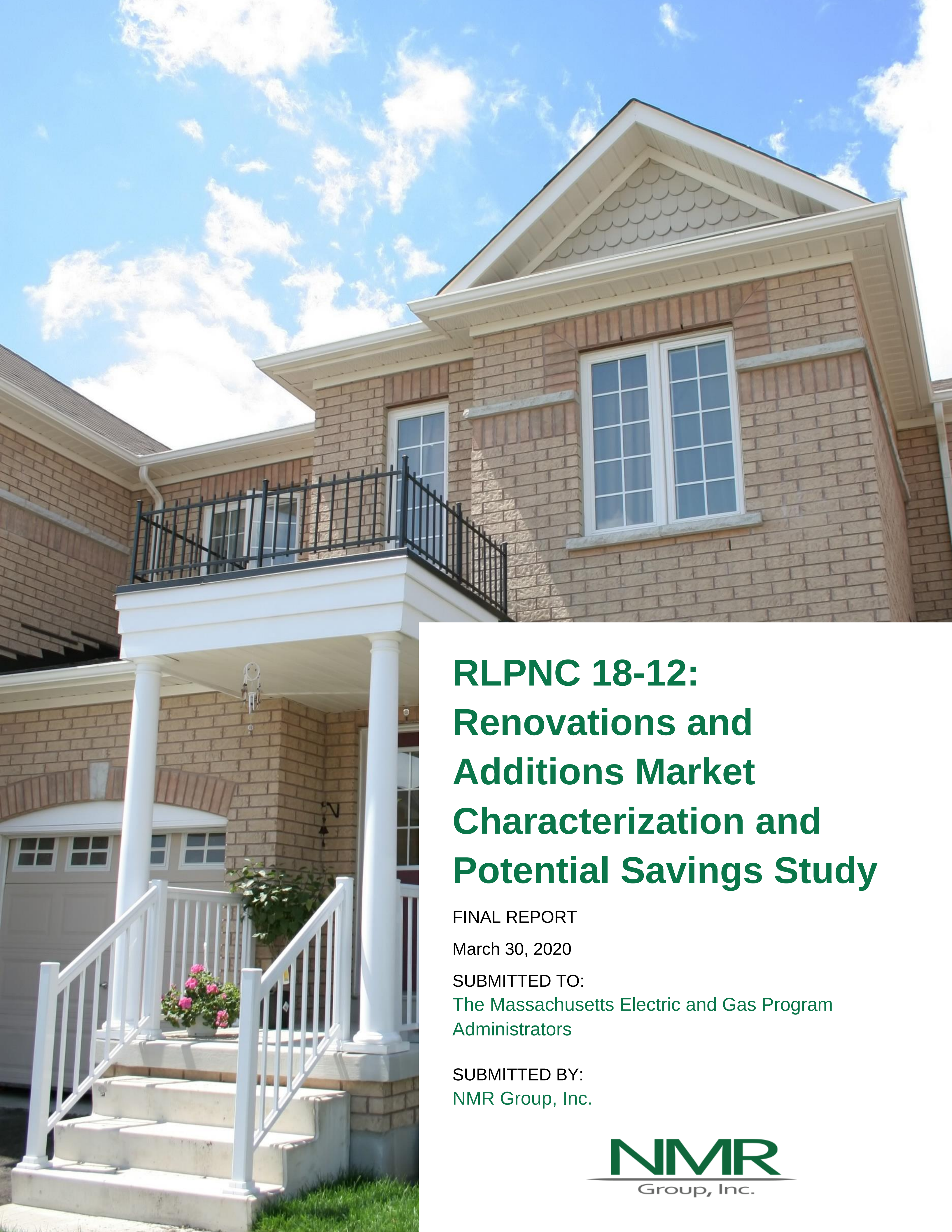

RLPNC 18-12: Renovations and Additions Market Characterization and Potential Savings Study

FINAL REPORT

March 30, 2020

SUBMITTED TO:
The Massachusetts Electric and Gas Program Administrators

SUBMITTED BY:
NMR Group, Inc.

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Massachusetts Renovations and Additions Market Characterization and Potential Savings Study

NMR conducted a detailed assessment of the size, scope, and potential savings of the single-family renovations and additions (R&A) market. The study was conducted to inform the design of the PAs' current R&A offering within the Residential New Homes and Renovations initiative. For the assessment, the team conducted a detailed review of online building permits and conducted four other primary data collection activities with market actors involved in the single-family renovation and additions market.

Main Findings

Size of the Market

The single-family R&A market in Massachusetts includes approximately 130,000 projects (9% of the single-family owner-occupied housing stock) each year, including permitted and non-permitted projects. Of these projects, over 55,000 are program-eligible, compared to 7,200 new homes built in a year in the state.

	Renovation Only (R)	Addition Only (A)	R&A	**Total**
Single-family R&A	89,424	30,364	12,828	**132,616**
Percent	67%	23%	10%	**100%**
Program Eligible	33,087	13,968	8,595	**55,649**
Percent	60%	25%	15%	**100%**

Statewide Potential Annual Gross Savings (MMBtu) Relative to Industry Standard Practice Baseline

(Based on projects adding or renovating at least 500 sq. ft. of floor area)

Fuel Type	Savings	%
Electric	274,173	26%
Natural Gas	411,251	39%
Oil	337,631	32%
Propane	32,900	3%

End Use	Savings	%
Heat	835,128	79%
DHW	71,885	7%
Lighting	146,547	14%
Cooling	2,911	<1%

Project Type	Savings	%
R	647,694	61%
A	121,202	12%
R&A	287,059	27%

Scope of Typical Renovation and Addition Projects

Size of projects
800-900 sq.ft.

Project location
R: bathrooms & kitchens
A: basements

Common measures
Wall insulation (filling cavities), lighting, & windows

Effect on HVAC
More replacements than repairs

HVAC installations
Air source heat pumps

Recommendations and Considerations

- Adopt an 'Industry Standard Practice Baseline' like the one used in this study's potential modeling assessment.
- Consider planning to measure NTG for this offering prior to the next three-year cycle.
- Consider conducting a process evaluation given the nascent nature of the current offering.
- Consider a follow-up assessment that could help understand how the estimated savings potential from this initiative might overlap with those from other PA programs.
- Consider a follow-up assessment with additional combinations of upgrade scenarios that might better reflect real-world projects.
- Consider a partnership between the PAs and Massachusetts municipalities to ensure that permit databases contain fields relevant to the PAs' research needs.

Table of Contents

Acronyms

Acronym	Meaning
AC	Air Conditioning
ACH50	Air Changes per Hour with a 50-pascal pressure gradient
AFUE	Annual Fuel Utilization Efficiency
ASHP	Air-Source Heat Pump
BTU	British Thermal Unit
CAC	Central Air Conditioner
CFA	Conditioned Floor Area
CFM25	Cubic Feet per Minute with a 25-pascal pressure gradient
COP	Coefficient of Performance
DHW	Domestic Hot Water
EEAC	Energy Efficiency Advisory Council
EER	Energy Efficiency Ratio
EF	Energy Factor
Ekotrope™	A cloud based residential energy modeling software
ERV	Energy Recovery Ventilation
GSHP	Ground Source Heat Pump
HERS	Home Energy Rating System
HES	Home Energy Services, the PAs' former residential retrofit program
HPWH	Heat Pump Water Heater
HRV	Heat Recovery Ventilation
HSPF	Heating Season Performance Factor
HVAC	Heating Ventilation and Air Conditioning
ISP	Industry Standard Practice
kWh	Kilowatt Hour
LED	Light-Emitting Diode
MSHP	Mini or Multi-Split Heat Pump (commonly referred to as a ductless mini-split)
MWh	Megawatt Hour
NMR	NMR Group Inc.
PAs	Program Administrators of Massachusetts Energy Efficiency Programs
RCD	Residential Coordinated Delivery, the PAs' current residential retrofit program
REM/rate™	Residential Energy Modeling and Rating software by NORESCO
RNC	Residential New Construction
R-value	A measure of material's resistance to the flow of heat
SEER	Seasonal Energy Efficiency Ratio
U-Factor	Measure of the rate of heat transfer of a window or other glazing
UDRH	User-Defined Reference Home
UEF	Uniform Energy Factor

Executive Summary

NMR Group, Inc. (from here on referred to as *NMR* or *the team*), on behalf of the Massachusetts Program Administrators (PAs) and the Energy Efficiency Advisory Council (EEAC), conducted a detailed assessment of the size and scope of the single-family (one-unit attached[1] and detached) renovations and additions market in Massachusetts. This study investigated the state and size of this market and helped inform the design of the PAs' current additions and renovations offering (Additions and Renovations offer) that operates within the Residential New Homes and Renovations initiative (referred to holistically in this report as *the program*).[2]

For the purposes of this evaluation, renovations and additions are defined as follows:

- **Renovations** include home remodeling or major improvements that do not add to the conditioned square footage of the house but would generally involve changes to multiple home components (e.g., building shell, HVAC, electrical, plumbing). They do not include routine work, such as painting, decorating, fixing broken water pipes, or landscaping. They also do not include projects that were limited to mechanical system replacements.
- **Additions** expand the conditioned square footage of the home. Examples include conditioning previously unconditioned space, such as finishing a basement or bonus room; expanding the home by building a new attached structure; or adding a new story.

[1] Single-family attached is defined as a single family dwelling that shares a common wall, such as a townhouse.
[2] https://www.masssave.com/en/saving/residential-rebates/renovations-and-additions/

The current program is designed to capture energy savings from renovation and addition projects – a portion of the residential market not formerly targeted by the Massachusetts PAs' weatherization and new construction programs. The program requires participant projects to obtain a building permit and to alter or affect at least 500 sq. ft. of building shell or conditioned floor area. The program uses a pay-for-savings model. Projects are inspected by an energy auditor and modeled using a whole-house approach. Within the modeling software, the final post-renovation/addition energy model is used to calculate savings by comparing the as-built home to a home built to baseline standards.

This study had three primary goals, all focused on the single-family attached and detached renovations and additions market:

- **Market size:** develop an estimate of the number of projects occurring in a given year.
- **Project scope:** identify the typical scope associated with these projects.
- **Potential savings:** assess the gross technical potential savings associated with a program serving these projects, limiting the estimate to program-eligible projects.

To address these goals, the team conducted a detailed review of online building permits and conducted four other primary data collection activities with market actors who had recently been involved in the single-family renovation and additions market, as shown in Table 1.

Table 1: Data Collection Overview

Method Details	Online Permit Databases	General Contractors	HVAC Contractors	Contractor Focus Groups	Homeowners
Data collection	Compiling database contents	Web survey	Phone-based in-depth Interviews	In-person focus groups	Web survey
Sample size	56 (databases reviewed)	77	10	24 participants (5 focus groups)	207

Below, we summarize key findings from the study and offer a series of recommendations and considerations for the PAs and EEAC.

Market Size Estimates

The single-family renovations and additions market in Massachusetts comprises approximately 130,000 projects each year, including permitted and non-permitted projects. These represent about 7.5% of all single-family homes in the state, a market nearly 18 times larger than the annual single-family new construction market (about 7,200 homes).

The study included two different approaches to develop overall market size estimates:

Approach 1: Online building permit review + contractor survey. NMR reviewed building department websites for the 351 municipalities in Massachusetts. Fifty-six (16%) had online databases that included permit records with project descriptions.[3] The team used a keyword analysis to identify relevant projects. The team then used regression models to estimate permit counts for the municipalities without online databases, yielding an estimate of the number of permitted projects across the state. The team then used the general contractor web survey results (n=77) to estimate the number of projects completed without permits; contractors reported that they pulled permits for 97% of their addition projects and 88% of their renovation projects.

Approach 2: Census data + contractor survey responses. In the general contractor web survey, contractors reported how many single-family renovation and addition projects they had been a part of in the past 12 months. The team combined these results with Census data on the number of renovation and addition firms and employees to develop an estimate of the market size based on the average number of projects completed by an individual and the average number completed by a firm, yielding a low and high estimate of project activity.

Comparison of approaches. Table 2 compares the two approaches. The team believes Approach 1 yields the best estimate of the market size. Approach 1 factors in a review of thousands of permits, incorporates primary data collection, and falls within the wide range (62,575 to 174,816 projects) yielded from Approach 2. As a result, we believe that the statewide market includes approximately 130,000 projects each year, about 70% of which are renovation-only projects.

[3] Four more municipalities had online databases, but they did not provide any aggregated or summary information of online records, meaning the reviewer had to open each permit record individually to ascertain what the permit covered. These databases were not included in our analyses.

Table 2: Comparison of Market Size Estimates

Estimate Type		Renovation Only	Addition Only	Renovation and Addition	Total
Approach 1	Permit Analysis + Contractor Survey for Non-Permitted Activity	89,424	30,364	12,828	132,616
Approach 2	Contractor Survey + Census data	46,463-125,104	16,112-49,712	--	62,575-174,816

Project Scope Results

The study investigated the scope of renovation and addition projects in Massachusetts, based on projects completed in the past year. This research included questions about all renovation and addition projects, regardless of the size of the project (the gross technical potential task focused on projects that were clearly large enough to be eligible for the current program and were large enough to be a focus of the program).[4] Topics that we investigated with market actors focused on the following key areas:

- The size (square footage) of projects
- The location in the home where these projects take place
- The measures that are commonly affected by these projects
- The extent to which HVAC equipment is affected by these projects
- The types of HVAC equipment that are commonly installed

Project Size and Location

General contractors indicated that renovations and additions were comparably sized, both averaging between 800 and 900 sq. ft. (Table 3). Smaller projects, though common, may not always qualify for the program.

Table 3: Average Square Footage of Renovations and Additions Projects from the Past 12 Months – General Contractor Survey

Average Square Footage	Min	Max	Mean
Renovations (n=58*)	50	2,400	887
Additions (n=29)	100	2,500	808

*Removed two renovation-specific responses that were over 2,400 sq. ft.

Homeowners described a wide size range for recent projects, though, in general, contractors may be better able to estimate square footage than their customers (Table 4).

[4] Small renovations (affecting less than 500 sq. ft. of conditioned floor area) could still be eligible for the program as long as they affected at least 500 sq. ft. of shell area. Since these have minor savings associated with them, they are not a significant focus of the program and they are not included in the potential estimates.

Table 4: Typical Project Sizes – Homeowner Survey

Size of Project (Sq. Ft.)	Renovation Only (n=148)	Addition Only (n=26)	Renovation and Addition (n=33)	Total (n=207)
Less than 100*	18%	0%	0%	13%
100 to 300*	20%	15%	6%	17%
301 to 500*	16%	35%	21%	19%
501 to 1,000	14%	38%	24%	18%
1,001 to 1,500	13%	0%	12%	11%
More than 1,500	10%	8%	30%	13%
Don't know	9%	4%	6%	8%

*May not be program-eligible, affecting less than 500 sq. ft. of envelope (renovations) or 500 sq. ft. of floor area (additions).

Bathrooms and kitchens dominated recent renovation projects and finished basements were common additions. Both the homeowner survey and the online permit analysis suggest that renovations most commonly included a bathroom or kitchen upgrade, while additions commonly included adding square footage to the home by finishing a basement, adding a story, or expanding the footprint of the existing home.

Key Measures Affected

General contractors and homeowners reported that wall insulation, lighting, and windows were the energy-related measures most commonly included in the scope of their projects (Table 5). Water heaters were generally the least affected measure, meaning they were rarely part of the scope of renovation and addition projects.

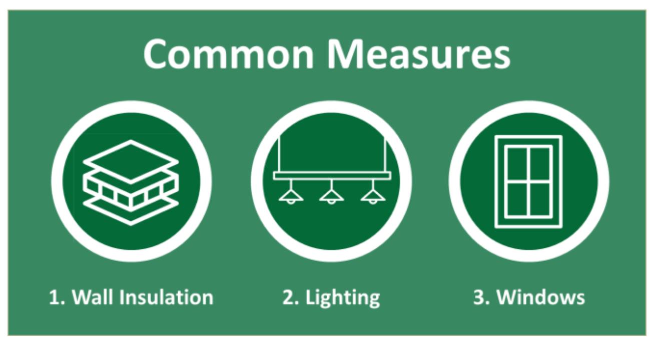


Table 5: Average Percent of Projects with Specific Measures Affected

Measures	General Contractor Survey		Homeowner Survey	
	Renovations (n=67)	Additions (n=32)	Renovations (n=181)	Additions (n=59)
Wall insulation	70%	90%	60%	81%
Lighting	59%	86%	63%	66%
Windows	56%	88%	56%	59%
Air sealing	35%	69%	25%	29%
Air conditioning	32%	50%	31%	42%
Heating	28%	65%	45%	51%
Ventilation (incl. HRV, ERV, and bath fans with automatic controls)	26%	37%	31%	37%
Duct work	24%	49%	28%	34%
Appliances	23%	45%	44%	32%
Water heating system	19%	39%	24%	17%

Wall insulation was rarely left as-is in renovation projects. Focus group participants suggested that wall insulation was frequently included in the scope of renovation projects. Opening walls allows for the installation or repair of electrical wires or plumbing lines, but opening the walls also triggers code's insulation requirements, thereby forcing insulation to be part of the project.

Some participants preferred to open the walls in renovation projects, gutting the space to better address hidden issues. Also, focus group contractors said that wall insulation (except for spray-foam) is inexpensive relative to other renovation components; therefore, it is an easy decision to replace pre-existing insulation. Leaving existing wall insulation untouched might occur in projects with extremely limited scopes, or in non-permitted projects without a code official's inspection.

Mechanical Systems

HVAC system replacements were more common than repairs or alterations. Based on contractor and homeowner survey responses, approximately 49,000 (37%) of the roughly 130,000 annual renovation and addition projects identified in the state involved some kind of mechanical equipment upgrade or change. More than one-half of general contractors (52%) and over three-quarters of homeowners (78%) said that when a renovation affected the heating system, it was being replaced with a new system, rather than being repaired or modified. These numbers rise to 75% for general contractors and 87% for homeowners when considering addition projects. Similarly, HVAC contractors indicated that, on average, about two-thirds of addition and/or renovation projects included new equipment, rather than system modifications.

Heat pumps installations were common in renovation and addition projects. As shown in Table 6, over 40% of homeowners with renovation projects and new HVAC equipment indicated they installed an ASHP, while that number rises to over 50% for homeowners involved in an addition project that included new equipment. The remainder installed other new systems, such as GSHPs, or more traditional equipment (such as boilers, furnaces, and central air conditioners).

