: Base Code	NP: Stretch or Specialized	NP: Overall
n[28]	913	719	3,107	3,826
HERS only	16%	33%	8%	13%
Prescriptive R	–	38%	–	–
Additional Mandatory Requirements				
ACH_{50} (A)	*75%*	*89%*	*64%*	*69%*
Ducts (D)†	*78%*	*91%*	*71%*	*75%*
Ventilation (V)	1%	0%	8%	6%
Combined				
HERS + A + V	1%	31%‡	2%	8%
Prescriptive + A + D	–	35%	–	–
TOTAL	**1%**	**66%**	**2%**	**8%**

† Duct leakage requirements apply to prescriptive Base Code, but all homes with uncond. ducts must be tested
‡ The draft Base Code does not appear to require recovery ventilation for the ERI ("performance") path.

[25] The requirement of 4 kW of solar panels for SF, mixed-fuel Specialized homes is excluded from this analysis since there was no comparable requirement in the Ninth Edition and builders could bypass this by building all-electric.
[26] Recovery ventilation efficiency was not included in RESNET data. Since 16 of 17 recovery ventilation systems in 19X02 satisfied code requirements, we assume here that all such installations also satisfy the 65% SRE requirement.
[27] The Additional Efficiency Options were moved to R408 in the 10th Edition. The recovery ventilation and high efficiency combustion options were removed, and a new option for fully-conditioned ductwork was added. The other mandatory requirements are omitted for brevity given their similarity to the previous code. The stricter lighting requirement of no inefficient permanent fixtures is omitted from the table given the low compliance with 10% permissible inefficient fixtures under the previous code in Table 22. Finally, a credit of 3 points is afforded for homes with solar panels which are assumed to provide 4 kW of power, similar to the 5 points for 2.5 kW under the Ninth Edition.
[28] The counts in Table 23 differ slightly from Table 22 because two municipalities switched from Stretch Code under the Ninth Edition to Base Code in the Tenth.

Section 12 Insights from Code Officials & Market Actors

12.1 Trends in Base Code Communities, as Reported by Code Officials

The study included brief outreach to code officials in the 50 municipalities in Massachusetts that follow the Base Code; 17 provided usable responses about trends in their communities. Respondents described:

- what portion of new homes in their jurisdictions comply with the energy code via the prescriptive vs. ERI path,
- what portion of new homes in their jurisdictions are approximately code compliant vs. built to above-code standards, and
- how they expect either of those estimates to change under the new, more stringent Base Code coming into effect in 2024.

This information was gathered in order to provide insight about a segment of the market – non-HERS rated Base Code homes – that were not included in the RESNET data.

12.1.1 Prescriptive vs. ERI Compliance

Code officials said that the prescriptive compliance path is extremely common in Base Code communities, particularly for multifamily buildings.

Single-family. On average, code officials in Base Code towns said that **80% of the new, single-family homes built in their communities followed the prescriptive compliance path** and only 20% followed the optional ERI path that is mandatory under Stretch Code. In fact, 13 out of 16 respondents said that prescriptive compliance represented at least 70% of their projects (six even said all of their homes were prescriptive path).

Only **three out of 16 officials said ERI compliance is prevalent among single-family homes** in their towns (70% to 75% of their single-family projects). One such official reported "We are starting to see more homes being built above the Base standards. We don't enforce builders to go above and beyond but given the new standards coming I think we will continue to see more homes building at ERI standards."

Homes without HERS ratings might underperform their HERS-rated counterparts, given that they lack the benefit of a HERS rater's guidance. A possible indication of this is that while a HERS score of 55 would satisfy the Base or Stretch Code under the 2018 IECC, the average HERS score for *HERS-rated*, single-family Base Code homes was two points better – 53 – even though Base Code officials described non-participant homes outperforming code as uncommon.

Multifamily. On average, code officials reported that **95% of multifamily homes in their communities were built under the prescriptive pathway** rather than the ERI path. The lowest estimate provided was that 80% of multifamily units in that jurisdiction were prescriptive. As with single-family homes, it is possible that multifamily units built under the prescriptive path might underperform the HERS-rated homes described in this study. However, the average HERS score for HERS-rated multifamily homes is 54.7, much closer to the applicable HERS threshold of 55.

12.1.2 Building to Above-Code Standards

Code officials reported that building to above-code standards is rare in Base Code towns.

On average, code officials in Base Code communities said that only **7% of single-family and 4% of multifamily homes in their communities were built to above-code standards**; the rest just meet the Base Code. Every code official said that at least 80% of their new single-family homes are just built to minimum Base Code requirements. For multifamily, that figure was 90%. For context, the non-program, HERS-rated single-family homes included in the RESNET data had an average HERS score of 53, two points better than the HERS-based compliance path available to Base Code builders. In contrast, the non-program, HERS-rated multifamily homes in RESNET data were 54.7, on average, much closer to the code threshold of 55.

12.1.3 Market Response to Changing Code

Code officials mentioned that the new code changes will not have a huge effect on homes built within their community, other than builders needing to adjust practices to minimally comply with any new requirements. Nearly three-quarters of the 15 code officials (73%) said that the percentage of homes that followed the prescriptive path or that were built to above-code standards would most likely continue, even as the code changes in the coming year.

Additionally, two code officials predicted that the new code changes will increase construction costs, with one mentioning, “In my jurisdiction, there is no incentive to go above code; the new ‘tighter’ standards only increase the costs of achieving minimum compliance.” One code official noted a recent slight increase in single-family homes built above the current Base Code standards in their community.

12.2 RNC Trends in MA, as Reported by Builders and HERS Raters

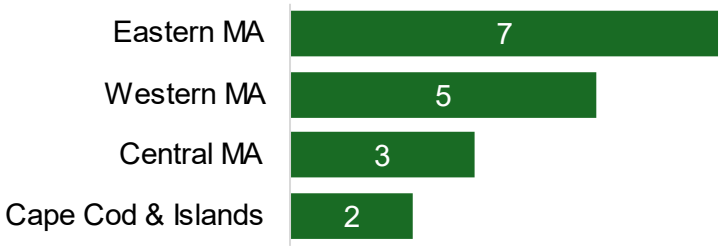
Ten market actors (seven builders and three HERS raters) provided feedback on the following topics; results are described in the sub-sections that follow.

- **Activity level:** How many new homes did respondents work on in the past year? What portion went through the program? What portion were in Base vs. Stretch Code?
- **Baselines and code compliance:** The new 2021 IECC-based energy code represents a big jump relative to the previous code cycle – what will code compliance be like early in the new, 2021 IECC-based code cycle? What HERS values do builders normally target?
- **Representativeness of RESNET data:** What compliance paths are used in Base Code communities? Why do builders get HERS ratings in Base Code communities, where it is not required?
- **Net-to-Gross issues:** What do market actors think about all-electric homes? How is the program affecting decisions about energy efficiency or fuel choice?

12.2.1 Location, Activity Level, and Program Participation

Respondents represented projects across the entire state. Most had recently worked in eastern Massachusetts (Figure 10).

Figure 10: Builder and Rater Project Activity by Region



Respondents had a mix of single- and multifamily experience. Table 24 summarizes how many new homes the respondents rated or built during the last year. Most worked on single-family homes (six of seven builders and all three raters); two builders and two raters also worked on multifamily projects.

Table 24: Units Built or Rated During the Last Year

Type	Range	Average
Single-Family		
Builders (n=6)	2-12	4
Raters (n=3)	14-75	55
Multifamily†		
Builders (n=2)	100 (n=1)	N/A
Raters (n=2)	100 (n=1)	N/A

† Two MF respondents provided project, not unit counts.

Respondents were highly active in the PAs' RNC program and mostly worked in Stretch Code. All seven builders worked *exclusively in the PAs' RNC program in the past year*; raters estimated that 90% to 100% of their new home projects participated. In addition, nearly all of the projects were in Stretch Code communities: only one builder and one rater worked on any (approximately eight total) projects in Base Code communities during the past year.

12.2.2 Experience with Base Code

While most code officials reported that prescriptive compliance was common in Base Code communities, the two market actor respondents who worked in Base Code communities (one builder and one rater) followed the ERI path exclusively because all of their projects participate in the PAs' RNC program. The builder reported building all homes (regardless of jurisdiction) the same way with regards to energy efficiency: **"The ability to say to the folks who are buying it that its Stretch Code compliant was the icing on the cake."**

As to why homes in Base Code communities get HERS ratings given that it is not required, the rater explained, **"Whenever we do get a home in a Base Code area it's a homeowner who is very enthusiastic about energy efficiency and they schedule this in order to be qualified for incentives or solar."**

Respondents were asked if they bypass getting official HERS ratings in Stretch Code communities, calculating an ERI instead of a HERS score (as some non-RESNET software tools can generate ERI values without use of a HERS rater).[29] Most respondents reported that they do always get full, registered HERS ratings. Only one respondent said that some of his homes in Stretch Code municipalities got ERI values without a full HERS rating – seemingly a rare occurrence,[30] suggesting consistency and reliability of the RESNET data.

12.2.3 Opinions about Code Changes

Stretch code changes in 2023: not a big challenge. Most (seven) respondents thought that builders had been able to comply with the 2023 Stretch Code changes relatively easily (Figure 11). Respondents explained they were able to achieve these targets because: 1) it was not a big change from the previous code, 2) builders were able to learn and adapt, and 3) HERS raters helped builders achieve the scores. On the first point, the previous, 2018-IECC based code set HERS requirements of 55; the 2023 Stretch Code updates only changed that to 52 for fossil-fuel and 55 for all-electric homes.