Table 6: New HVAC Equipment – Homeowner Survey
(Multiple Response)

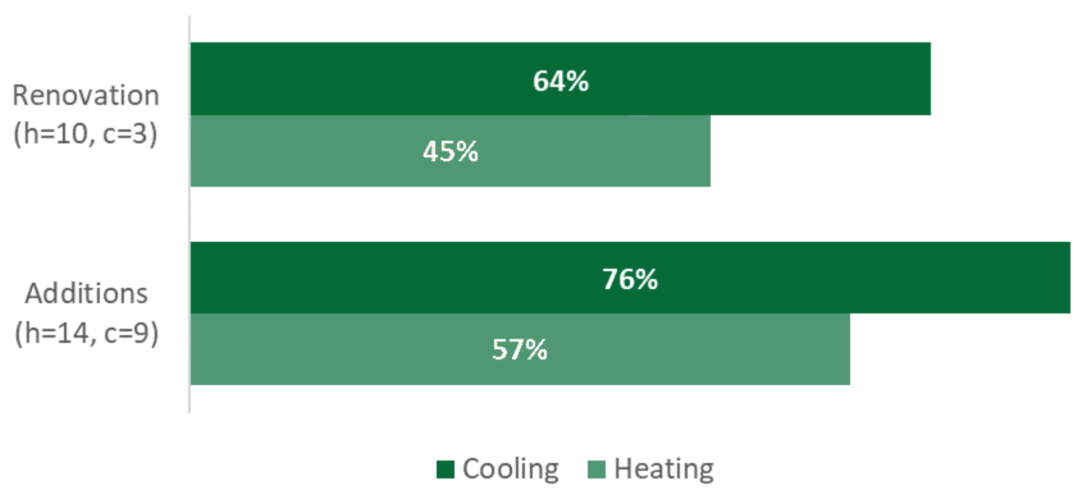
New Heating or Cooling Type	Renovations (n=76)	Additions (n=31)
Ductless mini-split heat pump	22%	29%
Conventional air source heat pump	20%	26%
Ground source heat pump	0%	6%
Boiler	21%	9%
Furnace	9%	0%
Central air conditioning	5%	0%
Water heating*	3%	0%
Other	32%	13%
None of these equipment types	12%	23%
Don't know	14%	0%

*System may have provided heating or just domestic hot water.

HVAC contractors indicated that heat pumps were the most commonly installed heating and cooling equipment in renovation and addition projects. New heating systems were most often replacing gas furnaces and boilers, while cooling systems were most often being added to homes for the first time (please refer to Table 112 and Table 113 for additional details).

Similar to the HVAC contractors, general contractors who said they installed a new heating or cooling systems in their addition or renovation projects reported that close to or a majority of those new systems were heat pumps (Figure 1).

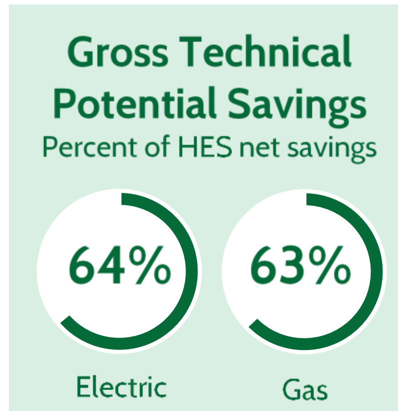
Figure 1: Average Percent of New Heating or Cooling Installations that Included a Heat Pump – General Contractor Survey



Ductless mini-splits were the most common type of heat pump installed, as reported by HVAC contractors (please refer to Table 114 for additional details). Contractors participating in the focus groups reporting growing homeowner interest in ductless mini-splits. Most of the contractors indicated that they saw them as relatively cheap and easy to install as opposed to tying into duct work or installing new ducts. Please refer to Appendix E for more details.

Gross Technical Potential Savings

Current program baselines may overstate savings, but there is tremendous opportunity in this market, even with a more efficient baseline. The gross savings potential for renovations and additions in single-family homes alone is several times higher than claimed savings (net) for the RNC program's traditional single- *and* multifamily projects.



Even if per project savings are limited, the scale of the renovation and addition market provides a substantial savings opportunity. For example, using the ISP baseline, electric gross technical potential savings represent 445% of the savings claimed by the RNC initiative in 2018 (evaluated net savings), while gas savings represent 270% of the 2018 RNC initiative's claimed savings.[5] These gross technical potential savings also represent 64% of the net electric savings and 63% of the net gas savings claimed through the residential Home Energy Services (HES) program.[6]

Savings potential approach. While the team estimates 130,000 renovation and addition projects are performed each year in Massachusetts, the potential analysis is limited to the estimated 55,500 homes that renovated or added at least 500 sq. ft. of floor area – projects that would be clearly eligible for the program.[7]

We developed 72 prototype energy models to represent differences in project type, scope, heating fuel, and location. We then built an additional 288 models to represent various baseline and upgrade scenarios, for a total of 360 models. We modeled three different baseline scenarios (pre-renovation or addition) to compare to the upgrade scenario (post-renovation or addition, assuming the project participated in the program and increased its efficiency).

- **Current baseline:** the program's current baseline (i.e., pre-existing conditions for a renovation and the UDRH standards for an addition).
- **Adjusted baseline:** a slightly more efficient baseline for renovation projects that assumes some improvements in a renovation would have occurred even without the program; UDRH standards for an addition.

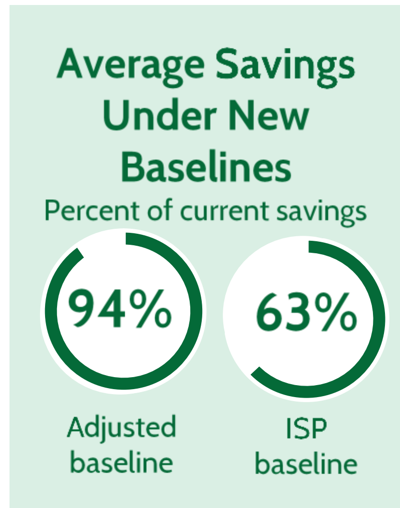
[5] The claimed savings from 2018 were pulled from masssavedata.com. https://www.masssavedata.com/Public/PerformanceDetails
[6] HES has since evolved into the Residential Coordinated Delivery Initiative.
[7] The program accepts renovations that affect at least 500 sq. ft. of envelope, which may be achieved with a renovation smaller than 500 sq. ft. of CFA. Accordingly, these potential values may be conservative as modeling excluded smaller projects, though larger projects generally offer more savings potential.

- **Industry standard practice (ISP) baseline:** a more efficient baseline than currently used for renovation projects that approximates standard or typical renovation practices based on our assessment and the results of this study; UDRH standards for an addition.[8]

The team scaled up the prototype model savings results using a weighting scheme based on the penetration of project types (renovation, addition, or renovation and addition), project scope (small or large), heating fuel, and climate zone (three across the state).

Readers should note that the following savings results are purely estimates. Even if the program reached every eligible project, gross savings would differ than the values shown here because contractors and homeowners will make choices to best meet their unique needs.

Average project savings. Table 7 shows mean potential savings per project, with results weighted by statewide mixes of heating fuel type, location, project type, and project scope. Savings are presented in MMBtu and are a sum of savings across all modeled measures potentially affected by the program, including shell measures, mechanical equipment, and lighting. It also shows how switching to one of the two alternative baselines considered in this study would impact savings. On average, switching to the adjusted baseline (detailed in Appendix A), in which mechanical system efficiencies would have been somewhat improved over the pre-existing conditions, would result in the homes achieving about 94% of current savings, on average. Shifting to the ISP baseline would yield nearly two-thirds (63%) of current gross savings levels on average, a reduction driven by the assumption that contractors would normally fill affected cavities with insulation.



Oil savings may be overstated because in models where the HVAC system was being upgraded, the team assumed the upgrade would entail switching at least some of the load to a ductless mini-split ASHP system, rather than a more efficient oil system. Models with fuel-switching resulted in negative electric savings due to new electric heating and cooling consumption.

Table 7: Average Savings Per Model by Fuel (MMBTU)

Fuel	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Electric	6.3	6.3	99%	4.9	78%
Natural Gas	12.8	12.2	96%	7.4	58%
Oil	9.8	8.8	89%	6.1	62%
Propane	1.0	1.0	96%	0.6	58%
Project Total*	**30.0**	**28.2**	**94%**	**19.0**	**63%**

*Totals are averaged across all modeled projects; no one project would use all fuel types.

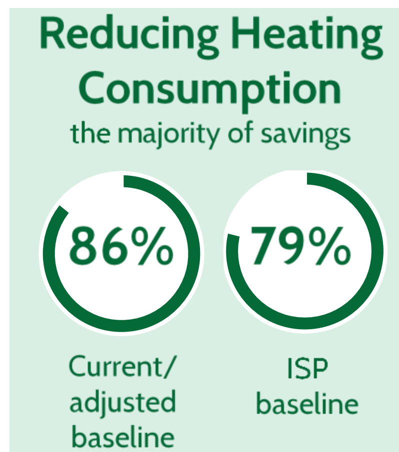
[8] See Appendix A.6 for more detail on the measures included in the baseline and upgrade scenarios. The ISP includes modest shell improvements in the affected area.

Statewide potential savings by fuel. Natural gas represents the highest estimated potential savings across the state since the energy savings were substantially driven by heating and gas is the most prevalent fuel (Table 8). There are also significant savings associated with reducing oil use. This is partially driven by the assumption that oil-heated homes undergoing HVAC upgrades would install high-efficiency heat pumps, increasing oil savings but also increasing electricity use. Shifting to the adjusted baseline scenario would have a small effect on potential savings, while shifting to the ISP baseline would result in a sizable reduction in claimed savings.

Table 8: Statewide Potential Savings by Fuel (MMBTU)

Fuel	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Electric	352,440	349,186	99%	274,173	78%
Electric (MWh)	*103,290*	*102,336*	*99%*	*80,352*	*78%*
Natural Gas	712,713	681,163	96%	411,251	58%
Oil	546,535	487,978	89%	337,631	62%
Propane	57,016	54,493	96%	32,900	58%
Total	**1,668,704**	**1,572,820**	**94%**	**1,055,955**	**63%**

Statewide potential savings by end use (Table 9.) Reducing heating consumption represents the vast majority of potential savings (86% of savings in the current and adjusted baseline scenarios and 79% against the ISP baseline). Potential savings from DHW are limited but remain consistent across baseline scenarios. Cooling savings are negligible due to the low use of cooling and low cooling loads, as well as the fact that some models were designed without cooling and some added cooling demand from heat pumps. Lighting savings are based on the program replacing all lights in a home, not just the renovated portion, and are consistent across baseline scenarios.[9]



[9] Under this program design, the potential savings from lighting in the remainder of the home (the part not being renovated or added) would, in theory, be savings that could be considered potential lighting savings for the PAs' weatherization programs.

Table 9: Statewide Potential Savings by End Use (MMBTU)

End Use	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Heat					
Electric	162,984	162,984	100%	89,430	55%
Electric (MWh)	*47,766*	*47,766*	*100%*	*26,210*	*55%*
Natural Gas	668,879	647,707	97%	377,840	56%
Oil	546,535	487,978	89%	337,631	62%
Propane	53,510	51,817	97%	30,227	56%
Heat Total	**1,431,908**	**1,350,485**	**94%**	**835,128**	**58%**
Domestic Hot Water					
Electric	35,807	35,807	100%	35,801	100%
Electric (MWh)	*10,494*	*10,494*	*100%*	*10,494*	*100%*
Natural Gas	43,834	33,456	76%	33,411	76%
Propane	3,505	2,676	76%	2,673	76%
DHW Total	**83,147**	**71,939**	**86%**	**71,885**	**86%**
Other Electric					
Cooling	7,618	4,364	57%	2,911	38%
Cooling (MWh)	*2,233*	*1,279*	*57%*	*853*	*38%*
Lighting	146,547	146,547	100%	146,547	100%
Lighting (MWh)	*42,950*	*42,950*	*100%*	*42,950*	*100%*
Total	**1,669,219**	**1,573,335**	**94%**	**1,056,470**	**63%**

Measure Level Contribution to Savings. Table 10 shows the relative contribution of the various measures that are altered during a renovation or addition on heating savings. We focus on heating given that heating represents the vast majority of potential savings. Based on energy model results, insulation improvements are the largest contributors to heating savings in the current and adjusted baseline scenarios. However, wall and ceiling insulation measures show a decrease in their contribution to savings in the ISP baseline due to the assumption that these measures would be upgraded in a standard renovation outside of the program. Air sealing also plays a large role in savings, particularly in the ISP baseline with the decreased contribution of wall and ceiling insulation savings. There was also a large share of savings that was not tied to a particular measure in the energy models, but a portion of the remainder can be attributed to mechanical system upgrades.

Table 10: Measure Level Contribution to Potential Heating Savings

Measure	Current Baseline	Adjusted Baseline	ISP Baseline
Floor Insulation	21%	22%	31%
Ceiling Insulation	21%	22%	10%
Wall Insulation	18%	19%	11%
Air Sealing	16%	17%	23%
Windows	6%	7%	9%
Other*	18%	14%	17%

*Remainder of heating savings were not specified in models but include mechanical system efficiencies and interactive effects.

Statewide potential savings by project type (Table 11). Among the project types included in the technical potential assessment, renovation-only projects represent the largest statewide savings as they are the most prevalent project type. Savings for renovation projects would also be the most negatively affected by adopting the ISP baseline as it assumes contractors would substantially improve insulation even without the program. Potential savings are limited for addition-only projects because they were compared to the RNC UDRH, a relatively efficient baseline. Renovation and addition projects have lower potential savings as they are the least prevalent project type.

Table 11: Statewide Potential Savings by Project Type (MMBTU)

Fuel	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Renovation Only					
Electric	225,684	225,684	100%	165,332	73%
Electric (MWh)	*66,144*	*66,144*	*100%*	*48,515*	*73%*
Natural Gas	530,201	517,062	98%	292,683	55%
Oil	333,159	297,464	89%	166,064	50%
Propane	42,415	41,365	98%	32,415	55%
Renovation Total	**1,131,460**	**1,081,576**	**96%**	**647,694**	**57%**
Addition Only					
Electric	59,099	59,082	100%	59,082	100%
Electric (MWh)	*17,321*	*17,316*	*100%*	*17,316*	*100%*
Natural Gas	46,078	42,287	92%	42,287	92%
Oil	18,424	16,450	89%	16,450	89%
Propane	3,686	3,383	92%	3,383	92%
Addition Total	**127,287**	**121,202**	**95%**	**121,202**	**95%**
Renovation and Addition					
Electric	67,656	64,419	95%	49,558	73%
Electric (MWh)	*19,829*	*18,880*	*95%*	*14,525*	*73%*
Natural Gas	136,434	121,813	89%	76,281	56%
Oil	194,952	174,065	89%	155,118	80%
Propane	10,915	9,745	89%	6,102	56%
R&A Total	**409,957**	**370,042**	**90%**	**287,059**	**70%**
State Total	**1,668,704**	**1,572,820**	**94%**	**1,055,955**	**63%**

Per-home savings compared to other PA programs. Table 12 compares average claimed savings from RNC and legacy HES participants to the potential savings from renovation and addition projects (after weighting to represent projects across the state). Though this is an imperfect comparison (the RNC and HES savings are net savings for actual projects, while the savings estimates from potential renovation and addition projects are gross savings), it demonstrates how the home-level savings from a potential renovation and addition project compares favorably to the savings from RNC and legacy HES projects. Per-home gross savings for renovation and addition projects are lower but still substantial. The number of program-eligible single-family renovation and addition projects is over four times higher than the number of RNC participants in 2018 (including multifamily projects), and is comparable to the number of legacy HES participants that year.

Table 12: Average Savings for Program Homes (MMBTU)

Fuel	RNC (SF+Low-Rise MF; Net Savings)	HES (SF+Low-Rise MF; Net Savings)	R&A (SF Only; Gross Savings)
n	*11,883**	*52,888**	*55,500***
Electric	5.2	8.1	4.9
Natural Gas	12.8	12.4	7.4
Oil	0.1	8.9	6.1
Propane	4.4	1.1	0.6
Total	**22.4**	**30.5**	**19.0**

* Evaluated net savings based on actual 2018 program participants, using MassSaveData.com.
**Estimated gross technical potential savings across all potential annual participants.

Conclusions, Recommendations, and Considerations

Below, we present key conclusions, recommendations, and considerations for the PAs and EEAC consultants.

Conclusions

Market size. The size of the single-family renovations and additions market includes approximately 130,000 projects per year – permitted and unpermitted – including small projects that may not be eligible for the program. Based on homeowner responses, we estimate this figure drops to about 55,500 projects that affect at least 500 sq. ft. of floor area, a project size that would be clearly eligible for program participation. Depending on the amount of envelope area affected, additional renovation projects beyond that 55,500 may be eligible for the program. We estimate that this is a reliable predictor of future activity in this market as we did not find any conclusive trends when comparing real estate economics and renovation and addition activity over time for a small sample of municipalities.

Project size. Renovation and addition square footages vary widely, but market-wide, the average size of renovations and additions both appear to be around 800 sq. ft., falling squarely into the program-eligible category. That said, homeowners stated that about 63% of their most recent renovations and 54% of their additions are smaller than 500 sq. ft., potentially excluding them from participation, based on the program's current design.

Common measures affected. Walls, lighting, and windows were described as the most commonly affected measures in renovation and addition projects by both general contractors and homeowners. Contractors clearly indicated that when renovation projects are permitted (97% of major projects), insulating exposed cavities is a typical practice.

HVAC system repair/replacement. When heating systems were part of project scopes, they were often replaced, rather than repaired, resulting in substantial opportunity to increase the efficiency of these systems. All market actors (homeowners, general contractors, and HVAC contractors) suggested that some form of heat pump was the most commonly installed equipment in these circumstances, a clear market trend worth monitoring.

Potential technical savings. The technical potential savings with the single-family renovations and additions market are substantial. Even when limiting the market to program-eligible projects, these savings, using the ISP baseline, represent 445% of the electric savings and 270% of the gas evaluated net savings claimed by the 2018 RNC initiative, and 64% and 63% of electric and gas savings, respectively, claimed by the legacy HES program.[10] This market has the potential to provide considerable energy savings to the Residential New Homes and Renovations Initiative, though the cost-effectiveness of achieving those savings was not assessed as part of this study.

[10] The claimed savings from the RNC initiative include low-rise multifamily buildings that were not considered as part of this study. As such, the potential savings presented in this report are an underestimate for the overall low-rise renovation and additions market.

Recommendations and Considerations

1 **Recommendation.** Starting in 2020, adopt a baseline similar to the ISP baseline that was used in this study's potential modeling assessment.

Rationale. NMR previously issued a memo (Appendix G), that suggested the PAs adopt the *Adjusted Baseline*. That said, that memo was finalized prior to the conclusion of the various survey efforts included in this study. With more data in hand, we believe that the ISP Baseline – or a relatively similar one – would result in more accurate gross savings estimates for the program.

2 **Consideration.** Consider measuring NTG for this offering prior to the next three-year cycle.

Rationale. This program currently adopts the RNC NTG value, which may not be appropriate for this market given that it operates differently from the traditional new construction market and there is limited overall evaluation research on this market. A successful NTG evaluation will be dependent on the number of projects that have participated in the current program offering.

3 **Consideration.** Consider conducting a process evaluation or similar research to learn about early program experiences given the limited history of the current offering.

Rationale. Understanding the current program processes, as well as the opportunities and barriers to participation and implementation, could yield valuable information for program planning.

4 **Consideration.** Consider a follow-up assessment that could help understand how the estimated savings potential from this initiative might overlap with the savings potential associated with other PA programs that incentivize improvements to lighting, building shell, or mechanical systems.

Rationale. The savings associated with this program may cannibalize savings from other PA initiatives, such as the RCD program or equipment-level incentives for HVAC equipment. For example, lighting savings achieved from the Renovations and Additions offering would no longer be available to the weatherization program's direct install efforts. Similarly, if a home has participated in the RCD program, there would be reduced savings achievable as part of a future renovation project. The PAs should be aware that the estimated potential from this program offering and any estimated potential savings from related programs that incentivize lighting, building shell, or mechanical system upgrades would not be fully additive.

5 **Consideration.** Consider a follow-up assessment with additional combinations of upgrade scenarios that might better reflect real-world projects, potentially focusing on scenarios that most cost-effectively achieve savings for the program and/or the customer.

Rationale. Real-world measure combinations are limitless. Even with nearly 400 energy models, this study cannot adequately describe every possible project. An additional modeling effort may help the PAs better understand the savings associated with a wider range of project types, to better focus on the most cost-effective measures and measure combinations.

6 **Consideration.** Consider a partnership between the PAs and Massachusetts municipalities to ensure that permit databases contain fields relevant to the PAs' research needs.

Rationale. The permit database analysis was complex and iterative in nature. If the PAs could work with municipalities to suggest that they include project type identifiers (e.g., renovation or new construction) in their databases, the PAs would help develop data sources that would make this sort of research simpler and more reliable as a means of characterizing the market.

Section 1 Introduction

NMR Group, Inc. (from here on referred to as NMR or the team), on behalf of the Massachusetts Program Administrators (PAs) and the Energy Efficiency Advisory Council (EEAC), conducted a detailed assessment of the size and scope of the single-family renovations and additions market in Massachusetts. The purpose of this study was to understand the state and size of this market and to inform the design of the PAs' current renovations and additions offering.[11]

For the purposes of this evaluation, renovations and additions are defined as follows:

- **Renovations** include home remodeling or major improvements that do not add to the conditioned square footage of the house but would generally involve changes to multiple home components (e.g., building shell, HVAC, electrical, plumbing). They do not include routine work, such as painting, decorating, fixing broken water pipes, or landscaping. They also do not include projects that were limited to mechanical system replacements.
- **Additions** expand the conditioned square footage of the home. Examples include finishing and conditioning previously unconditioned space, such as finishing a basement or bonus room; expanding the home by building a new attached structure; or adding a new story to the home.

[11] https://www.masssave.com/en/saving/residential-rebates/renovations-and-additions/

1.1 Current Program Design

ICF, the program implementation contractor, provided the team with documents describing the current program, which is designed to capture energy savings from renovation and addition projects – a portion of the residential market not formerly targeted by the Massachusetts PAs' weatherization and new construction programs. The additions and renovations offering operates within the Residential New Homes and Renovations initiative. Target customers include homeowners in one-to-four family residential homes and low-rise multifamily projects (three stories or less).

The program requires participant projects to obtain a building permit and to alter or affect at least 500 sq. ft. of building shell or conditioned floor area. Projects must enroll prior to enclosing wall cavities, as the path requires a field inspection to ensure insulation installation quality.

The program uses a pay-for-savings model. Projects are examined using a whole-house approach. The program requires the involvement of either a Third-Party Verifier (currently this must be a HERS rater) or an ICF Account Manager. These parties are responsible for modeling the impacts of participating projects using the Ekotrope Field Tool, a version of the Ekotrope energy modeling software customized to the needs of the R&A path.[1] Within the modeling software, the final, post-renovation/addition energy model is used to calculate savings by comparing the as-built home to a home built to baseline standards (see details on baseline values in Table 188 in Appendix G).

The program promotes measures that are consistent with current Mass Save Program offerings. These include, but are not limited to, the following measures:

- Insulation, windows, and air sealing
- Heating, ventilation, and air conditioning (HVAC) equipment
- Domestic hot water equipment
- Duct sealing
- Lighting and appliances
- Instant saving measures (ISMs)[2]

The incentive structure is displayed in Table 13.

Table 13: Incentive Structure

Single-Family Incentive Calculation	
A	Electric Savings (kWh) * $0.35/kWh
B	Fuel Savings (MMBtu) * $35/MMBtu
C	Percent Savings Relative to Baseline * $3,000
A+B+C	**Incentive to Participant**
$350	Incentive to Third-Party Verifier (HERS rater)

1.2 Study Goals

This study was conducted to inform the design of the PAs' Residential New Homes and Renovations initiative. The goals of the study were as follows:

1. Estimate the number of single-family renovation and addition projects occurring in a given year.
2. Describe the typical scope associated with these projects.
3. Develop a methodology for calculating gross savings from these projects and estimate the savings potential associated with this market and identify any opportunities for fuel optimization.
4. Begin to identify market effects indicators for this research area so they can be monitored over time.

This report does not include an evaluation of the new program's processes given its limited history at the time this research was planned.

1.3 Research Questions

The key research questions were as follows:

- What is the theory and logic behind the program? How will the program design bring about expected outcomes? What indicators could the PAs use to assess program success and progress towards desired outcomes?
- What is / are the appropriate baseline(s) for the program? How do the baselines vary by type and depth of renovation? How should the PAs calculate gross savings?
- What is the size and nature of the renovations and additions market in Massachusetts and each PA service area? What percentage of projects are permitted? What approaches can the PAs use to keep track of the renovations and additions market? Which parts of the market should they track?
- What are the energy-related elements of renovations and additions, and how do they vary by the type and depth of renovation / addition? What opportunities do renovations and additions offer for program intervention?
- What is the savings potential of the new program? How does savings potential vary between renovations and additions? How does savings potential vary across PAs?
- Who are the key market actors and decision makers that affect a project's efficiency? What factors affect their decision-making process in terms of energy efficiency, including cost? What proportion of builders and homeowners conducting renovation projects currently include energy efficiency as a primary consideration, a moderate or secondary consideration, or do not consider energy efficiency at all?

1.4 Summary of Research Activities

NMR conducted this study in three phases. The research phases, key research tasks, and interim project deliverables are summarized in Table 14.

Table 14: Summary of Research Activities

Phase	Research Tasks	Deliverables
1	➢ Develop Program Theory and Logic Model (PTLM) ➢ Define Gross Savings Methodology ➢ Estimate Market Size: Contractor Survey and Permit Analysis	➢ Final PTLM (1/22/19) ➢ Final Gross Savings Memo (5/3/19) ➢ Draft Building Permit Memo (2/13/19)
2	➢ Characterize Project Scope: Contractor Survey, Homeowner Survey, and Contractor Focus Groups	➢ Survey Summary Memo (10/21/19)
3	➢ Potential Savings Analysis ➢ Overall Reporting	➢ Potential Savings Methods Memo (9/6/19) ➢ Overall Draft Report

The PTLM can be found in Appendix F, while the final gross savings memo can be found in Appendix G. The building permit memo and survey summary memo results have been revised and incorporated into the body of this report, while the potential savings methods memo was only used to procure agreement on the proposed approach for the potential savings analysis, which is presented in Section 3.3.

Section 2 Methodology Overview

This section summarizes the methodologies used for this study. Additional methodological details can be found in Appendix A.

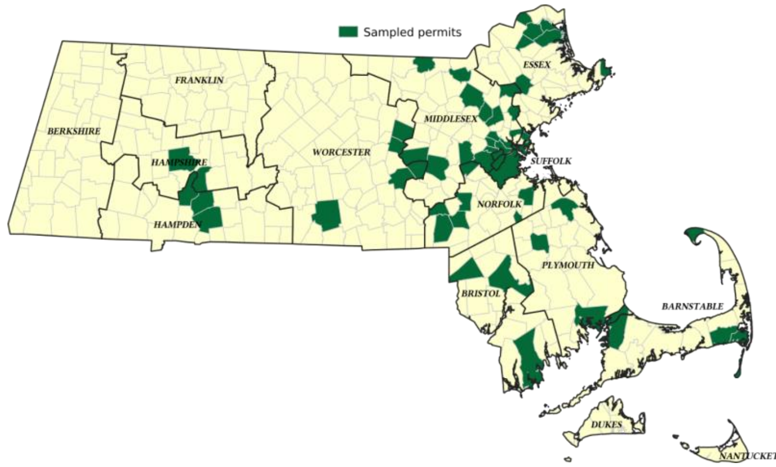
2.1 Online Building Permit Review

This study used an analysis of publicly-available online permit databases published by Massachusetts cities and towns to develop an initial estimate of the size of the single-family renovations and additions market (i.e., the number of such projects that occur in a given year).

2.1.1 Sample

NMR reviewed the building department websites of all 351 municipalities in Massachusetts. Fifty-six cities and towns, shown in Figure 2, had online databases that included permit records (16%), usually with at least some description of the type of work being permitted. NMR pulled all available permit records from these databases for 2017.[12]

Figure 2: Municipalities with Online Databases



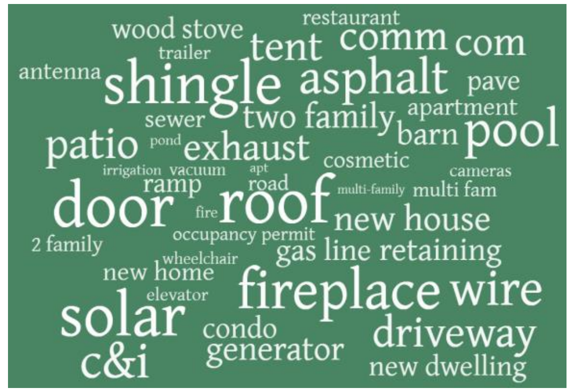
[12] The original plan for this study was to gather permit data via visits to 34 Massachusetts building departments. The online permit research replaced the building department visits as it allowed the team to collect data about far more homes from a larger sample of municipalities. The team confirmed that the permit databases were not systematically biased toward stretch code municipalities and that there were not key, systematic signs of demographic bias among the cities and towns that had these databases.

2.1.2 Identifying Relevant Permit Records

The team reviewed and filtered the available permit records to renovation and addition projects for single-family homes, using an iterative keyword analysis to exclude irrelevant projects. Figure 3 shows common keywords found in renovation and addition permit records, while Figure 4 shows keywords commonly found in records for projects not relevant to this study.

Figure 3: Keywords Found in R&A Permits

Figure 4: Keywords Found in Non-R&A Permits



Using the available permit records, the team ultimately identified projects as renovation only, addition only, or renovation *and* addition.

All but four of the 56 online databases included records for all of 2017. NMR imputed construction activity for any months lacking data by assuming that permit activity for that month would have followed the trends seen in the other municipalities' permit levels.

2.1.3 Statewide Permit Activity

The team conducted linear regression analysis on the 56 municipalities with permit data to determine the best demographic variables from the U.S. Census to use in estimating the permit counts for the municipalities without permit databases. The final regression model explained about 75% of the variation of the dependent variable (permit counts). Based on the regression, the team used the following equations to estimate a municipality's permit activity based on its single-family home count, population density, and median income.[13]

[13] The team also investigated the significance of independent, town-level variables, including median length of occupancy, median per-home room count, median home age, and median property value. While these data points might be useful predictors of how likely an individual home is to be renovated/added on to, they were not meaningful predictors of permit activity for a municipality as a whole.

$$\textbf{Renovation Permit Estimate} = \frac{(SFHomes \times 0.033510) + (MedIncome \times 0.004594) + (PopDensity \times 0.131258)}{3}$$

$$\textbf{Addition Permit Estimate} = \frac{(SFHomes \times 0.013345) + (MedIncome \times 0.001490) + (PopDensity \times 0.065888)}{3}$$

$$\textbf{Renovation and Addition Estimate} = \frac{(SFHomes \times 0.004896) + (MedIncome \times 0.000707) + (PopDensity \times 0.023645)}{3}$$

2.1.4 Estimates of Permitted and Non-Permitted Projects

The team used two approaches to triangulate an estimate of the total renovation and addition market size, including permitted and non-permitted projects. For the first approach, the team added the non-permitted project estimates from the contractor web survey (discussed in the next section) to the estimates of permitted projects from the permit database analysis. For the second approach, the team developed a market size estimate by applying the average number of projects completed by respondents to the general contractor web survey (discussed in the next section) with U.S. Census data for the number of remodeling companies and employees active in Massachusetts.

2.2 Interviews, Surveys, and Focus Groups with Market Actors

Table 15 describes the four market actor outreach efforts that NMR conducted for this study.

Table 15: Data Collection Overview by Group

Method Details	General Contractors	HVAC Contractors	Contractor Focus Groups	Homeowners
Data collection type	Web survey	Phone-based in-depth interviews	In-person focus groups	Web survey
Dates of data collection	February 4 - June 19, 2019	May 6 - July 3, 2019	May 14 - June 27, 2019	May 10 - July 15, 2019
Target number of completes	100	10	30 to 40 (5 focus groups)	200
Completes achieved	77	10	24 participants (5 focus groups)	207
Recruitment methods	Postal letters & emails (when available)	Phone & emails (when available)	Phone & emails (when available)	Postal letters
Compensation offered	$50	$100	$250	$25
Source of sample	Internet search	Contractor web survey & internet search	Contractor web survey & internet search	Publicly available permit records
Average time to complete	25 minutes	25 minutes	2 hours	13 minutes

2.2.1 General Contractor Survey

NMR conducted a web survey of 77 general contractors from a sample of 4,891 unique contacts developed from a web-scraping effort of the online Yellow Pages.[14] The team offered respondents a $50 Amazon gift card for completing the survey. NMR distributed the web link to complete the survey by postal mailers or email (when available).

The survey screened out respondents who had not served as the main contractor on a renovation or addition project in Massachusetts in the past year. Contractors were asked to speak to their work on renovation and/or addition projects, depending on their experience.

The survey was relatively complex and lengthy, particularly for respondents who had completed both renovation and addition projects. Accordingly, some respondents did not answer all questions, yielding a mix of sample sizes for different questions, all of which are noted in the body of the report. For future efforts, the team recommends a more streamlined survey instrument for contractors.

2.2.2 HVAC Contractor In-Depth Interviews

NMR conducted phone interviews with ten HVAC contractors from a sample of 97 unique contacts. In order to focus on projects relevant to this study, the team only interviewed HVAC contractors who had worked on renovation and/or addition projects in Massachusetts in the past year. NMR recruited participants by phone and email (when available) and offered respondents a $100 Amazon gift card. We based the sample on internet research and leads provided by general contractors who participated in the web survey.

2.2.3 Contractor Focus Groups

NMR conducted five focus groups with builders and remodelers across the state (24 attendees in total). These sessions included discussions of the scope of projects, drivers and barriers to energy-efficiency upgrades, factors that affect whether or not a permit is pulled, and what types of program interventions could influence the energy efficiency of a project.

NMR recruited participants from the general contractor web survey and conducted additional internet search to build out the sample. When recruiting the attendees, we asked screener questions to confirm that they had worked on renovation and addition projects in Massachusetts.

The focus groups occurred between May 14 and June 27 and ran for two hours. Participants received $250 as compensation for their time and insights.

2.2.4 Homeowner Survey

NMR administered a web survey through Qualtrics to 207 homeowners out of a sample of 5,353 unique contacts. The team offered a $25 Amazon gift card for a completed survey. NMR distributed the web link to complete the survey by postal mailers to addresses identified from publicly available permit databases.

[14] www.yellowpages.com

The survey asked respondents to describe their renovation and/or addition projects in the past year. In the report, we often present the homeowner findings grouped by *Renovations Only*, *Additions Only*, and *Renovations and Additions*, which groups together only those homeowners whose projects involved both renovations and additions. For example, if a homeowner did both renovations and additions, their responses are only shown within the Renovations and Additions column, and not within the Renovation-only and Addition-only columns.

2.3 Savings Potential

NMR estimated the savings potential of the renovation and addition market in Massachusetts by first creating energy models to simulate savings for different renovation or addition scenarios. We developed 72 prototype models in the Ekotrope energy modeling software to represent differences in project type, scope, heating fuel, and location across the state. We developed an additional 288 models to represent various baseline and upgrade scenarios, for a total of 360 energy models.

NMR calculated savings by creating models of prototype homes before and after a renovation or addition had taken place and taking the difference in energy consumption between the two. We modeled three different baseline scenarios (pre-renovation or addition) to compare to the upgrade scenario (post-renovation or addition).

- **Current baseline:** the program's current baseline (i.e., pre-existing conditions for renovations and UDRH standards for additions).
- **Adjusted baseline:** a slightly more efficient baseline for renovation projects that assumes some improvements in a renovation would have occurred even without the program; UDRH standards for additions.
- **Industry standard practice (ISP) baseline:** a substantially more efficient baseline for renovation projects that attempts to approximate standard or typical renovation practices, based on our assessment and the results of this study; UDRH standards for additions. It generally assumes that, in a renovation, contractors would upgrade wall and ceiling components immediately affected by a renovation to modest levels, such as filling an exposed cavity with fiberglass batt insulation.

For the upgrade scenarios, NMR developed energy models that reflected the typical upgrades associated with participation in the renovation and additions offering. For renovations, we assumed that the installed measures would mirror the average measure-level performance of homes that participated in the legacy Home Energy Services (HES) residential retrofit and weatherization program. We also assumed that all renovation projects participating in the program would include whole-home upgrades that would not be part of ISP, such as the following:

- Insulating the entire attic
- Insulating the entire frame floor over a basement
- Air sealing the entire home

For addition projects participating in the program, NMR assumed that installed measures would be similar to the performance of the installed measures typical of RNC program participants.

After calculating savings for each of the prototype models, NMR scaled the results up to each PA territory and to the entire state. NMR scaled results up based on the findings from the permit count analysis, including adjustments to account for non-permitted projects and excluding small projects not eligible for program participation (less than 500 sq. ft. of floor area).[15] We weighted the per home savings results by the statewide prevalence of project sizes, project types, climates, and heating fuels.