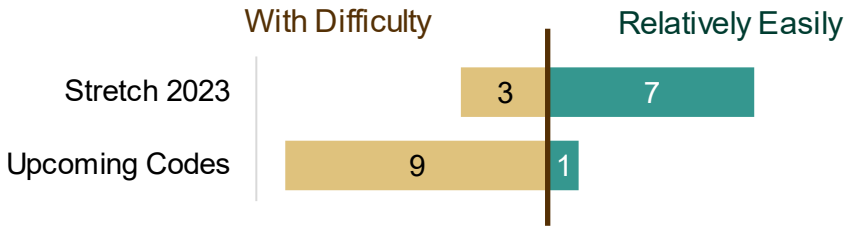
Stretch code changes in 2024: more challenging. In contrast, almost all (nine) respondents thought that builders will have difficulty complying with the new code versions that are coming. In 2023, while the interim requirements of the new Stretch Code required most homes to meet a HERS score between 52 and 55, as of July 1, 2024, those requirements drop to 42 and 45, a substantial change.

Multiple concerns: cost, technical concerns, and awareness. Seven respondents stated that it would be **more expensive** to comply with the new codes, including three who predicted that fewer people would be able to afford to buy homes, and two (a builder and a rater) who claimed to have already lost clients because of increased costs, when their clients changed course after seeing the costs: "Our HERS rater tells us what we need to do but then the price increases and we lose clients because of it." Five respondents pointed out that it was a **big lift compared to**

[29] ERI is closely related to the HERS score, though the values of the two systems can differ slightly for the same home. The previous version of the Massachusetts stretch code accepted either score; however, the current version of the Massachusetts stretch code accepts only HERS scores.
[30] When asked how common this was, the respondent replied, "It's only applicable when the HERS rater talks with my builders to get an understanding of the budget needed to fully complete the build to that rating."

the previous codes. Additionally, three respondents anticipated builders would find it difficult to meet the **new air tightness requirements**, and two questioned whether builders would even be **aware of new requirements**.

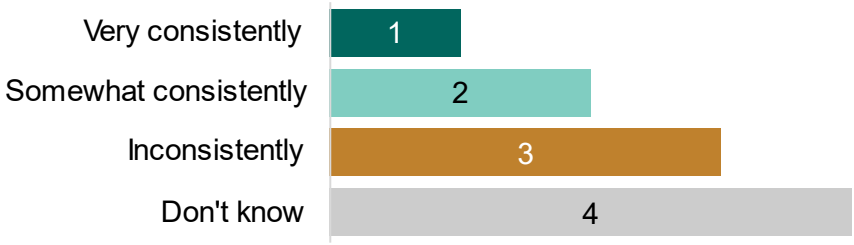
Figure 11: Builder Ability to Comply with Codes



The current energy stretch code, very simply, is this:
you're in a gym, you lift a 20-lb dumbbell, that's a piece of cake.
Then 30, that's OK. Now I want you to lift an 80-lb dumbbell.
And you're saying, "How in God's name am I gonna do that?"

Concerns about code enforcement. In light of comments about inconsistent energy code enforcement, the role of HERS raters in code compliance is key. Only one respondent, a rater who worked in western and eastern Massachusetts, reported code officials had very consistently been enforcing the energy-efficiency requirements of the Stretch Code that went into effect in early 2023 – the rest gave less optimistic assessments (Figure 12). Explanations for why code officials did not always enforce requirements included that some were unclear on which code applied to which town, that the code leaves room for interpretation regarding renovations and additions, and that code officials may overlook energy-efficiency items so long as they are not safety issues.

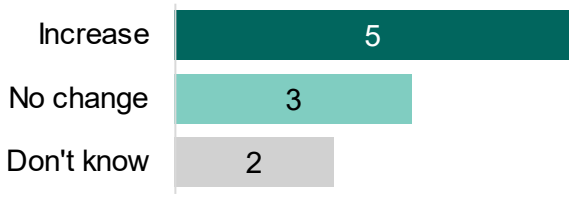
Figure 12: Enforcement of Stretch Code Energy-Efficiency Requirements



I went to the last two building official meetings.
They're all looking around each other like deer in headlights.

Potential increases in program participation to help with meeting code. Half (five) of the respondents thought that program participation would increase as a result of the new energy codes (i.e., the new Base Code in 2024 or Stretch and Specialized versions already in effect) (Figure 13). No one predicted a decline in participation.

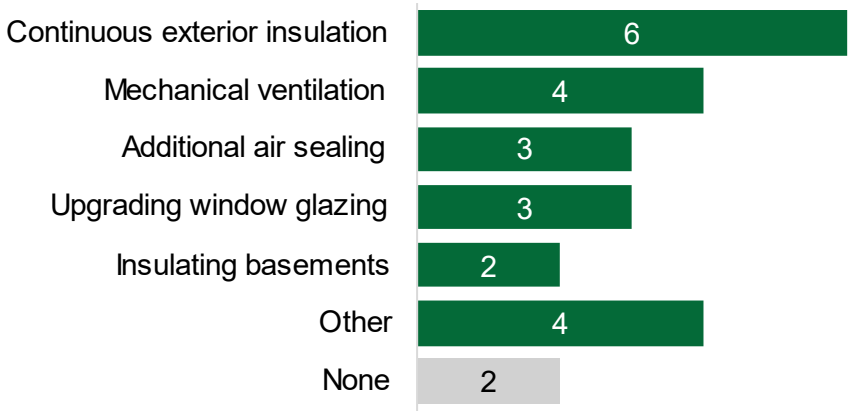
Figure 13: Impact of New Codes on Program Participation



12.2.4 Response to Code Changes

Measure-level changes. Figure 14 displays changes respondents have implemented to their building practices because of the new codes. The two most frequently mentioned changes were **adding continuous exterior insulation and mechanical ventilation**, followed by **additional air sealing and upgrading windows.** Two respondents said they had not made any changes to their building practices because of the new codes. Only one respondent expected to adopt further changes in the near term, namely, moving to 100% heat pumps. That said, several respondents voiced **concerns about air quality given how tight new homes were required to be.** One respondent noted that some people shut off their ERVs and/or do not clean heat pump filters, while another reported that they did not believe homes with fireplaces could pass the blower door test and therefore will no longer be a backup heating option during power outages.

Figure 14: Changes to Building Practices Because of New Codes



HERS score targets. Interviewers asked respondents to describe the typical HERS scores they planned to target in the next year for the following scenarios:

- non-program homes in Base Code communities,
- non-program homes in Stretch Code communities,
- non-program homes in Specialized communities,
- program homes (in any town), and
- all homes (in any town) if the current program went away.

Overall, respondents intended to build to code minimum within the respective towns. One respondent explained, "Most builders want to just reach code and not have to take the extra step to go below it," while another stated, "I don't see the benefit of trying to reach anything lower than state requirements."

> ***The way it's written is so confusing.***
> ***And then on top of that, having multiple codes in the same state is just dumb.***

12.2.5 Electrification and Passive House Trends

Respondents were concerned about requiring new homes to be all-electric, repeating issues raised in the PAs' 2023 RNC Electrification Barriers study (MA21R44).[31] Respondents reported that they opted not to go all-electric for recent projects primarily because of **(1) the added costs and (2) customers' preference for gas cooktops.** In addition to building expense, a couple of respondents mentioned that all-electric homes were overly **expensive to heat.** Three questioned the efficacy of all-electric homes given that a significant portion of Massachusetts' electricity comes from fossil fuels. Additional concerns about all-electric homes included: overloading the electric grid; heat pumps inadequately heating homes; inefficient electric water heating; and HPWHs reducing comfort in multifamily homes.

> ***I'm not shooting for [HERS scores better than code minimum]***
> ***unless they're looking for incentives.***

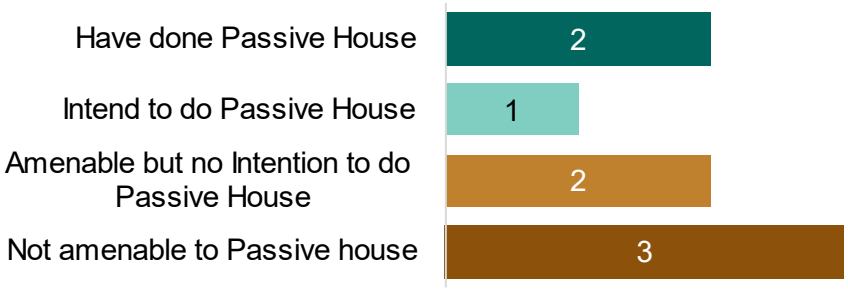
> ***What they're doing in Europe, I think that's what we should have.***
> ***Natural gas and propane taking care of peak demand and low temperatures,***
> ***and electric handling the rest (especially for hot water).***

[31] https://ma-eeac.org/wp-content/uploads/MA21R44-RNC-Electrification-Barriers-Study-Final-Report.pdf

Fallout from the program becoming all-electric. Most respondents indicated that they would have no choice but to adapt if the program shifts to an all-electric model. However, three anticipated a decrease in program participation, two predicted that builders would drop out of the industry, and one expected to see an increase in remodeling.[32]

Passive House. Eight respondents shared their perspectives on Passive House and the role it played in homes they worked on (Figure 15). Only two had completed any Passive House projects; three more were open to it, while the remaining three were not, saying that their customers did not want it.

Figure 15: Perspectives on Passive House

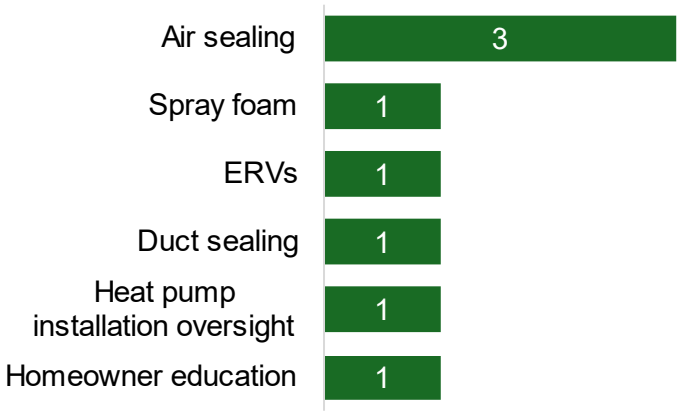


12.2.6 Suggestions for Continued Improvement and Builder Support

Key measures to improve efficiency outcomes. When asked for suggestions, respondents pointed to well-known measures for improving efficiency, including more air sealing, wider use of spray foam, recovery ventilation, duct sealing, oversight of heat pump installation, and homeowner education about proper use of energy-efficient equipment.