Readers should note that the savings values presented here are purely estimates of gross technical potential – they are based on a finite set of modeled scenarios that do not reflect the full universe of projects. Additionally, the savings values are based on the assumption that the program would continue with its current design, which may allow small projects but does not focus on them. This study does not assess the economic potential or cost-effectiveness of an expanded program that would focus more heavily on a broader range of project types.

[15] The program allows renovation projects to participate as long as they affect at least 500 sq. ft. of envelope area. For this study, we limit our models and potential assessment to those affecting at least 500 sq. ft. of floor area – a slightly larger size cutoff – due to the desire to focus on projects with greater potential savings and those that are large enough to be more likely to participate in the program.

Section 3 Findings

This study used multiple data sources to inform complex questions about the size and structure of the renovations and additions market in Massachusetts. Accordingly, NMR organized findings by research topic and, where appropriate, incorporated data gathered from multiple research activities.

This section includes high level discussions of the following topics:

- Size of the renovations and additions market (Section 3.1)
- Scope of renovation and addition projects (Section 3.2)
- Gross technical potential savings from an expanded renovations and additions program (Section 3.3)

Additional findings on these topics can be found in Appendix B, Appendix C, Appendix D, and Appendix E. Methodological details can be found in Appendix A.

3.1 Market Size

One of the primary goals of the study was to characterize the size of the single-family renovations and additions market in Massachusetts (i.e., the number of such projects performed in a given year). The team used two different approaches to develop overall market size estimates:

- **Approach 1:** the team estimated permitted project counts using the municipal building department permit databases (*permit analysis*) and non-permitted project counts from the estimates provided by surveyed general contractors.
- **Approach 2:** the team merged firmographics about Massachusetts contractors (U.S. Census data) with renovation and addition activity described by contractors in the web survey task.

The estimates derived from each approach are discussed and compared below.

3.1.1 Market Size Approach 1: Permit Analysis + Contractor Survey Results

For 2017, we estimate that there were about 122,000 renovation and addition projects in single-family homes Massachusetts that obtained permits. This represents approximately 7.5% of the 1.6 million single-family homes in the state and is far more than the approximately 7,200 new homes estimated to have been built that year (over 5,000 of which were RNC program participants). Using a keyword analysis of online municipal permit databases, we make the following estimates:

- Two-thirds (66%) of these permits were for *renovation-only projects*;
- One-quarter (24%) were for *addition-only projects*; and
- Ten percent were for projects that included both a *renovation and an addition*.

These estimates only reflect projects that obtained permits. We assume there are more projects that were not permitted, despite the fact that Massachusetts code would certainly require a permit for this type of project.

Geographic distribution. There is a high correlation between single-family home counts and the number of renovation and addition permits. Accordingly, the county with the highest count of single-family homes, Middlesex County, also has the greatest estimated number of renovation and addition permits (Figure 5 and Table 16). PA-level estimates are included in Appendix C.

Figure 5: 2017 County-Level Permit Estimates

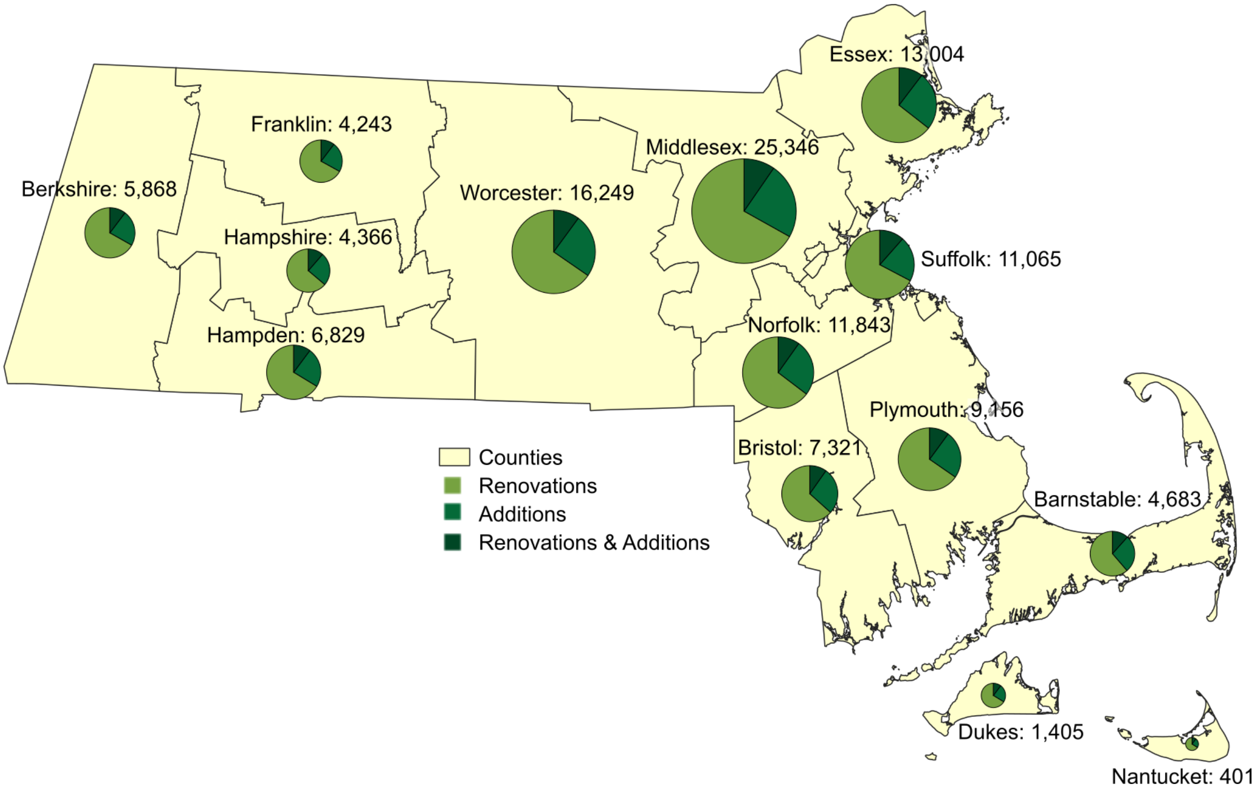


Table 16: 2017 County-Level Permit Estimates

County	Renovation	Addition	Renovation and Addition	Total
Barnstable	2,871	1,268	544	4,683
Berkshire	3,921	1,343	604	5,868
Bristol	4,637	1,969	715	7,321
Dukes	932	329	144	1,405
Essex	8,381	3,276	1,347	13,004
Franklin	2,842	963	438	4,243
Hampden	4,529	1,605	695	6,829
Hampshire	2,787	1,082	497	4,366
Middlesex	16,957	5,952	2,437	25,346
Nantucket	265	96	40	401
Norfolk	7,658	3,021	1,164	11,843
Plymouth	5,986	2,247	923	9,156
Suffolk	7,450	2,343	1,273	11,065
Worcester	10,628	3,987	1,634	16,249
Total	**79,843**	**29,480**	**12,454**	**121,778**

Obtaining permits. Massachusetts code requires a permit for all addition projects and for nearly all renovation projects, which, for the purpose of this study, include projects that generally affect multiple home components. However, some projects still move forward without permits, avoiding inspections from local code officials.

As shown in Table 17, surveyed contractors acknowledged that not all of their renovation and addition projects are permitted. On average, they reported that they pulled permits for 97% of their addition projects and 88% of their renovation projects.

Table 17: Obtained Building Permits – Contractor Survey

Permits	Renovations (n=67)	Additions (n=32)
Average Percent of Projects Getting Permits	88%	97%

In the focus groups, contractors discussed non-permitted projects. Generally, contractors indicated that they always pulled permits for their jobs when it is required, particularly if they were licensed contractors who risked losing their licenses should a building inspector find out about non-permitted work. That said, when probed on the issue, some contractors acknowledged that they might skip permits on some projects (e.g., project was under a rush deadline, the contractor knew the customer well, or the project was unlikely to be noticed by neighbors or code officials), and that there is a small portion of unlicensed contractors in the market who do not pull permits and work on renovation projects as a side job.

Combining permitted and unpermitted results. The team added the non-permitted project estimates from the contractor web survey (Table 17) to the estimates of permitted projects (Table 16) to get a more complete estimate of the total market size, using the calculations shown in

Appendix A.1.3.[16] Combining these results yields a total market size of approximately 130,000 single-family renovation and addition projects per year (Table 18).[17]

Table 18: Market Size Estimate from Approach 1: Permit Analysis + Contractor Survey for Non-Permitted Projects

Estimate Type	Renovation	Addition	Renovation and Addition	Total
Permitted + Non-Permitted Projects	89,424	30,364	12,828	132,616

3.1.2 Market Size Approach 2: Census Data + Contractor Survey

The second approach entailed developing a market size estimate based on U.S. Census data (the number of remodeling companies and employees in Massachusetts) and results from the general contractor web survey (the average number of projects completed). Those results are described below.

On average, surveyed contractors indicated that they had served as the general contractor on about four addition and 12 renovation projects in Massachusetts in the past year (Table 19).[18]

Table 19: MA Projects Served as General Contractor on in the Past Year – Contractor Survey

Project Type	Min	Max	Mean
Additions (n=32)	1	15	4.3
Renovations (n=67)	1	100	12.4

The U.S. Census provides the following estimates for the number of residential remodeling companies and employees active in Massachusetts (Table 20).

Table 20: U.S. Census Residential Remodeler Statistics for Massachusetts[19] (2016)

Residential Remodeler Categories	Count
Firms	3,747
Employees	11,561

Multiplying the average number of projects from the contractor web survey by the number of firms and employees from the Census data yields a range for the number of projects that might have

[16] We applied the non-permitted estimate for addition projects to the renovation and addition permit estimates based on the assumption that any project including addition work is more likely to have a permit pulled.
[17] The permit analysis reflects a snapshot in time of the single-family renovation and additions market as we only reviewed one year of comprehensive permit data. We explored a more comprehensive timeline of online permit data for seven municipalities that had comprehensive permit data for the 2010 to 2016 period. See Appendix C.1.
[18] This survey was implemented in the Spring of 2019; therefore, contractor responses represent a period of Spring 2018 to Spring 2019.
[19] U.S. Census American Fact Finder, using the NAICS code for Residential Remodelers (236118). Residential Remodelers are defined by the Census as follows: "*This U.S. industry comprises establishments primarily responsible for the remodeling construction (including additions, alterations, reconstruction, maintenance, and repair work) of houses and other residential buildings, single-family, and multifamily. Included in this industry are remodeling general contractors, for-sale remodelers, remodeling design-build firms, and remodeling project construction management firms.*"

been completed in a given year. However, neither the number of firms nor the number of employees represents an ideal scaling mechanism. For small firms, it is likely that any individual residential remodeler would be involved in every project. For larger firms, there may be multiple crews and any individual employee is unlikely to be involved in every project.

Using the number of residential remodeling firms as the multiplier yields a low estimate of approximately 63,000 renovation and addition projects from 2018 to early 2019, which is the timeframe that contractors used to estimate how many projects they completed each year. Using the number of residential remodeling employees as the multiplier yields a high estimate of about 175,000 projects. The calculations are presented in Appendix A.1.3.2 and the results are shown in Table 21.

Table 21: Market Size Estimate from Approach 2: Census + Contractor Survey

Estimate Type	Renovation	Addition	Total
Residential Remodeling Firm Multiplier	46,463	16,112	62,575
Residential Remodeling Employee Multiplier	125,104	49,712	174,816

3.1.3 Comparison of Market Size Estimates from Permit Analysis/Contractor Survey (Approach 1) and Census/Contractor Survey (Approach 2)

Table 22 compares of the market size estimates from the two approaches. The permit data combined with the contractor survey results for non-permitted projects (Approach 1) yield an estimate in between the two values developed by scaling the contractor survey estimates using Census data (Approach 2). We believe Approach 1 is the most reasonable approach due to the large number of permits that we reviewed and because it falls in between the contractor survey estimates. As a result, we believe that the single-family renovations and additions market in Massachusetts includes approximately 130,000 projects each year, with about 55,500 affecting at least 500 sq. ft. of floor area. Renovation-only projects represent roughly 70% of the total.

Table 22: Comparison of Market Size Estimates

Estimate Type		Renovation	Addition	Renovation and Addition	Total
Approach 1	Permit Analysis + Contractor Survey for Non-Permitted Activity	89,424	30,364	12,828	132,616
Approach 2	Contractor Survey + Census data (Firm Multiplier)	46,463	16,112	--	62,575
	Contractor Survey + Census data (Employee Multiplier)	125,104	49,712		174,816

3.2 Project Scope

In addition to estimating market size, the study aimed to characterize the scope of renovation and addition projects in Massachusetts.

Each of the primary data collection efforts with market actors that we conducted as part of this study (contractor survey, contractor focus groups, HVAC contractor interviews, and homeowner survey) included questions about the scope of single-family renovation and addition projects, as appropriate. These questions focused on the following key areas:

- Project size (square footage)
- Location in the home where these projects take place
- Measures commonly affected by these projects
- Extent to which HVAC equipment is affected by these projects and types of HVAC equipment commonly installed

Below, we provide the relevant information associated with these key areas from each of the primary data collection efforts. We present counts instead of percentages when there are ten or fewer respondents for a given question.

3.2.1 Project Size

Both the general contractor and homeowner survey asked questions about the typical size of renovation and addition projects, while the homeowner survey asked homeowners about the location of their recent renovation and/or addition work.[20]

General contractors indicated that renovations and additions were comparably sized, both averaging between 800 and 900 sq. ft. (Table 23).

Table 23: Average Square Footage of Renovations and Additions Projects from the Past 12 Months – General Contractor Survey

Average Square Footage	Min	Max	Mean
Renovations (n=58*)	50	2,400	887
Additions (n=29)	100	2,500	808

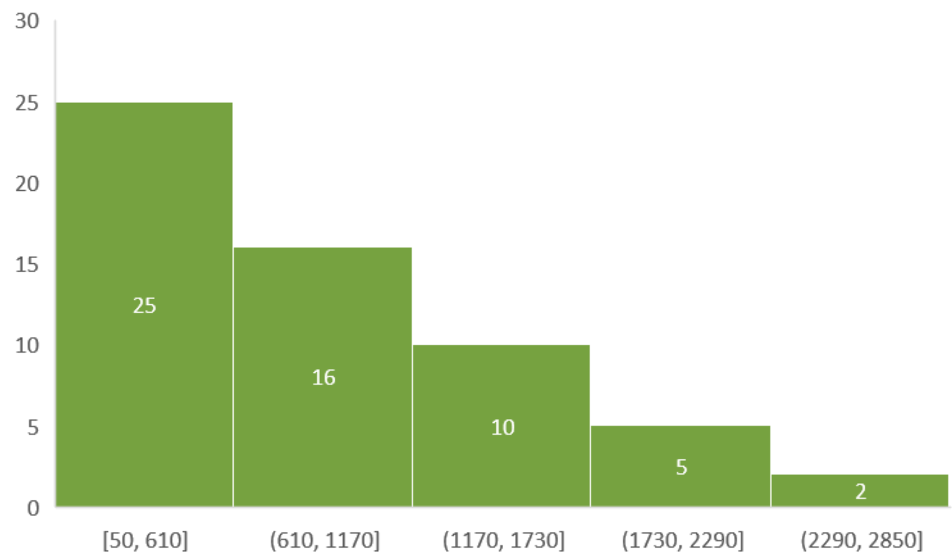
*Removed two renovation-specific responses that were over 2,400 sq. ft.

The histograms in Figure 6 and Figure 7 show the distribution of all project sizes reported by general contractors for renovation and addition projects, respectively. Higher bars indicate that more contractors said their average project falls into that square footage range. Each histogram indicates a trend towards smaller-sized projects: over two-fifths (43%) of contractors' average renovation projects were smaller than 610 sq. ft. and over one-half (55%) of contractors' average additions were smaller than 750 sq. ft.[21]

[20] These topics were not a focus of the general contractor focus groups or the HVAC contractor interviews.
[21] Though there are many small projects, the potential study portion of this study focuses on projects that affect at least 500 sq. ft. of floor area, in order to focus on those projects that are more likely to generate sufficient savings to increase the likelihood of program participation.

Figure 6: Average Square Footage of Renovation Projects from the Past 12 Months – General Contractor Survey*

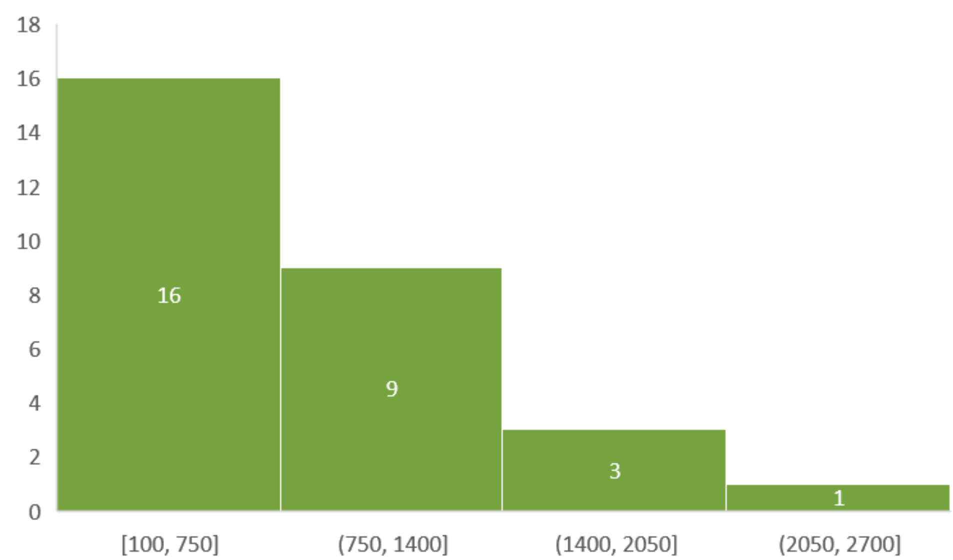
(n=58)



*Removed two renovation-specific responses that were over 2,400 sq. ft.

Figure 7: Average Square Footage of Additions Projects from the Past 12 Months – General Contractor Survey

(n=29)



Surveyed homeowners described a wide size range for their recent renovation and addition projects, which, at a high-level, indicates the general contractor responses about project square footages are likely a reasonable representation of what is happening in the market (Table 24).