[32] A recent Connecticut RNC study (CTR2209, RNC Net-to-Gross and UDRH Baseline Update), conducted while that state's RNC program shifted to an all-electric model, also gathered evidence that that builders would leave that program due to its shift to an all-electric model, due to factors such as costs, lack of homeowner demand, and a workforce not trained to handle all-electric construction. https://app.box.com/s/thejaisoo22wnmqc96ygnrj0wnb16ujr (See page 5.)

Figure 16: Ways to Make Homes More Efficient



Air sealing is probably one of the bigger areas they can improve on.

Opportunities to support builders. When asked what support the program could provide to help builders, nearly one-half of respondents (four) recommended builder education, particularly regarding code requirements. While this study did not target feedback about renovations and additions, respondents were quick to note concerns there: how the codes applied to renovations and additions was a common point of confusion. For example, two raters stated that the code was not clear about whether HERS ratings were required for renovations and additions, two builders thought that renovations would trigger code, and one builder thought renovations would not trigger code.

Appendix A Detailed Methodology

A.1 Market Actor Interviews

A.1.1 Sample Frame

To develop the sample frame, the team obtained program tracking data from the program implementer, ICF, covering homes permitted under the 2018 IECC-based energy code, permitted between November 8, 2020, and December 31, 2022. The data included fields with incentive recipient names, incentive recipient phone numbers, incentive recipient emails, HERS rater companies, HERS rater phone numbers, HERS rater emails, and physical addresses for the projects.

Incentive recipient data included homeowners, contractors/builders, architects, property managers, financial lenders, HERS raters, non-profit builders, as well as other roles. The role of the incentive recipient on a given project was not always clear, and the incentive recipient name and associated contact information were not always aligned. For example, the incentive recipient name, email, and phone number might be for the homeowner, builder, and HERS rater, respectively. The team determined the role of the identified incentive recipient as best as possible based on information in the program tracking data. If the incentive recipient's contact information indicated they were a contractor/builder, they were classified as such. We excluded non-profit builders and housing authorities from the sample frame because they are held to different building requirements that may confound results. If the contact information did not indicate the incentive recipient was a contractor/builder, they were classified as "other." HERS rater contact information was provided in a different field and seemed to only include HERS raters.

Table 1 summarizes the number of unique contractors/builders and HERS raters with projects in the program tracking data by availability of contact information.

Table 1: HERS Raters and Incentive Recipients in Sample Frame, by Availability of Contact Information[1]

Incentive Recipients	Phone & Email	Phone Only	Email Only	No Contact Info	Total # Contacts	Total # Projects
Contractor/Builder	1,595	88	15	4	1,695	8,171
Non-Profit Builder	Not tallied by type (see totals to the right)				11	32
Other Role	Not tallied by type (see totals to the right)				1,268	1,828
HERS Raters						
HERS Rater	29	1	31	0	62	10,031

[1] HERS raters cover all projects in the sample frame as their information was provided separately from the incentive recipient.

A.1.2 Sample Design

County-level considerations. Table 2 shows the geographic distribution of raters and builders in the program tracking data by county, within the timeframe of projects of interest to this study – permitted in late 2020 through the end of 2022. This shows the number of raters and contractors/builders who worked in each of those counties – the county-level figures overlap, as many market actors work in multiple communities.

Table 2: HERS Rater and Contractor/Builder Participants by County

Project County	Number of HERS Raters	Number of Contractors/Builders
Barnstable	26	192
Berkshire	14	39
Bristol	17	70
Dukes	8	28
Essex	27	163
Franklin	13	32
Hampden	14	76
Hampshire	10	77
Middlesex	37	439
Nantucket	5	20
Norfolk	31	193
Plymouth	19	237
Suffolk	21	71
Worcester	40	241

Code-level considerations. Table 3 shows the breakdown of HERS raters and contractors/builders by the code version in which they worked, based on the tracking data. (As with the previous table, each row does not represent a unique set of individuals – market actors work in multiple areas.)

Table 3: HERS Rater and Contractor/Builder Participants by Code Version[1]

Applicable Code	Number of HERS Raters	Number of Contractors/Builders
Base Code	35	103
Stretch Code	59	1,350
Specialized Code	43	360

[1] https://www.mass.gov/doc/building-energy-code-adoption-by-municipality/download

Soft targets. Due to the small number of interviews, our outreach targeted a variety of perspectives over statistical validity. The targets below were *soft* targets given the potentially difficult nature of getting market actors to participate in interviews, recognizing the goal of getting a variety of perspectives based on geography, activity in Base Code communities, and experience with multifamily housing (Table 4). The table also provides the number of completes, relative to each target.

Table 4: HERS Rater and Contractor/Builder Soft Targets

Respondent		Berkshire/ Hampden/ Hampshire County	Base Code	Multifamily	Total
HERS Raters	*Target*	1	3	1	3
	Complete	**2**	**1**	**2**	**3**
Contractors/ Builders	*Target*	2	5	2	7
	Complete	**3**	**1**	**2**	**7**

We also set soft targets based on the respondents' activity level, i.e., how many homes they built/rated in the previous year (Table 5 and Table 6). In the right columns, the tables provide the number of completes, relative to each soft target.

Table 5: Contractor/Builder Sample and Data Collection Approach

Program Activity Level (Projects Completed)	Sample Frame	Number Sampled	Soft Targets	Completes
Low (<10)	1,536 (91%)	25	3	**4**
Medium (10-49)	141 (8%)	25	2	**2**
High (50+)	16 (1%)	16	2	**1**
Total	**1,693**	**66**	**7**	**7**

Table 6: HERS Rater Sample and Data Collection Approach

Program Activity Level (Projects Completed)	Sample Frame	Number Sampled	Soft Targets	Completes
Low (<10)	11 (18%)	5	1	**-**
Medium (10-49)	17 (27%)	5	1	**1**
High (50+)	34 (55%)	5	1	**2**
Total	**62**	**15**	**3**	**3**

A.1.3 Instrument

See D.2 for the interview guide, showing the questions asked of market actors during interviews.

A.2 Acquire and Process RESNET HERS Data

A.2.1 Requesting RESNET Data

NMR requested and obtained HERS rating data from RESNET for all homes permitted from November 8, 2020, through the end of 2022. The data were non-anonymized, including addresses, to allow for cross-checking the dataset with program homes.

A.2.2 Cleaning RESNET Data

NMR performed extensive cleaning of the RESNET data, focused on properly classifying homes and ensuring that measure-level values included in the data complied with various reasonableness checks. This included ensuring that the data included only new homes (e.g., investigating homes with construction dates outside of the timeframe of interest or with performance values lower than typical for new homes), that homes were properly identified as single- vs. multifamily (including union with the state assessor's database, and spot checks of data against assessor databases, MLS sites, satellite mapping services, etc.), that addresses were formatted correctly to ensure reliable cross-checks between RESNET and program tracking data, and so forth. For example, RESNET records homes as "Single-Family," "Duplex," and "Low-rise Multi-family," but our work with this data source in 20R30 revealed that the "Low-rise Multi-family" designation includes duplexes, townhouses, and triple-deckers, which would be considered single-family under the RNC program, as well as mid-rise construction with more than three stories. NMR conducted follow-up research as necessary to properly classify sites, removing them from the analysis if necessary.

Table 25 compares measures specified in the single-family residential UDRH and the RESNET data. Exact equivalents (✓) are not available for all measures, but analogous data (~) may be available, with some caveats. Most shell measures are available as cavity and continuous insulation R-values, which are weighted averages across all instances of the measure in a home.

Table 25: Residential UDRH versus RESNET Data

	Measure	Sub-Measure	Values	Notes
~	Above Grade Walls	Conditioned to Ambient	R, Grade and Framing factor	Data is available for Conditioned to non-Adiabatic walls.
✓	Air Infiltration		ACH_{50}	
✗	Ceiling	Vaulted	R	The data does not distinguish between flat & vaulted ceilings, although flat or adiabatic ceilings are likely to dominate in multi-family construction.
~	Ceiling	Flat		
✓	Cooling	Ground Source HP	EER	
✓	Cooling	Air Conditioner	SEER	
✓	Cooling	Air Source Heat Pump	SEER	The data does not distinguish between ASHP and mini-splits.
~	Ducts	Ins. – Unconditioned Attic	R	The data includes a single average R-value for the home.
~	Ducts	Ins. – Other Unconditioned		
✓	Duct Leakage	Leakage to Outside		
✓	Foundation Walls	Conditioned Basement	R and Grade	The data includes a single R-value for this measure per home. Therefore, analysis must be limited to homes with a single foundation type (90%).
✓	Foundation Walls	Unconditioned Basement		
✗	Frame Floor	Unconditioned Basement	R	Data is available as an average R-value for floors across all locations.
✓	Heating	Combustion	AFUE	
✓	Heating	Electric	HSPF, COP	
~	Slab	Heated– All Locations	U_0	The data includes a single value per home for floor in contact with the ground. This could be analyzed by foundation type i.e.; conditioned slab.
✗	Slab	Unheated Below Grade		
✗	Slab	Unheated Above Grade		
✓	Water Heater	Combustion	EF	
✓	Water Heater	Electric	EF	
✓	Windows	Ambient	U, SHGC	

A.2.2.1 R- vs. U-values

The RESNET data include U-factors and R-values for many measures, although they frequently conflict with one another. RESNET informed the team that the U-factor should be considered the authoritative data point. Therefore, R-values were ignored where U-factors were available and fell within reasonable parameters,[33] and questionable data for individual measures were removed from the analysis. Unfortunately, this cleaning reduced the sample size and still yielded some questionable values. To address this, both flat attic ceilings and above-grade walls were analyzed twice, once with the cleaned RESNET data and again with NMR calculated U-factors.