Table 24: Typical Project Sizes – Homeowner Survey

Size of Project	Renovation Only (n=148)	Addition Only (n=26)	Renovation and Addition (n=33)	Total (n=207)
Less than 100 sq. ft.	18%	0%	0%	13%
100 to 300 sq. ft.	20%	15%	6%	17%
301 to 500 sq. ft.	16%	35%	21%	19%
501 to 1,000 sq. ft.	14%	38%	24%	18%
1,001 to 1,500 sq. ft.	13%	0%	12%	11%
More than 1,500 sq. ft.	10%	8%	30%	13%
Don't know	9%	4%	6%	8%

3.2.2 Room and Project Type

Table 25 presents the project types that homeowners reported recently completing. Respondents indicated that over two-fifths of renovation-only projects included a bathroom and/or a kitchen renovation (44% and 41%, respectively). Over one-half (54%) of addition-only projects involved finishing and conditioning a basement and over one-fourth (27%) involved removing an exterior wall and adding a new footprint to the original home. Over three-fourths of projects where both renovations and additions were completed involved a bathroom and/or a kitchen renovation (82% and 76%, respectively).

Table 25: Project Types – Homeowner Survey*

Type of Work	Renovation Only (n=148)	Addition Only (n=26)	Renovations and Additions (n=33)	Total (n=207)
Bathroom renovation	44%	0%	82%	44%
Kitchen renovation	41%	0%	76%	42%
Combining rooms by removing interior walls	18%	0%	55%	21%
Finishing and conditioning a basement	0%	54%	61%	16%
Removing an exterior wall and building a new section of the house that is finished, conditioned, and attached to the existing home	0%	27%	45%	11%
Other – Windows	11%	0%	0%	8%
Other – HVAC/water heating	9%	0%	0%	6%
Finishing and conditioning an attic space or bonus room over a garage	0%	19%	18%	5%
Other – Room addition	5%	0%	9%	5%
Other – Insulation	5%	0%	3%	4%
Other – Roof	5%	0%	0%	4%
Enclosing an existing porch or sunroom	3%	0%	9%	3%
Other – Gut renovation	3%	0%	3%	3%
Other	32%	0%	12%	25%

*Percentages sum to more than 100% because some projects affected multiple areas of the home. Additionally, not all project types identified here would be considered renovations or additions (i.e., not program eligible).

As part of the building department permit review, the team investigated what room types were affected in permitted renovation and additions projects. Consistent with the homeowner survey results, bathrooms and kitchens dominated the renovation projects in our permit review: 71% of renovation permits covered a bathroom and 58% covered a kitchen (Table 26).[22]

[22] Note that these are percentages of the 5,058 permitted renovation records that included a readily available project description in the online database. There were 74,785 additional projects without readily available project descriptions. This obviously leaves a significant number of the permit records out of this analysis, but the number of projects included in this analysis far outnumbers those that would have been included in a far more limited, in-person, building department-focused effort. Additionally, online databases included inconsistent levels of detail with their permit records, granting us more reason to consider these as estimates.

Table 26: Renovation Permits by Room Type

(*n = 5,058 Renovation Permits with Project Descriptions*)

	Permit Count	% of Permits
Bathroom	3,567	71%
Kitchen	2,887	58%
Bedroom	311	6%
Living room	269	5%
Closet	190	4%
Office	114	2%
Laundry	42	<1%

According to the permit review, the most common room affected in addition projects was a bathroom (50% of addition permits), followed by a basement (41%), a kitchen (29%), and a bedroom (22%) (Table 27). As with renovations, these percentages are only based on the permit records that included sufficient detail to determine the type of room being added.[23] The addition permit descriptions were generally not detailed enough to determine whether the addition included construction of a new structure or if the addition involved finishing a space.

Table 27: Addition Permits by Room Type

(*n = 1,517 Addition Permits with Project Descriptions*)

	Permit Count	% of Permits*
Bathroom	751	50%
Finish basement	616	41%
Kitchen	437	29%
Bedroom	327	22%
Living room	245	16%
Laundry	117	8%
Office	82	5%
Closet	74	5%
Mudroom	55	4%
Finish attic	40	3%

*Percentages add to more than 100% as many additions covered more than one room type.

Based on the permit review, 39% of renovation permits and about half (51%) of addition permits covered multiple room types under a single permit.

[23] There were 1,517 permit records that provided detail about the room type being added to the home. There were an additional 27,963 that lacked those readily available descriptions.

3.2.3 Key Measures Affected

Both the general contractor and homeowner web surveys asked respondents to indicate the measures that were affected in their renovation and addition projects. Table 28 shows the percentage of projects that affected each of the key measures that respondents were asked about. For both renovations and additions, respondents from both surveys indicated that wall insulation, lighting, and windows were the measures most commonly affected as part of their projects. Water heating systems were generally listed as the least affected measure.

Table 28: Average Percent of Projects with Specific Measures

Measures	General Contractor Survey		Homeowner Survey	
	Renovations (n=67)	Additions (n=32)	Renovations (n=181)	Additions (n=59)
Wall insulation	70%	90%	60%	81%
Lighting	59%	86%	63%	66%
Windows	56%	88%	56%	59%
Air sealing	35%	69%	25%	29%
Air conditioning system	32%	50%	31%	42%
Heating system	28%	65%	45%	51%
Ventilation (incl. HRV, ERV, and bath fans with automatic controls)	26%	37%	31%	37%
Duct work	24%	49%	28%	34%
Appliances	23%	45%	44%	32%
Water heating system	19%	39%	24%	17%

General contractors who indicated that they completed projects that included wall insulation, described their typical wall insulation practices for renovations and additions (Table 29). Most often, they reported adding more insulation to exceed code requirements (46% for renovations and 60% for additions). For renovations, nearly as many (44%) described using supplemental insulation to meet code requirements for renovations. Leaving insulation as-is was reportedly extremely uncommon. Additional details about typical duct work and blower door testing practices can be found in Appendix D.3.

Table 29: Typical Insulation Practices – General Contractor Survey
(Multiple Response)

Insulation Practice	Renovations (n=61)	Additions (n=30)
Add more insulation to exceed code requirements	46%	60%
Cut batt insulation to fit around wiring and other obstacles	44%	47%
Install rigid foam board	15%	23%
Stuff batt insulation into place around wiring and other obstacles	21%	17%
Supplemental insulation to meet code requirements	44%	33%
Use infrared cameras	2%	3%
Use spray foam or blown-in cellulose	41%	57%
Leave it as-is	3%	0%

Focus group participants suggested that wall insulation was frequently included in the scope of renovation projects. Opening walls allows for the installation or repair of electrical wires or plumbing lines, and also triggers code's insulation requirements. Some, though not all, participants also indicated that they prefer to open the walls in all of their renovation projects so that they know exactly what is involved in the area they are renovating. Some of these focus group contractors indicated that wall insulation is inexpensive relative to other renovation components; therefore, it is an easy decision to replace the pre-existing insulation.[24]

Surveyed general contractors provided details about how frequently the measures they implemented in renovation and addition projects were more efficient than code. As shown in Table 30, general contractors provided a wide range of responses to this question. In fact, it seems that for most measures, 20% to 40% of the general contractors indicated they always installed measures that were more efficient than code, while a comparable group suggested that they never install measures that are more efficient than code. Readers should note that reports of exceeding code do not indicate that the measures substantively surpassed code requirements. For example, a marginally-better R-21 insulation product would exceed an R-20 prescriptive code requirement in an addition. Also, unless mandated by a specific code official, Massachusetts code does not have prescriptive R-value requirements for exposed wall cavities in a renovation project and only requires filling the exposed cavity. Accordingly, the team theorizes that reports of above-code wall insulation in renovations may refer to using higher R-value products than the least efficient commercially available products that would satisfy the filled-cavity requirement (e.g., filling a cavity with closed-cell spray foam rather than filling it with fiberglass batts), achieving a higher total R-value.

[24] Appendix E provides more detail from the focus groups.

Table 30: How Frequently Measures were More Efficient than Code Requirements – General Contractor Survey

Measures		Always	More than half the time	About half the time	Less than half the time	Never	Don't know
Wall insulation	Additions (n=30)	37%	20%	10%	13%	20%	--
	Renovations (n=58)	22%	19%	16%	16%	28%	--
Heating	Additions (n=29)	41%	10%	10%	10%	28%	--
	Renovations (n=34)	24%	24%	15%	6%	32%	--
Air conditioning	Additions (n=24)	33%	17%	13%	8%	25%	4%
	Renovations (n=32)	22%	16%	22%	13%	25%	3%
Water heating	Additions (n=20)	25%	15%	30%	5%	25%	--
	Renovations (n=27)	26%	19%	19%	15%	15%	7%
Ventilation	Additions (n=21)	14%	24%	14%		48%	--
	Renovations (n=32)	38%	9%	9%	3%	34%	6%
Air sealing*	Additions (n=23)	30%	13%	13%	4%	39%	--
	Renovations (n=36)	--	--	--	--	--	--
Duct work	Additions (n=22)	23%	18%	18%	9%	32%	
	Renovations (n=32)	16%	19%	22%	6%	31%	6%
Windows	Additions (n=30)	57%	10%	7%	3%	23%	--
	Renovations (n=54)	39%	22%	9%	7%	20%	2%
Lighting	Additions (n=29)	38%	10%	7%	10%	34%	--
	Renovations (n=45)	31%	16%	20%	2%	27%	4%
Appliances	Additions (n=20)	25%	10%	15%	10%	40%	--
	Renovations (n=26)	19%	19%	23%	12%	15%	12%

*NMR did not ask renovation contractors about air sealing as there is no specific code requirement.

Contractors attending the focus groups indicated that any installation of high-efficiency measures was usually driven by contractors, as many homeowners understandably were not familiar with energy efficiency, nor did they prioritize it. Contractors also indicated that cost was a major barrier to high-efficiency measures as costs associated with building to code were quite high. Some contractors noted that increasing the efficiency of some measures to above code standards (e.g., air infiltration) often required using expensive insulation products (e.g., spray-applied foam) or the introduction of new equipment (e.g., ventilation), further increasing costs. Others thought that going above and beyond code was often not possible logistically and, when it was, it provided limited marginal value for the additional cost, except to those customers with higher budgets and/or environmental interests. Please refer to Appendix E for more details.

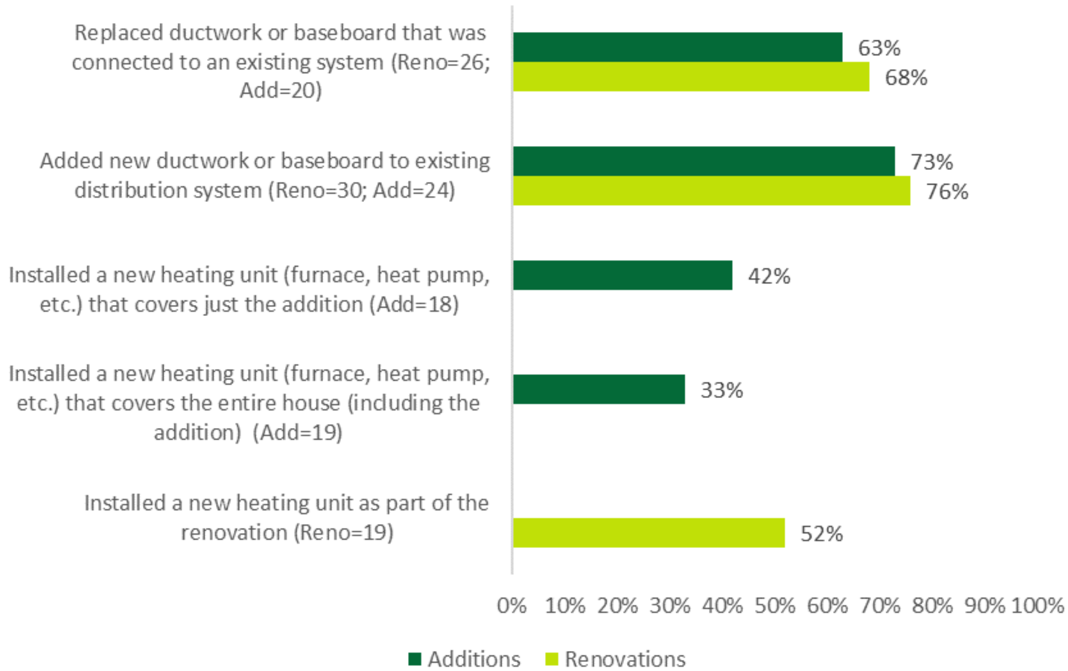
3.2.4 Mechanical Systems

Each of the primary data collection efforts with market actors included questions focused on HVAC systems. Please refer to Appendix D.1.2 for additional details.

3.2.4.1 Heating and Cooling Systems

General contractors provided details about what types of changes they made to heating systems during their renovation and addition projects. Figure 8 shows that over one-half (52%) of general contractors' renovation-specific heating system projects resulted in new equipment being installed. For additions, about two-fifths (42%) of the projects affecting the heating system resulted in a new unit that just covers the addition, while one-third (33%) of projects resulted in a new unit covering the entire house.

Figure 8: Heating Systems Changes – General Contractor Survey



Contractors attending the focus groups suggested that new equipment could be easier to deal with than trying to upgrade or retrofit existing equipment or systems. In general, some contractors may prefer to install new systems entirely rather than having to modify – and potentially end up responsible for – a system that was installed by a previous contractor who used different or unfamiliar practices. They also indicated that homeowners are often interested in adding cooling to their home, which can be easily added via heat pumps. Please refer to Appendix E for more details.

Table 31 shows that, when compared to the general contractor results, homeowners indicated that a higher percentage of heating equipment projects resulted in new equipment for both renovations and additions (for example, 52% of contractors' renovations included new heating equipment, compared to 78% of homeowners' renovations).

Table 31: Heating System Changes – Homeowner Survey

New Heating Equipment Installed	Renovations (n=81)	Additions (n=30)
Yes	78%	87%
No, altered existing	17%	13%
Don't know	5%	0%

Figure 9 and Table 32 present the results from cooling system questions that are comparable to those previously presented for heating systems.

Figure 9: Cooling System Changes – General Contractor Survey

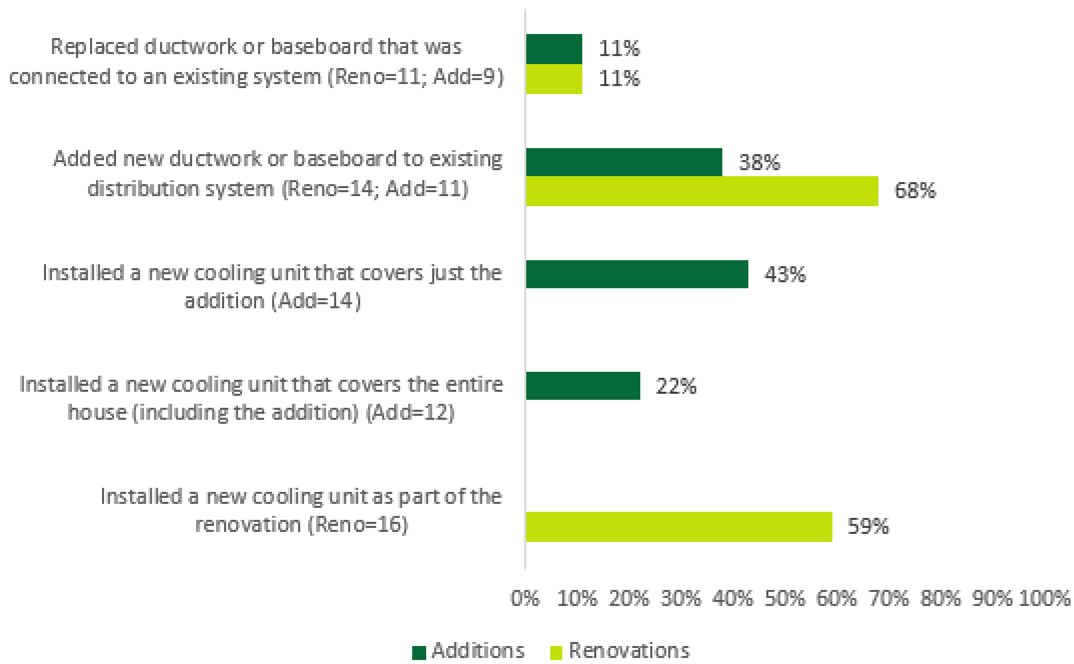


Table 32: Cooling Systems Changes – Homeowner Survey

New Cooling Equipment Installed	Renovations (n=57)	Additions (n=25)
Yes	96%	100%
No, altered existing	4%	0%

In the HVAC contractor interviews, respondents indicated that, on average, about two-thirds of their renovation and addition projects (69% and 67%, respectively) included new heating, cooling, or water heating equipment (Table 111 provides additional detail).

Air source heat pumps (ASHPs) are gaining traction in this market. Over 40% of surveyed homeowners with renovation projects and new HVAC equipment installed an air source heat pump. That number rises to over 50% for homeowners involved in an addition project that included new equipment (Table 33).

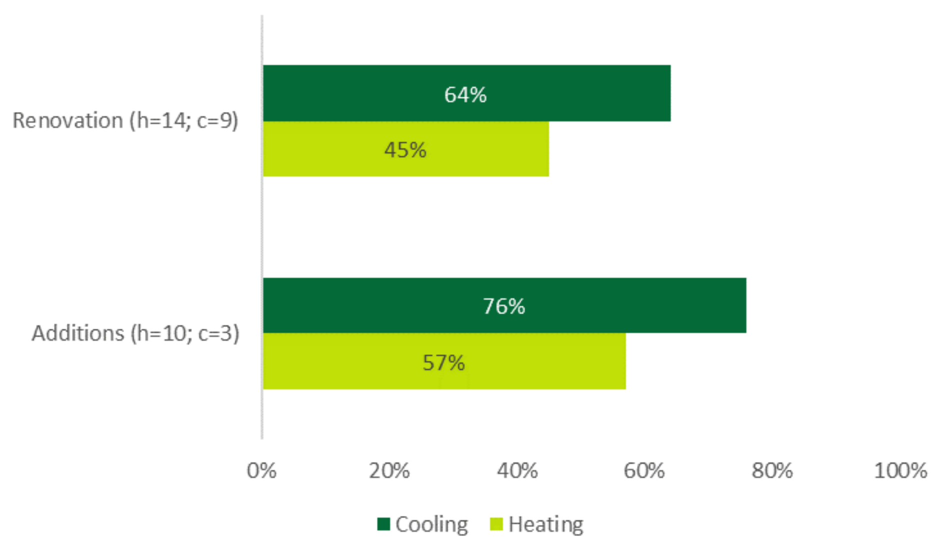
Table 33: New HVAC Equipment – Homeowner Survey
(Multiple Response)

New Heating or Cooling Type	Renovations (n=76)	Additions (n=31)
Ductless mini-split heat pump	22%	29%
Conventional air source heat pump	20%	26%
Ground source heat pump	0%	6%
Boiler	21%	9%
Furnace	9%	0%
Central air conditioning	5%	0%
Water heating	3%	0%
Other	12%	13%
None of these equipment types	12%	23%
Don't know	14%	0%

Interviewed HVAC contractors indicated that heat pumps were the most commonly installed types of heating and cooling equipment in both renovation and addition projects. New heating systems are most often displacing gas furnaces and boilers, while cooling systems are most often being added to homes for the first time (please refer to Table 112 and Table 113 for additional details).

Similar to the HVAC contractors, general contractors who said they installed a new heating or cooling systems in their projects reported that close to or a majority of those new systems were heat pumps (Figure 10).

Figure 10: Average Percent of Projects with New Heating or Cooling Installations that Included a Heat Pump – General Contractor Survey



3.2.4.2 Ductless Mini-Split ASHPs

Ductless mini-split ASHPs were the most common type of heat pump installed, as reported by HVAC contractors (please refer to Table 114 for additional details).

Contractors who participated in focus groups also reported growing homeowner interest in ductless mini-splits. Most of the contractors indicated that they see them as great options that are relatively cheap and easy to install, as opposed to tying into duct work or installing new ducts, thereby avoiding frustrations with old mechanical or distribution systems. Please refer to Appendix E for more details.

Nearly all homeowners who installed ductless mini-splits as a part of their renovation or addition projects chose systems that provided heating and cooling (Table 34).

Table 34: Ductless Mini-Split Heating and Cooling Details – Homeowner Survey

Mini-Split Type	Renovations (n=17)	Additions (n=9)
Heating only	0%	0%
Cooling only	6%	0%
Both	94%	100%

Close to the same number of homeowners performing renovations said they removed their existing systems prior to the mini-split installation as those that did not, whereas no homeowners performing additions removed their existing systems beforehand (Table 35). This does indicate that a significant number of homeowners are interested in switching to electric systems.

Table 35: Ductless Mini-Split – Whether Existing System Removed – Homeowner Survey

Removal of Existing System	Renovations (n=17)	Additions (n=9)
Yes	47%	0%
No	53%	100%

Natural gas was by far the most common fuel type used by the homeowners' previous heating systems before the ductless mini-splits were installed; ASHP systems are clearly displacing load normally served by gas systems, not just delivered fuels or electric resistance heating. (Table 36).

Table 36: Ductless Mini-Split – Previous Heating System Fuel Type – Homeowner Survey

Previous Heating Fuel	Renovations (n=17)	Additions (n=9)
Natural gas	53%	78%
Electric	29%	11%
Propane	6%	0%
Fuel oil	6%	0%
No prior heating	6%	11%

Room air conditioners were the most common type of cooling system used by homeowners performing renovation projects prior to their ductless mini-split installation. The type of cooling equipment that had been used by homeowners prior to their additions projects was more diverse (Table 37).

Table 37: Ductless Mini-Split – Previous Cooling Equipment – Homeowner Survey

Previous Cooling System	Renovations (n=17)	Additions (n=9)
Room air conditioner	47%	22%
Central air conditioner	24%	22%
Ductless mini-split	6%	11%
Fans	0%	22%
Nothing	18%	22%
Don’t know	6%	0%

Most homeowners’ ductless mini-splits only affected the renovated space or the addition and did not affect other areas of the existing home (Table 38).

Table 38: Ductless Mini-Split – Installation Location – Homeowner Survey

Installation Location	Renovations (n=17)	Additions (n=9)
Affected area only	59%	78%
Other areas in existing home as well	41%	22%

3.2.4.3 Water Heating

When water heaters were included in renovation or addition projects, homeowners typically installed new ones rather than altering their existing unit (Table 39).

Table 39: New Water Heating Equipment – Homeowner Survey

New Domestic Hot Water Heater	Renovations (n=44)	Additions (n=10)
Yes	89%	100%
No, altered existing	7%	0%
Don't know	5%	0%

Homeowners installing water heaters in their renovations projects typically installed high-efficiency, on-demand water heaters, whereas the type of water heating equipment installed by homeowners in their additions projects was more diverse (Table 40). Highly-efficient, electric heat pump water heaters made up 15% of new water heaters installed in renovations and 20% of those in additions, a significant portion of the market.

Table 40: New Water Heater Type – Homeowner Survey

Domestic Hot Water Heater Type	Renovations (n=39)	Additions (n=10)
Heat pump water heater	15%	20%
On-demand tankless condensing water heater	49%	30%
Neither of those types	36%	50%

Table 41 shows the most common types of water heating equipment installed by HVAC contractors in their residential renovations and additions projects. Tankless water heaters were the most commonly reported type across both renovation and addition projects (mentioned by five respondents each, respectively). The most common types of equipment replaced in renovations projects were older gas storage tanks (four responses), followed by one response each for electric storage tanks, tankless, and oil storage tanks.

Table 41: Most Common Water Heating Types Installed – HVAC Contractors

Water Heating Type	Type	Count of Respondents	Fuel	Efficiency - Average	Efficiency - Range
Tankless/On demand	Renovations	5	Gas (4), Propane (1)	0.94 EF**	0.90 to 0.95 EF
	Additions	5*	Gas (4) or propane (1)	0.95 EF	0.95 EF
Heat pump water heater	Renovations	1*	Electric	Don't Know	Don't Know
	Additions	2*	Electric	3.5 EF	3.5 EF
Storage tank	Renovations	3	Gas	0.79	0.63 to 0.87 EF
	Additions	2		0.69 EF	0.69 to 0.70 EF
Boiler	Renovations	1	Gas	90% AFUE	90% AFUE
	Additions	1	Gas	90+ AFUE	90+ AFUE

*One respondent did not know the equipment efficiency.
**One respondent did not the know installed equipment efficiency.

3.2.4.4 Altering Existing vs. Adding New HVAC and Water Heating Systems

As part of the HVAC contractor interviews and the focus group sessions, NMR asked participants about how they alter HVAC or water heating systems to serve the renovated or newly-built portion of a home, or in what cases they might prefer to add a system rather than alter the existing one. Appendix D.2 and Appendix E.1 provide additional details.

Typically, HVAC contractors do not expand the distribution systems of existing heating or cooling equipment so that it can also serve an addition (12% of projects on average). However, if the existing systems are in good repair and have sufficient excess capacity, some contractors may add additional ductwork or radiators that can tie into the existing distribution system (please refer to Table 115 and Table 116 for additional details).

Similarly, in the focus groups, most contractors said that when working on an addition, they typically install a new system dedicated to the new floor area to avoid time consuming and potentially expensive changes to existing systems. A minority said that they prefer to tie into the existing system and add on duct work or new radiators to serve the new area, but acknowledged that this is not always possible.

Interviewed HVAC contractors reported altering existing equipment for one-third (33%) of their renovations on average (please refer to Table 117 and Table 118 for additional details).

The interviewed HVAC contractors also reported that the scope of their projects rarely expanded beyond the initial scope of work agreed to with the customer so as to include additional energy-efficiency related improvements. In those rare instances of increasing scope, adding heat pumps was the most commonly reported type of additional work (please refer to Table 121 for additional details).

3.2.4.5 HRV and ERV

Heat-recovery ventilation systems (HRVs) and energy-recovery ventilation systems (ERVs) appear to be installed in limited numbers in renovation and addition projects. Table 42 shows the frequency with which HVAC contractors said they install them in residential renovation or additions projects. Only one said they install them often, noting that they do so about once per month. Of the four respondents who said they install them sometimes, one specified that they install them three or four times a year.

Of those four HVAC contractors that do not install HRV or ERV very often, two said that about 10% of their projects include them, and another specified that they install them less than 1% of the time (only when installing bathroom fans or in new construction). One respondent said they never install them in renovations or additions, but they do install them in new construction.

Table 42: How Often HRV or ERV are Installed – HVAC Contractor IDIs

HRV and ERV Frequency	Count (n=10)
Often	1
Sometimes	4
Not very often	4
Never for renovation/additions	1

Contractors participating in the focus groups indicated the HRVs and ERVs rarely came into play during renovation or addition projects. In general, participants did not seem highly interested in the technology, and some clearly were not aware of or misunderstood their function. The few who said they had installed them mentioned they had done so for air quality concerns in newly-finished basements.

3.2.5 Improving Other Areas of the Home

About one-half of surveyed homeowners performing renovations and additions said they did not upgrade the efficiency of any areas of their homes that were not part of the renovation or addition square footage during the course of the project (Table 43).

Table 43: Other Affected Areas of the Home – Homeowner Survey

Other Areas of Home Affected	Renovations (n=181)	Additions (n=59)
Yes	37%	32%
No	51%	58%
Don't know	12%	10%

The homeowners who did upgrade the efficiency of other portions of their home as a part of the renovation or addition project most often reported upgrading windows and insulation in these other areas (Table 44).

Table 44: Type of Work Performed in Other Areas of the Home – Homeowner Survey

(Multiple Response)

Work Performed in Other Areas of Home	Renovations (n=68)	Additions (n=19)
Windows	49%	58%
Insulation	46%	47%
HVAC	12%	21%
Roof	7%	5%
Gut renovation	6%	11%
Other	35%	42%

3.3 Gross Technical Potential Savings

A primary goal of the study was to estimate the energy savings potential represented by the renovations and additions market in Massachusetts (i.e., the amount of savings that could be achieved if all renovation and addition projects in the state in a given year participated in the program and achieved the levels of energy efficiency common to program projects). To make this estimate, NMR created energy models in the modeling software Ekotrope to simulate different renovation or addition scenarios that might take place, as well as their associated savings.

NMR created multiple baseline and upgrade scenarios for each prototype energy model, and calculated savings by taking the difference in energy consumption between baseline and upgrade scenarios. We created 360 energy models and scaled up the resulting model-level savings to the PA territory and to the state level using a weighted scheme representing the relevant distributions of project type, project scope, heating fuel, and climate for those areas.

3.3.1 Savings by Project

NMR first built energy models to simulate the baseline (pre-renovation/addition)[25] and upgrade (post-renovation/addition) scenarios for each model type. Table 45 shows the mean savings per project by fuel type, weighted by statewide portions of heating fuel, climate location, project type, and project scope. It also shows how switching to one of the two alternative baselines considered in this study would impact savings.

On average, switching to the adjusted baseline (detailed in Appendix A), in which mechanical system efficiencies would have been improved over the pre-existing conditions, would result in each of these prototype homes achieving about 93% of their current savings. Shifting to the ISP baseline, which assumes contractors would bring their projects up to typical building practices (e.g., filling cavities with insulation), would yield just under two-thirds (63%) of the current savings levels.

Oil savings may be somewhat overstated because, in models where the HVAC system was being upgraded, we assumed the upgrade would entail switching at least some of the load to a ductless

[25] For projects with addition components, the baseline for the addition reflected UDRH standards, given that there was no pre-existing addition.

mini-split ASHP system, rather than a more efficient oil system. Models with fuel-switching resulted in negative electric savings due to the new electric heating and cooling consumption.

Table 45: Average Savings Per Prototype Project by Fuel (MMBTU)

Fuel	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Electric	6.3	6.3	99%	4.9	78%
Natural gas	12.8	12.2	96%	7.4	58%
Oil	9.8	8.8	89%	6.1	62%
Propane	1.0	1.0	96%	0.6	58%
Total	**30.0**	**28.2**	**94%**	**19.0**	**63%**

Table 46 presents the weighted mean savings values for the prototype models by end use. Reducing heating consumption represents the largest opportunity for savings by a wide margin, though shifting to a more efficient baseline – the ISP baseline – would substantially decrease savings for a typical project. The ISP baseline assumes that contractors would have improved the envelope and, in some cases, the mechanical systems even without the program, yielding average heating savings 42% lower than the program's current baseline.

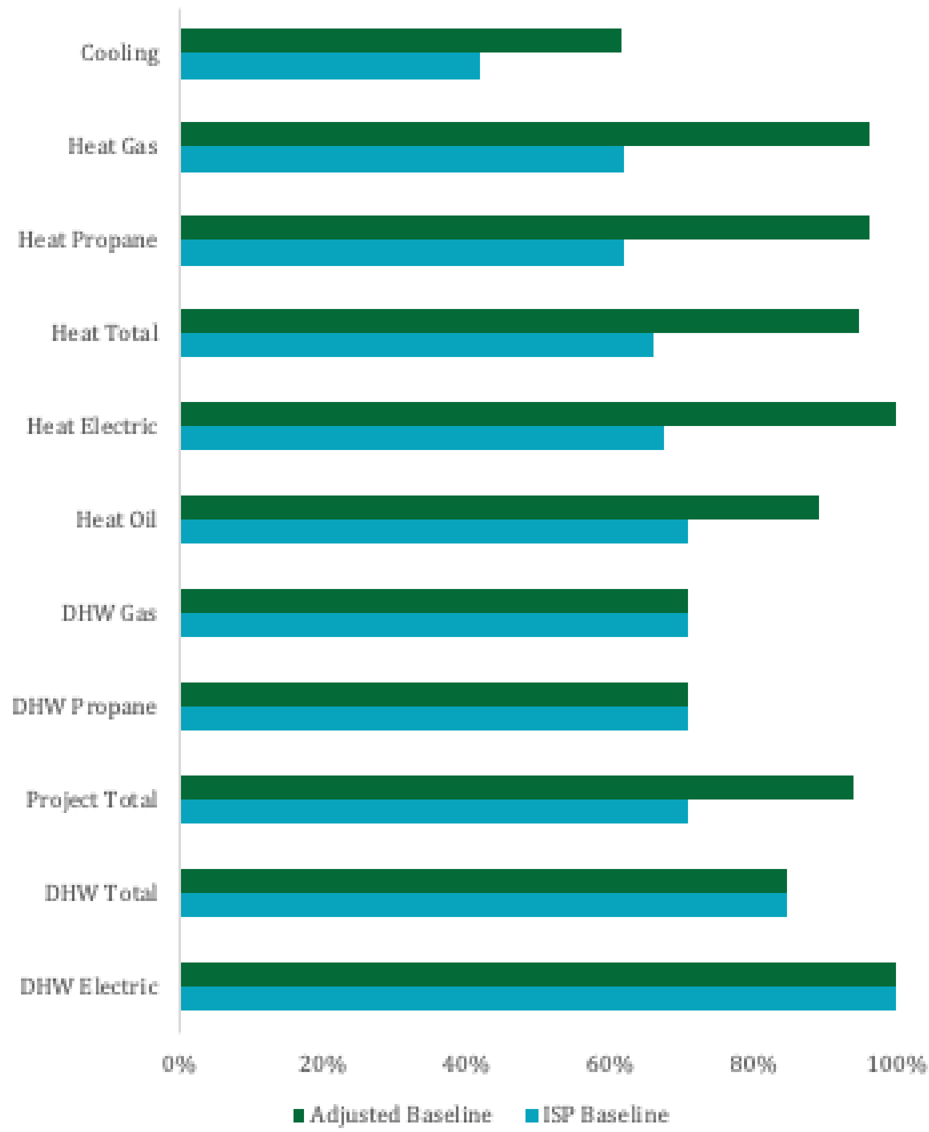
Regardless of the baseline scenario used by the program, domestic hot water savings are far lower than heating on average. Cooling savings are minimal in all scenarios due to generally low cooling loads and because some prototype homes were designed without cooling (half of prototypes) and some included additional cooling demand from heat pumps. This assessment assumes consistent lighting savings across baseline scenarios, given that the program upgrades lighting throughout the home, regardless of project scope. This analysis also assumes no savings from appliance upgrades.

Table 46: Average Savings Per Prototype Project by End Use (MMBTU)

End Use	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Heat					
Electric	2.9	2.9	100%	1.6	55%
Natural gas	12.0	11.6	97%	6.8	56%
Oil	9.8	8.8	89%	6.1	62%
Propane	1.0	0.9	97%	0.5	56%
Heat Total	**25.7**	**24.3**	**94%**	**15.0**	**58%**
Domestic Hot Water					
Electric	0.6	0.6	100%	0.6	100%
Natural gas	0.8	0.6	76%	0.6	76%
Propane	0.1	0.1	76%	0.1	76%
DHW Total	**1.5**	**1.3**	**87%**	**1.3**	**86%**
Other Electric					
Cooling	0.1	0.1	57%	0.1	38%
Lighting	2.6	2.6	100%	2.6	100%
Total	**30.0**	**28.2**	**94%**	**19.0**	**63%**

Figure 11 graphically depicts the reduced home-level savings available under the more efficient baseline scenarios. The average project-level savings from reducing heating consumption would be substantially reduced under the ISP baseline scenario.

Figure 11: Percentage of Current Baseline Savings by End Use



Measure Level Contribution to Savings. Heating is the main driver of overall savings for renovations and additions, based on modeling. Table 47 shows the relative contribution of various measures on heating savings. Insulation improvements are the largest contributors to savings in the current and adjusted baseline scenarios. Wall and ceiling insulation measures show a decrease in their contribution to savings in the ISP baseline due to the assumption that these measures would be upgraded in an ISP scenario. Air sealing plays a large role in savings, particularly in the ISP baseline with the decreased contribution of wall and ceiling insulation savings. A large share of modeled savings was not tied to a particular measure in the energy models, but a portion of those savings can be attributed to mechanical system upgrades, along with other interactive effects.

Table 47: Measure Level Contribution to Potential Savings

Measure	Current Baseline	Adjusted Baseline	ISP Baseline
Floor insulation	21%	22%	31%
Ceiling insulation	21%	22%	10%
Wall insulation	18%	19%	11%
Air sealing	16%	17%	23%
Windows	6%	7%	9%
Other*	18%	14%	17%

*Remainder of heating savings were not specified in models but include mechanical system efficiencies and interactive effects.

3.3.2 Statewide Savings

After calculating savings for each individual prototype model under the three different baseline scenarios, NMR scaled the resulting savings up to represent the potential savings associated with renovation and addition projects across the state. Using estimates of project counts adjusted to include non-permitted projects and exclude clearly non-program eligible projects (less than 500 sq. ft.), the project level savings were scaled up to the entire state using a weighting scheme based on the penetration of project types (renovation, addition, or renovation and addition), project scope (small or large), heating fuel, and climate zone (three across the state).

Table 48 shows the statewide potential savings estimates for the Massachusetts renovation and addition market, broken out by fuel type, as well as the percentage of the current baseline savings represented by the two additional baseline scenarios.