For the RESNET data, the NMR U-factor represents a U-factor calculation based on the R-values and applicable framing and grade information. The analysis is only possible for these measures because they report both cavity and continuous R-values.[34] Above-grade wall details also include framing factor and insulation grade.[35] Flat attic ceiling details do not contain information about framing or insulation grade but do record whether the insulation is blown-in or batt. The calculated ceiling U-factors therefore assume 2×10 joists with a 14% framing factor, and Grade II for batt insulation or Grade I for blown-in insulation.

The detailed results for shell measures in the appendices include the U-value results, effective R-value results (the mathematical inverse of the U-value), and then the nominal R-value, which is a calculated value representing the insulation properties of the insulation itself, ignoring the installation grade and framing factors. U-values are most appropriate for the UDRH, but we provide R-value results because some readers may be more comfortable with those values.

A.2.2.2 Lighting

This report does not present efficient lighting saturation from the RESNET data. They appear to be too low to be realistic. The study team suspects HERS raters are modeling artificially low values to make sure that their homes meet their HERS score targets without relying on lighting choices that might be changed by the occupant.

A.2.2.3 Appliances

Many new homes do not come with appliances – occupants might provide them. When the appliances are not in place at the time the HERS rater builds their model, the rater may use inefficient placeholder values from RESNET to create conservative energy models. The team removed any appliance efficiency values matching these RESNET defaults, leading to smaller sample sizes for appliances compared to other measures. Therefore, appliance efficiency values should be viewed with skepticism.

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[33] For example, the U-factors of some records indicated an uninsulated assembly, whereas the R-value indicated a typical level of insulation for new construction. In other cases, U-factors greater than 1 were recorded. Entries such as 23.66 could potentially be construed as mis-entered R-values, but a vaulted ceiling R-value of 97 is as suspect as a U-factor of 97 (R-0.01 equivalent).

[34] This recalculation assumes the walls and ceilings are uniformly insulated, whereas the RESNET-reported U-factor may represent multiple assembly types. However, the RESNET data included many ceilings with blown-in R-30 cavity insulation ranging from 0.036 U (R-27) to 0.072 U (R-13.9), and the latter would require that half of the ceiling be uninsulated to achieve such a low effective R-value.

[35] For standard wood-stud framed walls, the framing depth was inferred from the R-value, predominantly 2×6.

A.2.2.4 Solar PV

While builders can include solar panels on their homes, these are often installed by the homeowner. Accordingly, rates of solar PV use in the RESNET data likely far underpredicts how many of these homes are likely to have solar panels installed by their occupants. Rates of solar PV use should be viewed with skepticism.

A.3 Acquire and Process Program Data

A.3.1 Request Program Data

NMR requested data for relevant program homes from ICF, the RNC program implementer. We requested and obtained **program tracking data**, including contact information, incentives, and so forth, contact information logged on **program intake forms** (a source of contact information for participants we have identified from previous evaluations), and **program energy model data via Ekotrope exports**. We requested program home data for homes built in the same timeframe as those included in the RESNET data.

A.3.2 Cleaning Program Data

NMR reviewed and cleaned program home tracking data to allow the team to properly identify the program homes in the overall RESNET database. This involved ensuring that homes were appropriately categorized by home type, location, and construction date, and could be fully cross-checked against the RESNET data to identify instances of program homes in the RESNET data. We identified approximately 44% of program homes in the RESNET data. To match as many program homes in the tracking data as possible the team used multiple approaches to join the program home tracking data against with the RESNET records. Most homes were identified through address matching, but others were found using a "fingerprint" comprised of multiple high variability features e.g., the CFM50 air leakage test result.[36]

In some cases the team was able to fill in values absent from the RESNET data using program tracking data, particularly permit date and equipment fuel, helping to ensure that homes were appropriately categorized. With segmentation by home type, location, and construction date complete, the team conducted the baseline analysis on the RESNET data, cross-tabulating results by program and non-program status and by code version.

[36] Occasionally, are unable to distinguish between identical units in a building, but still sufficient to verify that the location includes program projects.

A.4 CODE COMPLIANCE

NMR has traditionally used the MA-REC approach for assessing code compliance of new homes in Massachusetts. This approach yields point-based whole home and measure-level compliance scores, with results calibrated to the relative contributors to a home's consumption. However, this approach was not appropriate for this study because it requires access to home energy models. RESNET data provide key inputs and outputs from those models, but do not include sufficient information to generate MA-REC compliance scores.

Accordingly, the study took a more limited approach to assessing program and non-program home performance relative to the 2018 IECC-based code (the applicable code) and the 2021 IECC based code (the more recent code version). We compared average measure-level efficiencies (e.g., wall R-values) to prescriptive code requirements, to any mandatory code requirements (e.g., air leakage, which much be met regardless of HERS score, even in Stretch Code communities), and we described the portion of homes that fall above and below those prescriptive code requirements. We also compared whole-home HERS scores to the HERS score thresholds set in Stretch Code communities.

Appendix B Detailed Data: Single-Family

B.1 General Characteristics

Table 26: Single-Family CFA

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*8,217*	*392*	*5,968*	*6,360*
Min	240	780	360	360
Mean	3,070	2,774	2,941	2,930
Median	2,716	2,483	2,524	2,520
Max	12,849	12,740	19,276	19,276
SD	1,480	1,442	1,677	1,664

Table 27: Single-Family Bedrooms

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*8,215*	*392*	*5,968*	*6,360*
Min	1	1	1	1
Mean	3	3	3	3
Median	3	3	3	3
Max	9	8	10	10
SD	1	1	1	1

Table 28: Single-Family Stories

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*8,217*	*392*	*5,969*	*6,361*
Min	1	1	1	1
Mean	2	2	2	2
Median	2	2	2	2
Max	4	4	4	4
SD	1	1	1	1

B.2 WHOLE HOME PERFORMANCE

Note that some HERS scores at the extremes appear to be higher or lower than we might expect for new construction, but overall means are not particularly affected by these high values, given the large number of homes included in the analysis.

Table 29: Single-Family HERS Index Scores without PV

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*8,145*	*390*	*5,962*	*6,352*
Min	26	35	25	25
Mean	51	53	51	52
Median	52	53	52	52
Max	69	73	66	73
SD	4	5	4	4

Table 30: Single-Family HERS Index Scores with PV

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*8,217*	*392*	*5,969*	*6,361*
Min	-61	8	-77	-77
Mean	51	52	51	51
Median	52	53	52	52
Max	69	64	66	66
SD	7	5	6	6

B.3 AIR INFILTRATION AND VENTILATION

See Section 6 for information about the portion of homes that meet the code's mandatory air leakage requirements.

Table 31: Single-Family Air Infiltration (ACH50)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*8,217*	*392*	*5,969*	*6,361*
Min	0.2	0.6	0.3	0.3
Mean	2.2	2.4	2.2	2.2
Median	2.2	2.6	2.4	2.4
Max	15.7	5.9	16.3	16.3
SD	0.7	0.6	0.7	0.7

Table 32: Single-Family Mechanical Ventilation Type

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*8,203*	*392*	*5,944*	*6,336*
Exhaust only	81%	80%	80%	80%
None	15%	14%	13%	13%
HRV or ERV	3%	6%	6%	6%

B.4 Building Shell

Readers should note that sample sizes for many building shell measures drop substantially compared to other measures. RESNET data included data transcription issues that yielded insulation values that were improperly populated in the database.

B.4.1 Walls

Table 33: Single-Family Above Grade Wall R-Values (Effective)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*6,892*	*278*	*3,994*	*4,272*
Min	13.5	16.1	14.9	14.9
Mean	22.1	21.5	20.6	21.0
Median	21.3	21.2	20.6	20.7
Max	50.9	35.6	45.2	45.2
SD	5.4	3.3	4.6	4.1

Table 34: Single-Family Above Grade Wall R-Values (Nominal)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*6,892*	*278*	*3,994*	*4,272*
Min	14.2	16.9	15.7	15.7
Mean	23.3	22.6	21.7	22.1
Median	22.4	22.3	21.7	21.8
Max	53.6	37.5	47.6	47.6
SD	5.7	3.5	4.8	4.3

Table 35: Single-Family Above Grade Wall U-Values

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*6,892*	*278*	*3,994*	*4,272*
Min	0.020	0.028	0.022	0.022
Mean	0.045	0.047	0.049	0.048
Median	0.047	0.047	0.048	0.048
Max	0.074	0.062	0.067	0.067
SD	0.010	0.008	0.010	0.010

B.4.2 Ceilings

Table 36: Single-Family Ceiling R-Values (Effective)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*8,093*	*277*	*4,682*	*4,959*
Min	19.6	25.6	24.0	24
Mean	41.7	41	41.4	41.4
Median	42.4	41.2	41.7	41.7
Max	78.1	55.6	59.2	59.2
SD	6.6	6	0.1	2.9

Table 37: Single-Family Ceiling R-Values (Nominal)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*8,093*	*277*	*4,682*	*4,959*
Min	20.2	26.4	24.7	24.7
Mean	43.0	42.3	42.7	42.7
Median	43.7	42.5	43.0	43.0
Max	80.5	57.3	61.0	61.0
SD	6.8	6.2	0.1	3.0

Table 38: Single-Family Ceiling U-Values

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*8,093*	*277*	*4,682*	*4,959*
Min	0.013	0.018	0.017	0.017
Mean	0.024	0.024	0.024	0.024
Median	0.024	0.024	0.024	0.024
Max	0.051	0.039	0.042	0.042
SD	0.004	0.004	0.004	0.004

B.4.3 Floors

Table 39: Single-Family Floor over Unconditioned Basement R-Values (Effective)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*3,216*	*165*	*1,961*	*2,126*
Min	12.8	17.3	18.9	17.3
Mean	32.7	33.9	31.4	31.6
Median	32.9	33.9	32.1	32.1
Max	51.6	48.1	51.5	51.5
SD	4.4	4.2	4.3	4.3

Table 40: Single-Family Floor over Unconditioned Basement R-Values (Nominal)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*3,216*	*165*	*1,961*	*2,126*
Min	13.5	18.2	19.9	18.2
Mean	34.4	35.7	33.1	33.3
Median	34.6	35.7	33.8	33.8
Max	54.3	50.6	54.2	54.2
SD	4.6	4.4	4.5	4.5