Natural gas represents the highest estimated potential savings, which is expected as the energy savings for these projects were substantially driven by heating and natural gas is the most prevalent heating fuel in the state. There are also significant potential savings associated with reducing oil consumption. As mentioned previously, this is partially driven by the assumption that oil-fired homes undergoing HVAC upgrades would be incorporating high-efficiency heat pumps, increasing oil savings and decreasing electric savings. Therefore, total electric savings in the table below represent a net value taking these negative electric heating savings into account. Shifting to the adjusted baseline scenario would have a small effect on potential savings, while shifting to the ISP baseline would have a sizable impact, particularly in terms of reducing natural gas and propane savings.

Table 48: Statewide Potential Savings by Fuel (MMBTU)

Fuel	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Electric	352,440	349,186	99%	274,173	78%
Natural gas	712,713	681,163	96%	411,251	58%
Oil	546,535	487,978	89%	337,631	63%
Propane	57,016	54,493	96%	32,900	58%
Total	**1,668,704**	**1,572,820**	**94%**	**1,055,955**	**63%**

*This number is slightly lower than the total by end use in the table below due to small lighting interactive effects in the energy models.

Table 49 shows the statewide potential savings estimates by end use. Reducing heating consumption represents the vast majority of potential savings (86% of statewide savings in the current and adjusted baseline scenarios and 79% in the ISP baseline scenario). Potential savings from domestic hot water savings are limited in comparison but remain relatively consistent across all baseline scenarios. Cooling savings are negligible due to the overall low use of cooling and low cooling loads, as well as the fact that some models were designed without cooling. Lighting savings remain consistent across all baseline scenarios; lighting savings are based on the program replacing all lights in a home, not just the renovated portion.[26]

Table 49: Statewide Potential Savings by End Use (MMBTU)

End Use	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Heat					
Electric	162,984	162,984	100%	89,430	55%
Natural gas	668,879	647,707	97%	377,840	56%
Oil	546,535	487,978	89%	337,631	62%
Propane	53,510	51,817	97%	30,227	56%
Heat Total	**1,431,908**	**1,350,485**	**94%**	**835,128**	**58%**
Domestic Hot Water					
Electric	35,807	35,807	100%	35,801	100%
Natural gas	43,834	33,456	76%	33,411	76%
Propane	3,505	2,676	76%	2,673	76%
DHW Total	**83,147**	**71,939**	**86%**	**71,885**	**86%**
Other Electric					
Cooling	7,618	4,364	57%	2,911	38%
Lighting	146,547	146,547	100%	146,547	100%
Total	**1,669,219**	**1,573,335**	**94%**	**1,056,470**	**63%**

Table 50 presents estimated statewide potential savings by project type. Despite having the smallest potential savings at the project level, renovation-only projects represent the largest statewide savings as they are the most prevalent project type. We estimate 32,938 qualifying renovation only projects statewide and modeled both small (500 sq. ft.) and large (1,500 sq. ft.) projects. Savings for renovation projects would also be the most negatively affected by adopting the ISP baseline, as it assumes contractors would improve insulation levels substantially even without the program. We estimate 13,968 qualifying addition only projects and modeled both small (500 sq. ft.) and large (1,000 sq. ft.) projects. Addition-only projects represent the smallest potential savings at the project and state levels, regardless of the baseline scenario. Potential savings are limited for addition-only projects because they were compared to the RNC UDRH, a relatively efficient baseline. Despite showing the largest potential savings at the project level, renovation and addition projects have lower potential savings when scaled to the state level as

[26] Under this program design, the potential savings from lighting in the remainder of the home (the part not being renovated or added) would in theory be savings that could be considered potential lighting savings for the PAs' weatherization programs.

they are the least prevalent project type, based on our market analysis. We estimate 8,595 renovation and addition projects, and modeled both small (500 sq. ft. renovation, 500 sq. ft. addition) and large (875 sq. ft. renovation, 875 sq. ft. addition) projects.

Table 50: Statewide Potential Savings by Project Type (MMBTU)

Fuel	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Renovation Only - 32,937 estimated projects					
Electric	225,684	225,684	100%	165,532	73%
Natural gas	530,210	517,062	98%	292,683	55%
Oil	333,160	297,464	89%	166,064	50%
Propane	42,415	41,365	98%	23,415	55%
Total	**1,131,460**	**1,081,576**	**96%**	**647,694**	**57%**
Addition Only - 13,968 estimated projects					
Electric	59,099	59,082	100%	59,082	100%
Natural gas	46,078	42,287	92%	42,287	92%
Oil	18,424	16,450	89%	16,450	89%
Propane	3,686	3,383	92%	3,383	92%
Total	**127,287**	**121,202**	**95%**	**121,202**	**95%**
Renovation and Addition – 8,595 estimated projects					
Electric	67,656	64,419	95%	49,558	73%
Natural gas	136,434	121,813	89%	76,281	56%
Oil	194,952	174,065	89%	155,118	80%
Propane	10,915	9,745	89%	6,102	56%
Total	**409,957**	**370,042**	**90%**	**287,059**	**70%**

Estimated potential savings by PA territory can be found in Appendix A.6.

Appendix A Detailed Methodology

This appendix provides additional methodological detail for the research tasks included in the study.

A.1 Market Sizing

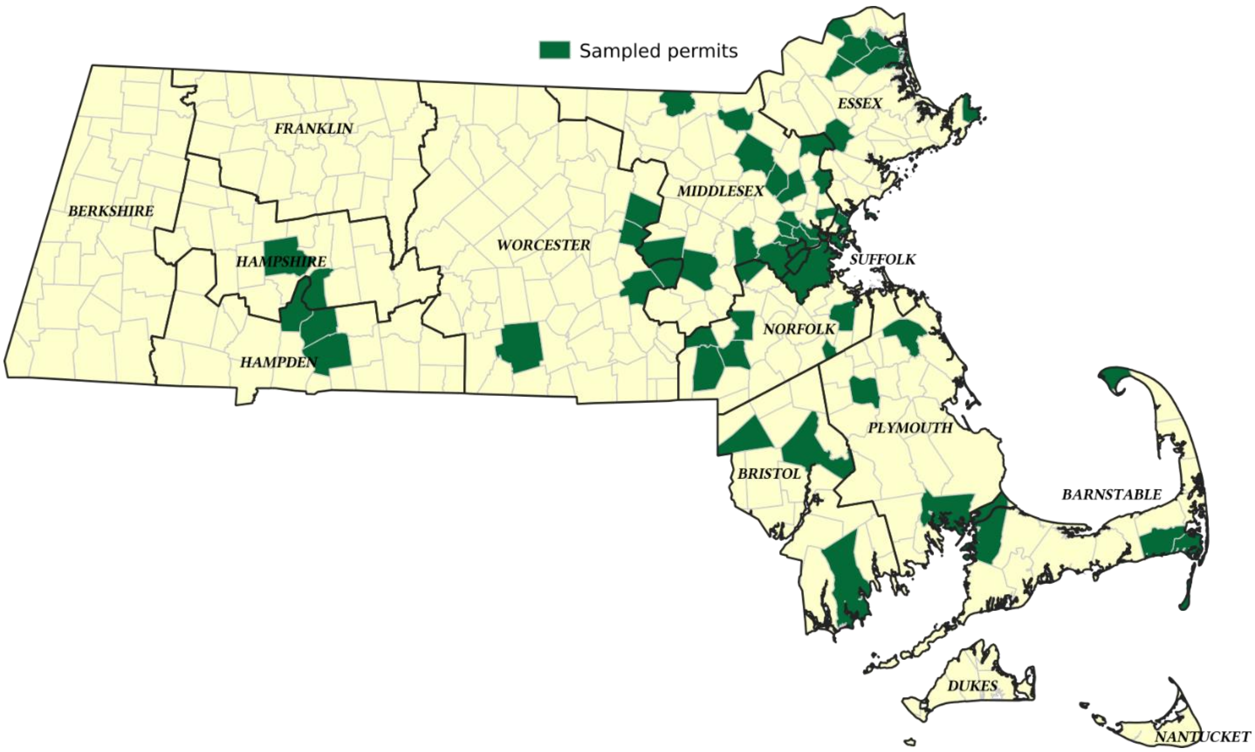
This section details the methodology that we used to develop an estimate of the market size for single-family renovations and additions in Massachusetts, including the online permit database review. The original scope of work for this study included in-person visits to building departments. However, after careful consideration and consulting with the PAs and EEAC, NMR determined that it would be more beneficial to conduct a robust review of online permits.

A.1.1 Online Permit Database Sample

Geographic distribution. NMR reviewed building department websites for each of the 351 municipalities in Massachusetts. Fifty-six of the 351 cities and towns (16%) had online databases that included permit records with some summary description of the type of work being permitted.[27] These 56 municipalities are mapped in Figure 12. NMR pulled online permit records for the full 2017 calendar year, when available.

[27] Four more municipalities had online databases, but they did not provide any aggregated or summary information of online records, meaning the reviewer had to open each permit record individually to ascertain what the permit covered. These databases were not included in our analyses.

Figure 12: Municipalities with Online Databases



The 56 municipalities are geographically dispersed across the state and nearly match the original building department visits sampling plan. We developed the original sampling plan for building department visits based on the number of contractors engaged in either renovation or RNC activities per county. Table 51 compares the original building department sampling plan targets with the number of online permit databases available for inclusion in this analysis. We generally met the original sampling targets. We failed to meet the county targets in two counties, but met or exceeded the initial targets for the other 12 counties.

Table 51: Sampling Plan Targets Compared with Online Permit Databases

County	Original Building Department Visit Sampling Plan	Online Permit Databases	Delta
Middlesex	9	17	8
Essex	4	9	5
Norfolk	4	8	4
Hampden	1	3	2
Hampshire	0	2	2
Bristol	2	3	1
Plymouth	2	3	1
Worcester	4	5	1
Barnstable	4	4	0
Franklin	0	0	0
Nantucket	0	0	0
Suffolk	2	2	0
Berkshire	1	0	-1
Dukes	1	0	-1
Total	**34**	**56**	

Stretch Code as a sign of potential bias. We wanted to ensure that using online permit databases (rather than in-person building department visits) did not introduce unwanted bias into the data collection effort. Accordingly, we investigated whether municipalities with online databases were more or less likely to be stretch code municipalities. As Table 52 shows, the stretch code penetration among municipalities with and without online databases is comparable and show no significant differences at the 90% confidence interval.

Table 52: Stretch Code Adoption

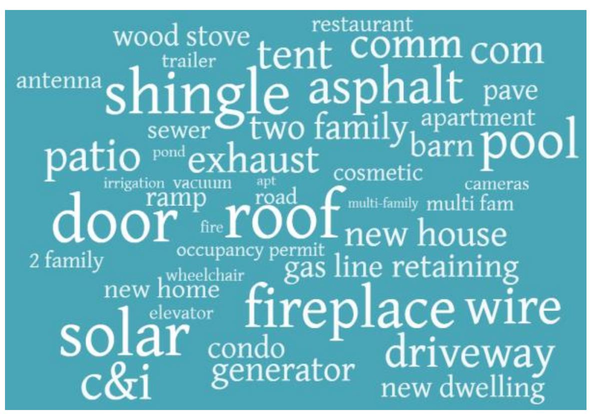
	Municipalities	% Stretch Code	% Non-Stretch Code
Municipalities with online database	56	75%	25%
Municipalities without online database	295	67%	33%

Database formats. While some municipalities provide permit records in spreadsheet form for download, others do not. Accordingly, NMR downloaded available permit records in whatever format they were made available: spreadsheets, PDF files, or manual data pulls from the website or html code. When available, we extracted the following variables from the permit databases: date issued, address, permit type, permit description, and project cost. Ten of the municipalities used the same permit database software, allowing for consistent data aggregation. Twelve of the 56 municipalities with permit data were *count only*, meaning the data contained no description of the permit except for whether it covered a renovation, addition, or both.

Record filtering and keyword analysis. The online permit databases included permit types that were not relevant to this project. Accordingly, we filtered the available permit data to only include renovations and additions for single-family homes. We conducted an iterative keyword analysis to identify relevant permit records. NMR first identified potentially relevant records by filtering permit records within the databases based on the provided permit descriptions. We completed keyword filtering for 44 of the 56 municipalities that had exportable descriptions of the permit data. Relevant permit records were identified manually in the databases of the other 12 municipalities as those databases did not include a filtering function. Figure 13 shows keywords that we used to flag permits that had the potential to be an addition and/or renovation, while Figure 14 shows keywords that we used to flag potentially irrelevant permit records. The keyword analysis was a highly iterative process; we continually reviewed permit records to ensure projects with relevant keywords were included or excluded, as appropriate.

Figure 13: Keywords Included in Initial Filtering

Figure 14: Keywords to Flag for Possible Exclusion from Analysis



Using available data from the online databases, NMR grouped the permits into four separate categories: renovation only, addition only, renovation *and* addition (a project that contained both components), and renovation *or* addition (a project that contained at least one of the components, but the record was initially unclear). We manually reviewed descriptions of permits tentatively binned into the *renovation or addition* category to properly classify the permit record.

Permit records for relevant timeframe. NMR gathered all 2017 permit data from each municipality when available, but four of the 56 municipalities did not make that much data available. We created a full year estimate for those municipalities by assuming that monthly permit activity would have followed trends from the other municipalities. For example, if a town did not have permit records for January 2017, we assumed that construction activity in January would represent the same portion of its annual permits, as was the average for January among the other municipalities. We applied these monthly estimates to the four municipalities that did not have a complete year of data. Table 53 shows the average percentage of renovation and addition permits by month used for imputing values.

Table 53: Monthly 2017 R&A Permit Activity

Month	Renovation	Addition	Renovation and Addition
January	8.2%	8.1%	6.7%
February	7.1%	6.3%	7.4%
March	8.8%	8.7%	8.0%
April	8.4%	8.1%	9.0%
May	9.7%	9.6%	9.5%
June	8.8%	9.3%	10.3%
July	8.9%	8.1%	8.7%
August	9.0%	9.5%	9.9%
September	7.8%	7.8%	8.3%
October	8.9%	9.4%	8.3%
November	8.2%	8.4%	8.1%
December	6.3%	6.8%	5.8%

A.1.2 Analysis Methods for Online Permit Databases

This section describes the methods we used to estimate the count of renovation and addition permits for municipalities lacking permit databases, given that only 56 of the 351 municipalities had such databases online.

Using Census data to predict permit activity. NMR investigated the relationship between demographic variables for Massachusetts municipalities using Census data (independent variables) and the number of renovation and addition permits (as dependent variables). We conducted regression analysis on the 56 municipalities with permit data to determine the best demographic variables to use in estimating the permit counts for the municipalities without permit databases. We evaluated the p values of the independent variables, amount of variance explained (adjusted R-squared), and the model F statistic. The key independent variables the model identified were single-family home count, population density, and median income. These three independent variables had a strong effect on the dependent variables (permit counts for renovations, additions, and permits covering both). The adjusted R-square values indicated that the regression model explained about 75% of the variation in the permit count estimates (the dependent variable).

We considered using population as a predictor of permit activity, but ultimately excluded it from the model due to multicollinearity between single-family home counts and population. These two variables were too highly correlated; incorporating both would have biased the regression model.

Therefore, NMR estimated renovation and addition permit counts for the 295 municipalities without online permit databases by applying adjustment factors (ratios) to each municipality's single-family home count, median income, and population density. Table 54 shows the adjustment factors developed from the 56 municipalities with renovation and addition permit data. We calculated these factors by dividing the renovation, addition, and renovations and addition permit counts by the three census variables to create nine ratios for each of the 56 municipalities. These weighting ratios in the table below are an average for the 56 municipalities with a renovation and addition online database.

Table 54: Weighting Ratios Derived from R&A Permits with Online Databases

	Renovation	Addition	Renovation and Addition
Single-family homes ratios	0.033510	0.013345	0.004896
Median income ratios	0.004594	0.001490	0.000707
Population density ratios	0.131258	0.065888	0.023645

We used the following formulas to estimate renovation and addition permits for municipalities without an online database.

$$\textbf{\textit{Renovation Permit Estimate}} = \frac{(SFHomes \times 0.033510) + (MedIncome \times 0.004594) + (PopDensity \times 0.131258)}{3}$$

$$\textbf{\textit{Addition Permit Estimate}} = \frac{(SFHomes \times 0.013345) + (MedIncome \times 0.001490) + (PopDensity \times 0.065888)}{3}$$

$$\textbf{\textit{Renovation and Addition Estimate}} = \frac{(SFHomes \times 0.004896) + (MedIncome \times 0.000707) + (PopDensity \times 0.023645)}{3}$$

A.1.3 Total Market Size Estimates – Approach 1 and Approach 2

To develop an estimate of the total market size, including permitted and unpermitted projects, the team used two different approaches:

1. Permit data from municipal building department databases along with estimates of non-permitted projects from the web survey with general contractors; and
2. U.S. Census data on contracting companies along with the web survey with general contractors.

A.1.3.1 Approach 1: Permit Analysis + Contractor Survey

The team added the non-permitted project estimates from the contractor web survey (Table 17) to the estimates of permitted projects (Table 16), using the calculations shown below.[28]

$$\#\ of\ Reno\ Projects = Reno\ Permits\ \times\ \left(1\ +\ (1\ - \%\ Reno\ Permits)\right)$$

$$89{,}424 = 79{,}843\ \times\ \left(1\ +\ (1\ - 0.88)\right)$$

$$\#\ of\ Add\ Projects = Add\ Permits\ \times\ \left(1\ +\ (1\ - \%\ Add\ Permits)\right)$$

$$30{,}364 = 29{,}480\ \times\ \left(1\ +\ (1\ - 0.97)\right)$$

$$\#\ of\ Reno/Add\ Projects = Reno/Add\ Permits\ \times\ \left(1\ +\ (1\ - \%\ Add\ Permits)\right)$$

$$12{,}828 = 12{,}454\ \times\ \left(1\ +\ (1\ - 0.97)\right)$$

A.1.3.2 Market Size Approach 2: Census Data + Contractor Survey

The second approach entailed developing a market size estimate based on U.S. Census data (the number of remodeling companies and employees in Massachusetts – Table 20) and results from the general contractor web survey (the average number of projects completed – Table 19).

The calculations used are presented below.

Residential Remodeling Firm Multiplier

$$\#\ of\ Reno\ Projects = Avg\ \#\ of\ Renos\ \times \#\ of\ Residential\ Remodeling\ Firms$$

$$46{,}463 = 12.4\ \times\ 3{,}747$$

$$\#\ of\ Add\ Projects = Avg\ \#\ of\ Add\ \times \#\ of\ Residential\ Remodeling\ Firms$$

$$16{,}112 = 4.3\ \times\ 3{,}747$$

Residential Remodeling Employee Multiplier

$$\#\ of\ Reno\ Projects = Avg\ \#\ of\ Renos\ \times \#\ of\ Residential\ Remodeling\ Employees$$

$$125{,}104 = 12.4\ \times\ 11{,}561$$

$$\#\ of\ Add\ Projects = Avg\ \#\ of\ Add\ \times \#\ of\ Residential\ Remodeling\ Employees$$

$$49{,}712 = 4.3\ \times\ 11{,}561$$

[28] We applied the non-permitted estimate for addition projects to the renovation and addition permit estimates based on the assumption that any project including addition work is more likely to have a permit pulled.