Table 41: Single-Family Floor over Unconditioned Basement U-Values

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*3,216*	*165*	*1,961*	*2,126*
Min	0.019	0.021	0.019	0.019
Mean	0.031	0.029	0.032	0.032
Median	0.030	0.029	0.031	0.031
Max	0.078	0.058	0.053	0.058
SD	0.003	0.004	0.004	0.004

B.4.4 Foundation Walls

Table 42: Single-Family Conditioned Foundation Walls R-Values (Effective)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*2,246*	*48*	*1,353*	*1,401*
Min	3.0	7.6	5.0	5.0
Mean	20.6	20.2	18.9	18.9
Median	20.7	20.4	19.5	19.5
Max	50	30.5	49.4	49.4
SD	7.2	4.7	6.5	6.4

Table 43: Single-Family Conditioned Foundation Walls R-Values (Nominal)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*2,246*	*48*	*1,353*	*1,401*
Min	3.2	8.0	5.3	5.3
Mean	21.7	21.3	19.9	19.9
Median	21.8	21.5	20.5	20.5
Max	52.6	32.1	52.0	52.0
SD	7.6	4.9	6.8	6.7

Table 44: Single-Family Conditioned Foundation Walls U-Values

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*2,246*	*48*	*1,353*	*1,401*
Min	0.02	0.033	0.02	0.02
Mean	0.048	0.05	0.053	0.053
Median	0.048	0.049	0.051	0.051
Max	0.333	0.131	0.2	0.2
SD	0.017	0.016	0.019	0.019

B.4.5 Windows

Table 45: Single-Family Window U-Factor

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*8,208*	*392*	*5,963*	*6,355*
Min	0.11	0.17	0.12	0.12
Mean	0.28	0.28	0.28	0.28
Median	0.28	0.29	0.28	0.28
Max	0.39	0.34	0.49	0.49
SD	0.02	0.02	0.02	0.02

Table 46: Single-Family Window SHGC

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*8,217*	*392*	*5,969*	*6,361*
Min	0.14	0.17	0.13	0.13
Mean	0.29	0.28	0.29	0.29
Median	0.28	0.27	0.28	0.28
Max	0.72	0.46	0.60	0.60
SD	0.06	0.05	0.05	0.05

B.5 MECHANICAL EQUIPMENT

B.5.1 Heating

Table 47: Single-Family Heating Fuel

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*7,325*	*354*	*5,072*	*5,426*
Natural gas	60%	54%	47%	47%
Propane	27%	42%	44%	43%
Electric	13%	4%	10%	9%

Table 48: Single-Family Heating System Type

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*7,325*	*354*	*5,072*	*5,426*
Fuel-fired air distribution (furnace)	85%	95%	85%	85%
Ducted ASHP	7%	3%	6%	6%
Ductless ASHP	5%	1%	3%	3%
Fuel-fired hydronic distribution (boiler)	2%	1%	6%	5%
GSHP	<1%	0%	<1%	<1%
Other*	<1%	<1%	<1%	<1%

*Includes electric baseboard or radiant and electric air distribution.

Table 49: Single-Family Fuel-Fired AFUE

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*6,382*	*340*	*4,587*	*4,927*
Min	80.0	85.4	80.0	80.0
Mean	95.6	95.4	95.4	95.4
Median	96.0	96.0	96.0	96.0
Max	98.7	97.0	98.1	98.1
SD	1.2	1.3	1.3	1.3

Table 50: Single-Family Ducted ASHP HSPF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*502*	*11*	*293*	*304*
Min	6.5	8.9	7.2	7.2
Mean	10.0	10.1	9.8	9.8
Median	10.0	10.0	9.7	9.7
Max	14.0	11.5	14.0	14.0
SD	1.1	0.9	1.1	1.1

Table 51: Single-Family Ductless ASHP HSPF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*390*	*2*	*144*	*146*
Min	7.7	10.5	8.3	8.3
Mean	10.7	10.7	10.7	10.7
Median	10.4	10.7	10.5	10.5
Max	13.5	11.0	14.0	14.0
SD	1.1	0.4	1.1	1.1

Table 52: Single-Family GSHP COP

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*32*	*0*	*22*	*22*
Min	3.1	–	3.1	3.1
Mean	4.1	–	4.2	4.2
Median	4.1	–	4.1	4.1
Max	5.2	–	5.2	5.2
SD	0.6	–	0.6	0.6

B.5.2 Cooling

Table 53: Single-Family Cooling System Type

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*6,910*	*328*	*4,641*	*4,969*
Central air conditioning	85%	95%	89%	89%
Ducted ASHP	9%	5%	8%	8%
Ductless ASHP	5%	1%	3%	3%
GSHP	<1%	0%	<1%	<1%

Table 54: Single-Family CAC SEER

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*5,892*	*310*	*4,111*	*4,421*
Min	11.9	13.0	12.0	12.0
Mean	13.9	13.7	13.9	13.8
Median	13.6	14.0	13.5	13.5
Max	23.5	20.0	22.5	22.5
SD	1.0	0.8	1.1	1.1

Table 55: Single-Family Ducted ASHP SEER

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*607*	*16*	*358*	*374*
Min	12.2	14.0	12.2	12.2
Mean	18.0	17.8	17.5	17.5
Median	18.0	17.7	17.8	17.8
Max	26.1	20.5	23.1	23.1
SD	2.3	1.9	2.2	2.2

Table 56: Single-Family Ductless ASHP SEER

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*380*	*2*	*151*	*153*
Min	13.0	16.5	14.3	14.3
Mean	20.0	17.1	19.6	19.6
Median	20.0	17.1	19.7	19.7
Max	28.2	17.7	26.1	26.1
SD	2.5	0.8	2.1	2.1

Table 57: Single-Family GSHP EER

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*31*	*0*	*21*	*21*
Min	16.1	–	14.0	14.0
Mean	20.9	–	21.1	21.1
Median	19.8	–	20.3	20.3
Max	40.0	–	26.2	26.2
SD	4.9	–	3.2	3.2

B.5.3 Water Heating

Table 58: Single-Family Water Heater Fuel

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*7,383*	*370*	*5,314*	*5,684*
Natural gas	48%	42%	38%	38%
Propane	20%	27%	36%	35%
Electric	32%	31%	26%	27%

Table 59: Single-Family Water Heater Type

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*7,383*	*370*	*5,314*	*5,684*
Instantaneous	57%	53%	62%	61%
Heat pump	30%	28%	24%	24%
Conventional	13%	19%	13%	13%
Integrated	<1%	<1%	1%	1%

Table 60: Single-Family Fossil Fuel Water Heater EF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*5,003*	*257*	*3,908*	*4,164*
Min	0.59	0.59	0.59	0.59
Mean	0.91	0.89	0.92	0.92
Median	0.95	0.93	0.95	0.95
Max	0.99	0.99	0.99	0.99
SD	0.08	0.10	0.08	0.09

Table 61: Single-Family Electric Water Heater EF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*2,371*	*113*	*1,404*	*1,517*
Min	0.80	0.71	0.65	0.65
Mean	3.41	3.29	3.33	3.33
Median	3.45	3.45	3.45	3.45
Max	4.32	4.05	4.32	4.32
SD	0.66	0.79	0.80	0.80

Table 62: Single-Family Instantaneous Water Heater EF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*4,180*	*195*	*3,283*	*3,478*
Min	0.78	0.80	0.78	0.78
Mean	0.94	0.94	0.94	0.94
Median	0.95	0.95	0.95	0.95
Max	0.99	0.99	0.99	0.99
SD	0.03	0.03	0.03	0.03

Table 63: Single-Family Heat Pump Water Heater EF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*2,236*	*105*	*1,277*	*1,382*
Min	1.93	1.93	2.10	1.93
Mean	3.56	3.47	3.57	3.56
Median	3.45	3.45	3.48	3.48
Max	4.32	4.05	4.32	4.32
SD	0.25	0.45	0.25	0.27

Table 64: Single-Family Conventional Water Heater EF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*944*	*69*	*692*	*761*
Min	0.59	0.59	0.59	0.59
Mean	0.79	0.74	0.80	0.80
Median	0.81	0.70	0.83	0.82
Max	0.98	0.95	0.98	0.98
SD	0.11	0.10	0.10	0.11

Table 65: Single-Family Integrated Water Heater EF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*14*	*1*	*63*	*64*
Min	0.86	0.87	0.75	0.75
Mean	0.87	0.87	0.86	0.86
Median	0.87	0.87	0.87	0.87
Max	0.88	0.87	0.98	0.98
SD	0.01	n/a	0.03	0.03

B.5.4 Ducts

See Section 6 for information about the portion of homes that meet the Base Code's mandatory duct leakage requirements.

Table 66: Single-Family Duct Leakage to Outside (CFM25/100 ft2 CFA)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*7,357*	*377*	*5,187*	*5,564*
Min	0.0	0.0	0.0	0.0
Mean	1.9	2.4	1.9	1.9
Median	1.7	2.3	1.7	1.8
Max	7.6	7.2	7.6	7.6
SD	1.4	1.4	1.4	1.4

Table 67: Single-Family Total Duct Leakage (CFM25/100 ft2 CFA)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*6,763*	*361*	*4,521*	*4,882*
Min	0.0	0.0	0.0	0.0
Mean	5.7	5.7	5.7	5.7
Median	3.9	3.8	3.9	3.9
Max	30.1	29.3	29.5	29.5
SD	4.7	4.9	4.6	4.7

Table 68: Single-Family All Supply Ducts Located in Conditioned Space

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*7,665*	*381*	*5,407*	*5,788*
Yes	45%	42%	47%	47%
No	55%	58%	53%	53%

Table 69: Single-Family Supply Duct Insulation R-Value
(Ducts in Unconditioned Space Only)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*775*	*32*	*853*	*885*
Min	0.0	6.0	0.0	0.0
Mean	7.9	7.8	7.7	7.7
Median	8.0	8.0	8.0	8.0
Max	35.0	8.0	38.0	38.0
SD	1.5	0.7	1.7	1.7

B.6 RENEWABLES

As noted in A.2.2.4, these values reflect the extent to which solar panels were installed at the time of the HERS rating; homeowners in many cases would install solar panels later, post-occupancy.

Table 70: Single-Family Renewables Penetration

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*8,217*	*392*	*5,968*	*6,360*
Photovoltaics	1.4%	1.3%	0.9%	0.9%

Table 71: Single-Family On-Site Power Production (kWh)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*119*	*5*	*54*	*59*
Min	1,741	3,705	330	330
Mean	11,839	6,223	11,665	11,204
Median	11,701	4,404	10,577	10,372
Max	31,922	12,075	28,543	28,543
SD	5,985	3,508	6,270	6,254

B.7 LIGHTING

As noted in A.2.2.2, lighting values in the RESNET data do not appear to be reliable.

B.8 APPLIANCES

As noted in A.2.2.3, sample sizes for appliances are lower than for other measures, and the presented values should be considered with skepticism.

B.8.1 Refrigerators

Table 72: Single-Family Refrigerator kWh/Year

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*6,601*	*297*	*4,973*	*5,270*
Min	254	279	218	218
Mean	639	628	638	638
Median	665	656	665	665
Max	999	991	999	999
SD	103	109	104	104

B.8.2 Dishwashers

Table 73: Single-Family Dishwasher kWh/Year

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*4,125*	*148*	*3,000*	*3,148*
Min	140	170	144	144
Mean	260	263	260	260
Median	265	269	260	260
Max	463	463	463	463
SD	16	28	18	18

B.8.3 Ranges

Table 74: Single-Family Range Fuel

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*8,217*	*392*	*5,969*	*6,361*
Natural Gas	49%	37%	37%	37%
Propane	25%	31%	34%	34%
Electric	26%	33%	28%	28%

B.8.4 Clothes Washers

Table 75: Single-Family Clothes Washer kWh/Year

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*4,950*	*264*	*4,320*	*4,584*
Min	50	75	50	50
Mean	372	440	389	392
Median	175	704	188	208
Max	710	704	704	704
SD	278	285	282	282

B.8.5 Clothes Dryers

Table 76: Single-Family Clothes Dryer Fuel

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*7,074*	*331*	*5,109*	*5,440*
Electric	99%	95%	96%	96%
Natural Gas	1%	5%	2%	2%
Propane	1%	0%	2%	1%

Table 77: Single-Family Clothes Dryer Energy Factor

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*7,074*	*331*	*5,109*	*5,440*
Min	1.6	2.3	2.0	2.0
Mean	3.1	3.2	3.1	3.1
Median	3.0	3.0	2.6	2.6
Max	9.9	4.5	9.8	9.8
SD	0.6	0.6	0.7	0.7

Appendix C Detailed Data: Multifamily

C.1 General Characteristics

Table 78: Multifamily CFA

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,052*	*717*	*3,964*	*4,681*
Min	399	575	320	320
Mean	1,140	1,052	1,176	1,157
Median	1,026	931	1,029	1,007
Max	3,725	3,487	6,419	6,419
SD	508	366	592	565

Table 79: Multifamily Bedrooms

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,052*	*717*	*3,964*	*4,681*
Min	1	1	1	1
Mean	2	2	2	2
Median	2	2	2	2
Max	4	3	6	6
SD	1	1	1	1

Table 80: Multifamily Stories

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,052*	*717*	*3,964*	*4,681*
Min	1	1	1	1
Mean	1	1	1	1
Median	1	1	1	1
Max	4	4	4	4
SD	1	0	1	1

C.2 Whole Home Performance

Note that some HERS scores at the extremes appear to be higher or lower than we might expect for new construction, but overall means are not particularly affected by these high values, given the large number of homes included in the analysis.

Table 81: Multifamily HERS Index Scores without PV

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,046*	*717*	*3,923*	*4,640*
Min	28	40	31	31
Mean	47	55	49	50
Median	48	54	49	50
Max	62	86	80	86
SD	6	7	5	6

Table 82: Multifamily HERS Index Scores with PV

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,052*	*717*	*3,964*	*4,681*
Min	25	40	-17	-17
Mean	46	55	48	49
Median	48	54	49	50
Max	62	86	74	86
SD	8	7	6	7

C.3 Air Infiltration and Ventilation

See Section 11 for information about the portion of homes that meet the code's mandatory air leakage requirements.

Table 83: Multifamily Air Infiltration (ACH50)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,052*	*717*	*3,960*	*4,677*
Min	0.2	0.2	0.2	0.2
Mean	2.5	2.6	3.0	2.9
Median	2.6	2.8	2.9	2.9
Max	10.0	6.7	10.5	10.5
SD	1.4	1.3	1.5	1.5

Table 84: Multifamily Mechanical Ventilation Type

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,051*	*717*	*3,907*	*4,624*
Exhaust Only	63%	76%	67%	68%
None	36%	24%	27%	27%
HRV or ERV	1%	0%	6%	5%

C.4 BUILDING SHELL

C.4.1 Walls

Table 85: Multifamily Above Grade Wall R-Values (Effective)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*856*	*601*	*3,176*	*3,777*
Min	11.6	13.1	13.3	13.1
Mean	21.5	26.6	21.7	22.7
Median	22.0	26.2	22.0	22.6
Max	50.0	45.5	37.0	45.5
SD	5.1	2.0	4.9	4.4

Table 86: Multifamily Above Grade Wall R-Values (Nominal)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*856*	*601*	*3,176*	*3,777*
Min	12.2	13.8	14.0	13.8
Mean	22.6	28.0	22.8	23.9
Median	23.2	27.6	23.2	23.8
Max	52.6	47.9	38.9	47.9
SD	5.4	2.1	5.2	4.6

Table 87: Multifamily Above Grade Wall U-Values

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*856*	*601*	*3,176*	*3,777*
Min	0.020	0.022	0.027	0.022
Mean	0.047	0.038	0.046	0.044
Median	0.045	0.038	0.045	0.044
Max	0.086	0.076	0.075	0.076
SD	0.012	0.003	0.011	0.009

C.4.2 Ceilings

Table 88: Multifamily Ceilings R-Values (Effective)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*388*	*173*	*1402*	*1575*
Min	26.1	28.5	19.0	19.0
Mean	38.7	41.2	39.9	40.0
Median	38.7	41.4	40.0	40.0
Max	73.6	54.6	75.8	76.9
SD	7.0	6.2	10.2	9.7

Table 89: Multifamily Ceilings R-Values (Nominal)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	388	173	1402	1575
Min	26.9	29.4	19.6	19.6
Mean	39.9	42.5	41.1	41.2
Median	39.9	42.7	41.2	41.2
Max	75.9	56.3	78.1	79.3
SD	7.2	6.4	10.5	10.0

Table 90: Multifamily Ceilings U-Values

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	388	173	1402	1575
Min	0.014	0.018	0.013	0.013
Mean	0.026	0.024	0.025	0.025
Median	0.026	0.024	0.025	0.025
Max	0.038	0.035	0.053	0.053
SD	0.004	0.003	0.006	0.006

C.4.3 Floors

Table 91: Multifamily Floors Above Unconditioned Space R-Values (Effective)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	111	36	250	286
Min	*22.6*	*31.0*	*17.9*	*17.9*
Mean	31.5	34.0	31.4	31.7
Median	31.3	34.0	31.4	31.6
Max	43.4	36.8	50.1	50.1
SD	4.3	1.6	4.4	4.1

Table 92: Multifamily Floors Above Unconditioned Space R-Values (Nominal)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	111	36	250	286
Min	23.8	32.6	18.8	18.8
Mean	33.2	35.8	33.1	33.4
Median	32.9	35.8	33.1	33.3
Max	45.7	38.7	52.7	52.7
SD	4.5	1.7	4.6	4.3

Table 93: Multifamily Floors Above Unconditioned Space U-Values

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	111	36	250	286
Min	0.023	0.027	0.020	0.020
Mean	0.032	0.029	0.032	0.032
Median	0.032	0.029	0.032	0.032
Max	0.044	0.032	0.056	0.056
SD	0.004	0.001	0.005	0.005

C.4.4 Foundation Walls

Table 94: Foundation Walls R-Values (Effective)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	51	10	207	217
Min	8.8	20.2	14.2	14.2
Mean	18.5	26.1	22.0	22.1
Median	19.0	25.4	22.1	22.1
Max	32.1	33.0	42.7	42.7
SD	*4.6*	*6.8*	*3.1*	*3.3*

Table 95: Foundation Walls R-Values (Nominal)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	51	10	207	217
Min	9.3	21.3	14.9	14.9
Mean	19.5	27.5	23.2	23.3
Median	20.0	26.7	23.3	23.3
Max	33.8	34.7	44.9	44.9
SD	4.8	7.2	3.3	3.5

Table 96: Foundation Walls U-Values

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	51	10	207	217
Min	0.031	0.030	0.023	0.023
Mean	0.054	0.038	0.045	0.045
Median	0.053	0.039	0.045	0.045
Max	0.114	0.050	0.070	0.070
SD	0.217	0.147	0.323	0.303

C.4.5 Windows

Table 97: Multifamily Window U-Factor

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,052*	*710*	*3,962*	*4,672*
Min	0.16	0.14	0.12	0.12
Mean	0.26	0.30	0.27	0.28
Median	0.28	0.30	0.28	0.28
Max	0.36	0.42	0.46	0.46
SD	0.04	0.03	0.04	0.04

Table 98: Multifamily Window SHGC

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,052*	*717*	*3,964*	*4,681*
Min	0.17	0.19	0.13	0.13
Mean	0.32	0.25	0.29	0.28
Median	0.30	0.21	0.28	0.28
Max	0.54	0.46	0.58	0.58
SD	0.07	0.06	0.06	0.06

C.5 Mechanical Equipment

C.5.1 Heating

Table 99: Multifamily Heating Fuel

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,038*	*676*	*3,531*	*4,207*
Natural gas	47%	85%	65%	68%
Electric	52%	13%	33%	29%
Propane	<1%	2%	2%	2%

Table 100: Multifamily Heating System Type

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,025*	*676*	*3,468*	*4,144*
Fuel-fired air distribution (furnace)	45%	87%	65%	69%
Ducted ASHP	20%	2%	19%	16%
Ductless ASHP	32%	6%	12%	11%
Fuel-fired hydronic distribution (boiler)	3%	0%	3%	2%
GSHP	0%	0%	<1%	<1%
Other*	0%	6%	1%	2%

*Includes electric baseboard or radiant and electric air distribution.

Table 101: Multifamily Fuel-Fired AFUE

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*492*	*588*	*2,373*	*2,961*
Min	80.0	80.0	81.0	80.0
Mean	95.5	91.4	95.5	94.7
Median	95.0	95.0	96.0	95.0
Max	97.1	97.1	98.0	98.0
SD	1.0	6.6	1.1	3.5

Table 102: Multifamily Ducted ASHP HSPF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*204*	*12*	*643*	*655*
Min	8.2	10.4	7.2	7.2
Mean	11.0	10.6	10.3	10.3
Median	11.8	10.4	10.2	10.2
Max	11.9	11.0	13.0	13.0
SD	1.1	0.3	1.0	1.0

Table 103: Multifamily Ductless ASHP HSPF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*329*	*38*	*405*	*443*
Min	8.7	10.0	7.7	7.7
Mean	10.5	10.7	10.4	10.4
Median	10.4	10.4	10.3	10.3
Max	12.5	12.5	13.7	13.7
SD	1.0	0.6	1.4	1.3

C.5.2 Cooling

Table 104: Multifamily Cooling System Type

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*997*	*714*	*3,376*	*4,090*
Central air conditioning	46%	93%	68%	72%
Ducted ASHP	21%	2%	20%	17%
Ductless ASHP	33%	5%	12%	11%
GSHP	0%	0%	<1%	<1%

Table 105: Multifamily CAC SEER

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*462*	*663*	*2,288*	*2,951*
Min	13.0	12.0	12.0	12.0
Mean	13.8	13.5	14.0	13.9
Median	13.5	13.0	14.0	14.0
Max	16.5	16.5	20.0	20.0
SD	0.7	1.6	1.1	1.3

Table 106: Multifamily Ducted ASHP SEER

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*206*	*12*	*669*	*681*
Min	11.5	19.2	11.1	11.1
Mean	14.9	19.3	17.3	17.4
Median	14.0	19.2	18.0	18.0
Max	22.0	19.5	25.5	25.5
SD	3.5	0.1	2.9	2.9

Table 107: Multifamily Ductless ASHP SEER

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*329*	*39*	*332*	*371*
Min	11.6	16.6	11.9	11.9
Mean	17.6	19.4	19.1	19.1
Median	18.0	19.2	19.5	19.2
Max	26.1	23.0	33.1	33.1
SD	3.0	1.0	4.0	3.9

C.5.3 Water Heating

Table 108: Multifamily Water Heater Fuel

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,052*	*676*	*3,795*	*4,471*
Natural gas	52%	55%	73%	70%
Electric	42%	44%	23%	26%
Propane	6%	0%	5%	4%

Table 109: Multifamily Water Heater Type

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,034*	*676*	*3,725*	*4,401*
Instantaneous	40%	55%	52%	55%
Conventional	26%	43%	31%	33%
Heat pump	34%	2%	15%	13%
Integrated	0%	0%	1%	1%

Table 110: Multifamily Fossil Fuel Water Heater EF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*597*	*450*	*3,390*	*3,243*
Min	0.83	0.90	0.61	0.61
Mean	0.95	0.96	0.93	0.93
Median	0.95	0.96	0.95	0.95
Max	0.99	0.97	0.99	0.99
SD	0.03	0.01	0.04	0.04

Table 111: Multifamily Electric Water Heater EF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*437*	*301*	*857*	*1,158*
Min	0.92	0.91	0.88	0.88
Mean	3.09	1.06	2.72	2.29
Median	3.57	0.92	3.46	0.95
Max	3.88	3.75	4.09	4.09
SD	1.11	0.61	1.33	1.39

Table 112: Multifamily Instantaneous Water Heater EF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*417*	*373*	*1,948*	*2,321*
Min	0.83	0.92	0.80	0.80
Mean	0.95	0.96	0.95	0.95
Median	0.95	0.96	0.95	0.95
Max	0.99	0.97	0.99	0.99
SD	0.03	0.01	0.02	0.02

Table 113: Multifamily Conventional Water Heater EF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*269*	*288*	*1,170*	*1,458*
Min	0.88	0.90	0.61	0.61
Mean	0.94	0.92	0.90	0.90
Median	0.95	0.92	0.91	0.92
Max	0.97	0.95	0.96	0.96
SD	0.03	<0.01	0.05	0.05

Table 114: Multifamily Heat Pump Water Heater EF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*348*	*15*	*555*	*570*
Min	3.35	3.35	2.73	2.73
Mean	3.65	3.72	3.69	3.69
Median	3.75	3.75	3.75	3.75
Max	3.88	3.75	4.09	4.09
SD	0.17	0.10	0.20	0.20

Table 115: Multifamily Integrated Water Heater EF

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*0*	*0*	*52*	*52*
Min	n/a	n/a	0.86	0.86
Mean	n/a	n/a	0.94	0.94
Median	n/a	n/a	0.95	0.95
Max	n/a	n/a	0.95	0.95
SD	n/a	n/a	0.03	0.03

C.5.4 Ducts

See Section 11 for information about the portion of homes that meet the Base Code's mandatory duct leakage requirements. Note that removing the high maximum values do not impact the mean shown.

Table 116: Multifamily Duct Leakage to Outside (CFM25/100 ft2 CFA)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*532*	*347*	*2,398*	*2,745*
Min	0.0	0.0	0.0	0.0
Mean	1.3	2.5	1.8	1.9
Median	0.7	2.5	1.4	1.5
Max	7.4	7.6	32.9	32.9
SD	1.7	2.0	2.1	2.1

Table 117: Multifamily Total Duct Leakage (CFM25/100 ft2 CFA)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*485*	*335*	*2,149*	*2,484*
Min	0.0	0.0	0.0	0.0
Mean	5.7	7.8	5.1	5.4
Median	3.6	3.9	3.8	3.8
Max	29.9	26.7	77.0	77.0
SD	6.8	7.0	6.6	6.7

Table 118: Multifamily All Supply Ducts Located in Conditioned Space

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*713*	*675*	*2,951*	*4,339*
Yes	81%	93%	86%	87%
No	19%	7%	14%	13%

Table 119: Multifamily Supply Duct Insulation R-Value
(Ducts in Unconditioned Space Only)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1*	*0*	*53*	*53*
Min	6.0	n/a	0.0	0.0
Mean	6.0	n/a	7.2	7.2
Median	6.0	n/a	8.0	8.0
Max	6.0	n/a	8.0	8.0
SD	n/a	n/a	2.2	2.2

C.6 RENEWABLES

As noted in A.2.2.4, these values reflect the extent to which solar panels were installed at the time of the HERS rating; owners in many cases may install solar panels later, post-occupancy.

Table 120: Multifamily Renewables Penetration

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,052*	*655*	*3,355*	*4,681*
Photovoltaics	14.8%	0.0%	2.0%	1.7%

Table 121: Multifamily On-Site Power Production (kWh)

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*156*	*0*	*80*	*80*
Min	425	-	1,259	1,259
Mean	1,074	-	3,024	3,024
Median	853	-	2,737	2,737
Max	1,613	-	9,048	9,048
SD	378	-	1,644	1,644

C.7 LIGHTING

As noted in A.2.2.2, lighting values in the RESNET data do not appear to be reliable.

C.8 APPLIANCES

As noted in A.2.2.3, sample sizes for appliances are lower than for other measures, and the presented values should be considered with skepticism.

C.8.1 Refrigerators

Table 122: Multifamily Refrigerator kWh/Year

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*954*	*557*	*3,760*	*4,317*
Min	279	240	254	240
Mean	525	486	521	516
Median	540	436	489	488
Max	747	691	988	988
SD	128	108	120	119

C.8.2 Dishwashers

Table 123: Multifamily Dishwasher kWh/Year

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*507*	*410*	*1,385*	*1,795*
Min	234	234	138	138
Mean	258	258	261	260
Median	258	255	260	258
Max	455	278	459	359
SD	25	7	24	22

C.8.3 Ranges

Table 124: Multifamily Range Fuel

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*1,052*	*717*	*3,964*	*4,681*
Electric	72%	79%	60%	63%
Natural Gas	27%	21%	39%	36%
Propane	<1%	0%	1%	1%

C.8.4 Clothes Washers

Table 125: Multifamily Clothes Washer kWh/Year

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*584*	*400*	*2,447*	*2,847*
Min	85	90	60	60
Mean	266	193	312	296
Median	151	240	150	150
Max	704	704	704	704
SD	250	112	271	258

C.8.5 Clothes Dryers

Table 126: Multifamily Clothes Dryer Fuel

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*824*	*475*	*3,319*	*3,794*
Electric	99%	100%	99%	99%
Natural Gas	1%	0%	1%	1%

Table 127: Multifamily Clothes Dryer Energy Factor

	Program	NP: Base Code	NP: Stretch Code	NP: Overall
n	*824*	*475*	*3,319*	*3,794*
Min	2.6	2.6	2.1	2.1
Mean	3.1	3.2	3.2	3.2
Median	2.7	3.0	3.0	3.0
Max	6.4	3.9	7.8	7.8
SD	0.6	0.5	0.9	0.8

Appendix D Data Collection Instruments

D.1 Code Official Survey

Code officials in Base Code communities were asked to fill out the table below, via email or phone (Table 128). Respondents were asked to describe typical practices in their communities, and reminded that *single-family homes* includes detached houses and units in a standalone building with two to four units, while *low-rise multifamily* includes buildings with five or more units with three stories or less.

Table 128: Code Official Survey

Question	Answer	
	Prescriptive (%)	ERI (%)
1. What percentage of *new, single-family homes* comply with the Base energy code via the **prescriptive** (including UA tradeoff) vs. **ERI** performance path? (Cells to the right should sum to 100%.)	____	____
	Prescriptive (%)	ERI (%)
2. What percentage of *new, low-rise multifamily homes* comply with the Base energy code via the **prescriptive** (including UA tradeoff) vs. **ERI** performance path? (Cells to the right should sum to 100%.)	____	____
	Base Code (%)	Above-code (%)
3. What percentage of *new, single-family homes* comply with the **Base energy code** vs. **above-code standards**? (Cells to the right should sum to 100%.)	____	____
	Base Code (%)	Above-code (%)
4. What percentage of *new, low-rise multifamily homes* comply with the **Base energy code** vs. **above-code standards**? (Cells to the right should sum to 100%.)	____	____
5. How do you expect any of your estimates above to change under the new, more stringent Base energy code coming into effect in 2024?	[OPEN RESPONSE]	

D.2 Market Actor Interview Guide

D.2.1 SF vs MF Definitions

We're going to be asking about your work in low-rise, residential new construction – just in Massachusetts. For this interview we're going to focus on single-family and low-rise multifamily homes in Massachusetts. By single-family, we're including units in buildings with 1-4 units. These could be detached homes, attached homes - which you might call townhomes or rowhouses - and then any other buildings with 2-4 units. For low-rise multifamily, we're just talking about buildings with at least 5 units and no more than 3 stories. I'll use that terminology throughout the interview.

Intro. Since November 2020, have you [BUILT/RATED] homes in the following regions of Massachusetts:

a. Cape Cod and Islands [IF NEEDED: Includes Barnstable, Dukes, and Nantucket County and excludes area before the Cape Cod Canal]
b. Central Massachusetts [IF NEEDED: Includes Worcester County]
c. Eastern Massachusetts [IF NEEDED: Includes areas east of Worcester County, but excludes Cape Cod and Islands]
d. Western Massachusetts [IF NEEDED: Includes areas west of Worcester County

D.2.2 Activity Level

I'd like to start by asking some questions about the number of new homes your company built or rated in the past year. [GATHER AS MUCH AS POSSIBLE FROM EMAIL BEFOREHAND.]

D.2.2.1 Project Counts and Program Participation

Q1. In the last year, how many **new single-family homes** did your company [BUILD/RATE] in Massachusetts? [REMIND OF DEFINITIONS] [ENTER RESULTS IN TABLE BELOW]

Q2. In the last year, roughly how many **new low-rise multi-family units** did your company [BUILD/RATE] in Massachusetts? [REMIND OF DEFINITIONS] [ENTER RESULTS IN TABLE BELOW]

Q3. Roughly what portion of all those projects participated in the Mass Save Residential New Home Construction Low-Rise program, that offers incentives for meeting certain energy efficiency requirements? [DESCRIBE PROGRAM AS NECESSARY TO CONFIRM AWARENESS] [ENTER RESULTS IN TABLE BELOW]

D.2.2.2 Project Counts by Code Version

As you may know, there are different energy codes in effect in Massachusetts. Massachusetts has a Base Code and a Stretch Code, and a new Specialized, opt-in code is coming online as well. The Stretch and Specialized codes require that homes get HERS ratings and perform better than the Base Code requirements. HERS ratings are optional in Base Code communities.

Q4. Roughly what portion of all the projects your company [BUILT/RATED] in the last year were in Base Code communities? [ENTER RESULTS IN TABLE BELOW]

Home Type	Units Built in Past Year (#)	Program Participation (%)	Built in Base Code (%)
Single-family (1-4 units)	[Q1]	[Q3]	[Q4]
Multifamily (5+ units, 1-3 stories)	[Q2]		

For the rest of this conversation, when we talk about "program homes," we're talking about homes that participated in the Mass Save Residential New Home Construction Low-Rise program; "non-program homes" are any homes that did not participate in that program.

D.2.3 Base Code Practices

In Base Code communities, you can comply with the energy code via three compliance paths: 1) a prescriptive path, 2) a performance path that allows some tradeoffs, or 3) the Energy Rating Index (ERI) path, where you can demonstrate compliance by getting a HERS score below a specific threshold. In Stretch Code and Specialized opt-in code communities, new homes must get HERS ratings.

Q5. Does that sound familiar to you? [PROBE TO CONFIRM GENERAL UNDERSTANDING]

D.2.3.1 Base Code Compliance Paths

Q6. [BASE] What portion of your homes in Base Code communities follow each of those three paths (prescriptive, trade-off, and ERI)? [ENTER RESULTS IN TABLE BELOW].

Path	Projects [column sums to 100%]
Prescriptive	[Q6a]
Trade-off	[Q6b]
ERI	[Q6c]

Q7. [BASE] Why do your Base Code homes follow that pattern?

D.2.3.2 Representativeness of RESNET Data

Q8. [BASE] Why do homes built in Base Code jurisdictions get HERS ratings given that it isn't required? [PROBE: program participation, bringing over practices from Stretch Code towns, SF vs MF, etc.]

Q9. [BASE] To what extent is there a difference in the energy efficiency of your Base Code homes that receive HERS ratings vs your Base Code homes that don't? [PROBE: difference in HERS scores, program participation, difference in equipment or building material, etc.]

Q10. [BASE AND STRETCH] [IF Q4 >0 AND <100%] How different are your Base Code homes and your Stretch Code homes in terms of their energy-efficiency? What features

are different in terms of their energy efficiency? [PROBE: SF vs MF; if the homes themselves are different, or the features they include in them are different]

D.2.4 Code Compliance

As you likely know, code has been changing in Massachusetts. Starting in January of 2023, the Stretch Code became based on the 2021 IECC, and more stringent requirements kick-in in the middle of 2024. Base code is shifting to the 2021 IECC in 2024, and some communities are adopting the Specialized opt-in code that is based on the Stretch Code.

Q11. How well do you think builders have been able to comply with the new Stretch Code that went into effect in early 2023, where homes had to achieve HERS scores no higher than 52 or 55, depending on the fuel they use? Why do you say that?

Q12. How well will they be able to comply with those other new code versions that are coming? What will be challenging for them in trying to meet those requirements? [PROBE: differences between the code versions – Base: 52/55, Stretch/Specialized: 42/45]

Q13. How consistently have code officials been enforcing the energy-efficiency requirements of the new Stretch Code that went into effect in early 2023? What aspects of the code are enforced less frequently? Why do you say that?

D.2.5 Net-to-Gross (NTG)

Q14. How, if at all, do you expect program participation to change as a result of the new energy codes, whether the new Base Code in 2024, or the Stretch and Specialized versions of the code that have already come into effect? [PROBE: Do you expect participation to go up, down, or stay the same? Will that look different in Stretch vs Base Code towns? Why?]

a. Does this differ between single-family and low-rise multi-family? How so?

Q15. What, if any, changes to your building practices have you implemented because of the new codes?

a. Do you expect to adopt any other changes in the near term? What, and why?

Q16. [BUILDERS WHO USE ERI/HERS PATH AND HERS RATERS] In the next year, what is the typical HERS score you plan to target for your non-program homes in Base Code towns? [EXPLAIN AS NEEDED: By “target”, we mean the typical or average HERS score that you expect your homes to achieve.]

a. In **Stretch Code** towns?

b. In **Specialized** opt-in towns?

c. Why is that? [PROBE: SF vs MF]

Q17. [BUILDERS WHO USE ERI/HERS PATH AND HERS RATERS] In the next year, what HERS score do you plan to target for your program single-family homes?

a. How about **multifamily**?

Q18. [BUILDERS WHO USE ERI/HERS PATH AND HERS RATERS] What would your target HERS score be for single-family homes going forward if the current program went away? For multifamily?

a. Would this vary depending on whether you were working in **Base** or **Stretch Code**?

Home Type	NP Base HERS	NP Stretch HERS	NP Specialized HERS	Program HERS	Counterfactual HERS
SF	[Q19]	[Q19a]	[b]	[Q20]	[Q21]
MF	[Q19]	[Q19a]	[b]	[Q20]	[Q21]

D.2.6 Electrification Trends and Program Influence

Let's keep thinking about the new homes you've [BUILT/RATED] in Massachusetts in the past year.

Q19. Is electric heating any more common in your program homes than in your non-program homes? [PROBE: how different, why, SF vs MF]

Q20. What about being fully all-electric – is that any more common in program homes than non-program homes? [PROBE: how different, why, SF vs MF]

Q21. [IF USE FOSSIL FUELS] Why have [YOU/YOUR BUILDERS] opted not to go all-electric for these recent new construction projects? [PROBE: program vs non-program, SF vs MF]

Q22. Do you see any of these trends changing in the next year? How so?

Q23. How would [YOU/YOUR BUILDERS] respond if the program became an all-electric program? How would it affect your participation in the program? Or the efficiency of what you build? [PROBE: Impacts in SF vs. MF]

D.2.7 Time Permitting

Q24. To what extent does Passive House play a role in the homes you work on? Why is that?

Q25. What other support from the program could encourage you or help you to build even more efficiently than you already do? [PROBE: training, public awareness, etc.]

Q26. Do you have ideas about ways to make homes even more efficient than required by Stretch and Specialized codes?

a. [IF YES] Are there particular measures that would achieve this? What HERS scores do you think are achievable?

Q27. [STRETCH] Do all of your homes in Stretch Code municipalities get full, registered HERS ratings, or do you [obtain/calculate] ERI values for some without pursuing a full rating? Why?

a. [STRETCH] How common is it to [obtain/calculate] ERI values in Stretch Code communities without pursuing a full rating?

b. [STRETCH] [IF THEY ACKNOWLEDGE THE EXISTENCE OF UNREGISTERED HOMES IN STRETCH] Is there a difference in efficiency between non-program homes with registered HERS ratings, and non-program homes with unregistered ERI ratings? If so, by how much? [Probe: difference in HERS points.]

D.2.8 Closing

Q28. As we finish this conversation, is there anything else you want to share with me about the energy efficiency of new homes in Massachusetts going forward?

Those are all the questions we have. Thank you for your time.