A.2 General Contractor Survey

NMR surveyed 77 general contractors from a sample of 4,891 unique contacts, which was close to the initial goal of 100 completes (Table 55).

Table 55: General Contractor Survey Disposition Report

Disposition Report	Count
Total Invited to Participate	**4,891**
Bad contact info (letters returned)	647
Ineligible	49
Partial completes	56
Duplicate response	4
No response	4,058
Complete responses	77

The team provided the survey to general contractors between February 4 and June 19 of 2019. The survey took an average of 25 minutes to complete. Respondents were able to stop the survey and return to it later without losing their prior responses.

The survey was administered online through Qualtrics, a web-based survey software. NMR programmed and tested the survey prior to its distribution and monitored the survey in the field.

NMR primarily distributed the web link to complete the survey through postal mailers, though we sent some of the sample the invitation to complete the survey via email (when an email address was available). We worked closely with a local mailing house to distribute all postal mailings and utilized Qualtrics survey software to send the email-based invitations. NMR drafted both the advance and reminder postal mailers, which were approved by the client prior to their distribution. The mailers included language about the purpose of the study, the study sponsors, and NMR's role.

The postal mailers and emails also provided homeowners with the name and contact information of NMR and Eversource employees who they could reach out to with any questions about the study. Within the postal mailers and emails, and at the beginning of the survey, general contractors were informed that their responses would be kept confidential and would be combined with those of other respondents.

In appreciation of the respondents' time, and because the sample was considered a hard to reach group, NMR provided a digital $50 Amazon gift card to those who completed all the questions in the survey. The survey requested that the respondents enter their email addresses, which allowed NMR to electronically send the gift card to the respondents.

In order to minimize the number of general contractors contacted, we sent the survey to the sample in four waves.

The sampling plan reflects the geographic distribution of contractors active in each county in the state. To design the sampling plan, we estimated the average number of residential renovation and remodeling contractors and single-family new construction employees by Massachusetts county and by year (from 2014 through 2017) using U.S. Census data from the Bureau of Labor

Statistics.[29] We used this data to calculate the percent distribution of those employees by county and then determined an estimated number of survey completes for each county, with the goal of reaching 100 completes across all counties. We exceeded, achieved, or came close to achieving the number of needed completes for all counties. We closed the survey before achieving the estimated completes for some counties in order to adhere to timing and budgetary constraints. Table 56 includes the sampling plan details.

Table 56: General Contractor Survey Sampling Plan

County	Four-Year Average	Percent Employees by County	Estimated Completes Needed*	Number of Completes Achieved**
Barnstable	1,624	12%	12	12
Berkshire	365	3%	3	3
Bristol	906	6%	7	4
Dukes	225	2%	2	1
Essex	1,568	11%	11	9
Franklin	130	1%	1	2
Hampden	586	4%	4	9
Hampshire	219	2%	2	7
Middlesex	3471	25%	25	19
Nantucket	231	2%	2	2
Norfolk	1403	10%	10	13
Plymouth	902	6%	6	10
Suffolk	845.5	6%	6	16
Worcester	1,515	11%	11	13
Total	**13,989**	**100%**	**100**	**120**

*This column totals to more than 100 due to rounding.

**This column totals to more than the number of survey respondents (n=77) because general contractors were asked to indicate all the counties where they performed renovations and additions.

At the beginning of the survey, NMR informed respondents that they would be asked about their work as the general or primary contractor in single-family homes in Massachusetts over the past 12 months. We also told them that the focus was on the single-family renovations and additions markets.

The survey also included a screener at the beginning that asked respondents to indicate if they had served as the general contractor on any renovations or additions of single-family homes in Massachusetts over the last 12 months. If they had not served as a general or primary contractor in this capacity, they were thanked for their time and screened out of the remainder of the survey. If they indicated they had done either renovations or additions or both in this capacity, they could continue through the survey. If respondents indicated completing both renovations and additions, the survey asked them questions about both areas.

[29] U.S. Census data from the Bureau of Labor Statistics: https://data.bls.gov/cew/apps/data_views/data_views.htm#tab=Tables

Given the complex nature of the survey questions and the related complexities of the web survey programming, respondents were not forced to answer all questions. In some instances, responding contractors skipped a question when they were not forced to respond. Because of this, the sample sizes for some of the general contractor-specific findings within this report are inconsistent, though typically not differing greatly. Even though they had been informed at the beginning of the survey that they could stop at any time and return to it later, it is possible that contractors may have skipped these questions if they felt the survey was taking too much of their time. This challenge speaks to the importance of keeping surveys as focused as possible to ensure that they are not overly-burdensome to respondents. Efforts should be made to simplify surveys instruments as much as possible in future survey efforts.

A.3 HVAC Contractor In-Depth Interviews

NMR conducted in-depth interviews (IDIs) with ten HVAC contractors active in Massachusetts. The interviewers asked the HVAC contractors to provide information on a range of topics related to their residential single-family renovation and addition work, including the type of projects they typically work on, measures installed, work performed, energy-efficiency considerations and barriers, permitting, and expected changes to the market.

NMR interviewed all ten of the required HVAC contractors from a sample of 97 unique contacts (Table 57).

Table 57: HVAC Contractor IDI Disposition Report

Disposition Report	Count
Total invited to participate	97
Bad contact info	4
Screened out (not eligible)	2
Refused	6
No response	75
Complete responses	10

HVAC contractors could complete the IDI between May 6 and July 3 of 2019. Interviewers administered the interviews over the phone and it took an average of 25 minutes to complete.

Prior to initiating the interviews, NMR programmed and tested the IDI guide with Qualtrics, a web-based survey software. Interviewers then used Qualtrics to enter responses when interviewing the HVAC contractors.

NMR developed the sample by conducting an internet search for HVAC contractors active in Massachusetts. Additionally, some contractors who completed the MA renovation/addition general contractor web survey provided contact information for HVAC contractors, which we also included in the HVAC contractor sample.

NMR primarily attempted to contact the sample by phone, but when email addresses were available, we also sent introductory emails that invited the contacts to participate in the interviews. When needed, we made multiple contact attempts at various times of day in order to reach non-responsive contacts, leaving voicemails, messages, or emails, as appropriate.

NMR drafted both the advance and reminder emails, which were approved by the client prior to their distribution. The emails included language about the purpose of the study, the study sponsors, and NMR's role. It also included information about the $100 Amazon gift card that was offered to those who completed the interview. The emails also provided HVAC contractors with the name and contact information of NMR and Eversource employees who they could reach out to with any questions about the study.

A.4 Homeowner Survey

To learn more about the market for residential renovation and additions in Massachusetts, NMR conducted a survey with homeowners who had completed a renovation or addition project since the beginning of 2017. The survey asked participants to provide information on a range of topics related to their renovation and addition project, including the type of renovation and/or addition completed (measures installed, work performed), decision-making associated with the renovation or addition, familiarity with HERS scoring and incentives/rebates, energy-efficiency considerations made, and permitting.

NMR surveyed 212 homeowners from a sample of 5,353 unique contacts, which surpassed the initial goal of 200 completes (Table 58).

Table 58: Homeowner Survey Disposition Report

Disposition Report	Count
Total invited to participate	5,353
Bad contact info (letters returned)	--
Ineligible	49
Partial completes	14
Duplicate response	5
No response	5,070
Complete responses	207

The sampling plan included a target of 200 completes, with county-level quotas to obtain responses that reflect the renovation and addition activity in each county, based on the team's permit analysis delivered to the PAs in early 2019. We either exceeded or came close to achieving the number of needed completes for most counties. For those counties where we did not achieve the estimated completes, we exceeded the target number of overall completes before reaching the estimated completes for that county. Table 59 includes the sampling plan details.

Table 59: Homeowner Survey Sampling Plan

County	Total Permits Pulled	Percent Permits by County	Estimated Completes Needed	Number of Completes Achieved
Barnstable	4,683	4%	8	7
Berkshire	5,868	5%	10	--
Bristol	7,321	6%	12	13
Dukes	1,405	1%	2	--
Essex	13,004	11%	21	14
Franklin	4,243	3%	7	--
Hampden	6,829	6%	11	9
Hampshire	4,366	4%	7	9
Middlesex	25,346	21%	42	77
Nantucket	401	0%	1	--
Norfolk	11,843	10%	19	23
Plymouth	9,156	8%	15	8
Suffolk	11,065	9%	18	33
Worcester	16,249	13%	27	14
Total	**121,778**	**100%**	**200**	**207**

Homeowners could complete the survey between May 10 and July 15 of 2019. It took an average of 13 minutes to complete. Please note that once respondents began the survey, they were able to stop the survey at any time (if needed) and return to it later without losing any of their prior responses.

The survey was administered online through Qualtrics, a web-based survey software. NMR carefully programmed and tested the survey prior to its distribution and monitored the survey while in the field.

NMR distributed the web link to complete the survey by postal mailers. NMR worked closely with a local mailing house to distribute all mailings. We drafted both the advance and reminder postal mailers, which were approved by the client prior to their distribution. The mailers included language about the purpose of the study, the study sponsors, and NMR's role.

The postal mailers also provided homeowners with the name and contact information of NMR and Eversource employees who they could reach out to with any questions about the study. Within the postal mailers and at the beginning of the survey, homeowners were informed that their responses would be kept confidential and would be combined with those of other respondents.

In appreciation of the respondents' time and because the sample was considered a hard to reach group, NMR provided a digital $25 Amazon gift card to those who completed all the questions in the survey. The survey requested that the respondents enter their email addresses, which allowed NMR to electronically send the gift card to the respondents.

Within the mailers, homeowners were provided with a unique ID that they were instructed to enter when prompted during the online survey. The unique ID allowed us to more easily answer any questions respondents may have had. It also allowed us to keep track of duplicate responses as there were a handful of instances where the same household completed the survey twice. In these instances, we removed one of the duplicate responses from the final data and only provided one gift card to the household.

NMR developed the sample from publicly available permit records. In order to try to minimize the number of homeowners contacted, we sent the survey to the sample in three waves. After the first wave of mailings did not generate the required number of completes, we sent the survey to the subsequent waves of sample to achieve the needed completes.

A.5 Focus Groups

To provide more in-depth detail on the renovations and additions markets in Massachusetts, NMR conducted focus groups with builders, remodelers, and handymen across the state. These sessions were designed to shed light on the scope of projects and factors that might affect scope, drivers and barriers to different energy-efficiency upgrades that might occur during a renovation or addition, factors that affect whether a permit is pulled, and what types of program interventions would have an effect on the energy efficiency of a project.

Five focus groups were held – each in a different region of the state – to best represent the state and get a broader understanding of the market. The focus groups included a total of 24 participants from a sample of 34 (Table 60).

Table 60: Focus Group Disposition Report

Disposition Report	Count
Total invited to participate	34
No response/not available	10
Total attendees	24

The focus groups occurred between May 14 and June 27, ran for two hours, and were led by experienced NMR staff. Participants received $250 as compensation for their time and insights.

NMR developed the sample from the general contractor web survey where respondents could indicate if they were interested in attending one of the focus groups. We also completed an internet search to further build out the sample. We then reached out to potential focus group participants through email and phone calls to confirm attendance in the sessions.

A.6 Savings Potential

NMR estimated the savings potential of the renovations and additions market in Massachusetts by building energy models of prototype homes – before and after undergoing renovation and/or addition projects – and then scaling up the associated savings from each of those prototype scenarios to reflect the market of program-eligible renovation and addition projects in Massachusetts (projects that renovated or added at least 500 sq. ft. of living space). We made a range of potential savings estimates based on multiple hypothetical baseline scenarios and multiple hypothetical upgrade scenarios that would reflect program participation. The section below describes the following:

- The program's current method for calculating savings
- Prototype home energy models developed to reflect typical renovation and addition projects
- Baseline scenarios the program could use for estimating savings (including model inputs and assumptions)
- Upgrade scenarios that reflect program participation (including model inputs and assumptions)
- This study's methodology for scaling up savings from the model-level results to the broader Massachusetts market

Readers should note that the energy models created for this effort, and the resulting savings values, are only estimates and do not reflect the myriad of possibilities for how a home might be renovated or added-on to in the real world.

A.6.1 Current Program Savings Assumptions and Methodologies

The renovations and additions path uses a performance-based modeling approach to calculate savings for participant projects. Third-party verifiers (currently these are HERS raters) are required to model the savings for all renovations and additions using Ekotrope software. The modeling software requires the creation of two energy models: the initial home prior to any renovation or addition activity, and then the final project, incorporating any additions and renovation work. Within the modeling software, the final, post-renovation/addition energy model is used to calculate savings by comparing the as-built home to a home built to baseline standards, which are based on the program's assumptions (see details on assumptions in Table 61).

The Ekotrope tool has been adapted to the program's needs such that it can use a hybrid baseline for calculating savings: the renovated portion of a home can be compared to the pre-renovation conditions, and the as-built addition can be compared to an addition built to (likely less efficient) UDRH levels. Table 61 displays the current baseline assumptions and savings calculation methodology.

Table 61: Current Program Baseline Assumptions

Scenario	Baseline	Savings Calculation Method
Addition only	RNC UDRH	Compare the consumption of the home with the as-built addition to the consumption of the home as if the addition had been built to UDRH levels.
Renovation only	Pre-existing conditions	Compare the consumption of the home post-renovation to the home pre-renovation.
Renovation and addition	RNC UDRH and pre-existing conditions	Hybrid of the above methodologies. Compare the consumption of the post-renovation/addition home to a version of the home as if the addition had been built to UDRH levels and as if the home had not been renovated.

A.6.2 Prototype Model Scenarios

NMR developed a series of prototype energy models using the Ekotrope simulation tool currently being used by the program. The prototypes included three core project types:

- Renovation-only projects
- Addition-only projects
- Projects with both a renovation and addition

For each of these three core project types, NMR created prototype model variants to better represent the pool of homes being renovated and added to in Massachusetts. NMR created prototype mode variants to adjust for differences in the following:

- Affected square footage
- Scope of work
- Climate
- Heating fuel

Each prototype model reflected different variable combinations, detailed in Table 62. The combination of these details resulted in 24 prototype models for each of the core project types, yielding 72 prototype models.

Table 62: Prototype Model Scenarios

Variable	Model Variants				Model Variations	Data Source
Home size (A)	Typical single-family existing home (2,000 ft^2)				1	Evaluator judgment, HES Data and Secondary Sources*
Renovation-only model: project size/scope (B1)	Minimum eligible size (500 ft^2) w/no HVAC changes	Large project (1,500 ft^2) w/no HVAC changes			2	Program requirements; RLPNC 18-12 Surveys
Addition-only model: project size/scope (B2)	Minimum eligible size (500 ft^2) w/no HVAC changes	Large project (1,000 ft^2) w/new supplemental HVAC			2	Program requirements; RLPNC 18-12 Surveys
Renovation and Addition Model: Project Size/Scope (B3)	Average size project (1,000 ft^2) w/new supplemental HVAC	Large project (1,750 ft^2) w/new whole-home HVAC			2	RLPNC 18-12 Surveys
Climate location (C)	Amherst	Lowell	Barnstable		3	Evaluator judgement
Heating fuel (D)	Electric	Gas	Oil	Propane	4	n/a
Renovation only models (A*B1*C*D)					24	
Addition only models (A*B2*C*D)					24	
Renovation and addition models (A*B3*C*D)					24	

*Secondary sources included local RASS or weatherization studies.

A.6.3 Measure-Level Inputs for Baseline and Upgrade Energy Models

The current program baseline for the renovated portions of the existing home (i.e., alterations that do not add new conditioned floor area) reflects how those areas were built and configured prior to the renovation. However, for some measures, it may not be appropriate to use the pre-existing conditions as the savings baseline because doing so ignores ISPs, yielding an artificially inefficient baseline. Accordingly, we developed additional energy models for additional baseline scenarios to provide the PAs with an estimate of how savings might be impacted if they adopt a different baseline.

NMR assessed the savings associated with the various scenarios included in Table 62 using three different sets of baseline conditions, as compared to an upgrade scenario that reflects program participation. The three baseline scenarios include the following:

- **Current baseline:** the program's current baseline (i.e., pre-existing conditions for renovations and UDRH standards for additions)

- **Adjusted baseline:** a slightly more efficient baseline for renovation projects that assumes some improvements in a renovation would have occurred without the program; UDRH standards for an addition.
- **ISP baseline:** a substantially more efficient baseline for renovation projects that approximates standard or typical renovation practices, based on our assessment and the results of this study; UDRH standards for an addition.

For the upgrade scenarios, we developed energy models that reflected the typical upgrades associated with participation in the renovation and additions program. For renovations, we assumed that the installed measures would mirror the average measure-level performance of homes that participated in the legacy HES program. For additions, we assumed that installed measures would be similar to the performance of typical RNC program participants or would meet Mass Save incentive levels for that measure.

Table 63 outlines the data sources used to develop measure-level inputs for these three baseline scenarios and the upgrade scenario.

Table 63: Data Sources for Baseline and Upgrade Inputs

Measure	Baseline			Upgrade
	Current	*Adjusted*	*ISP*	
Renovations				
Insulation		Pre-existing conditions	Evaluator assumption*	HES Program Data
Air sealing		Pre-existing conditions	Pre-existing conditions	HES Program Data
Duct sealing		Pre-existing conditions	Pre-existing conditions	HES Program Data
Windows	Pre-existing conditions	RNC UDRH	RNC UDRH	Mass Save Incentives
Heating		ROF from TRM	ROF from TRM	Mass Save Incentives
Cooling		ROF from TRM	ROF from TRM	Mass Save Incentives
Water heating		ROF from TRM	ROF from TRM	Mass Save Incentives
Appliances		Ekotrope Defaults	Ekotrope Defaults	Ekotrope Defaults
Instant savings measures		TRM	TRM	Mass Save Incentives
Lighting		Market adoption model	Market adoption model	Market adoption model
Additions				
All	RNC UDRH			RNC Program Data

*This was based on responses to other research activities in this study that determined common practice is to insulate up to code.

Table 64 describes the measure-level inputs used in the baseline and upgrade scenarios for renovation projects. For most envelope measures, baseline conditions assume that a renovation would be focused on the immediate area being renovated, while, in the upgrade scenario, we assume that the program would improve parts of the home outside of the direct scope of the renovation, such as upgrading the entire attic, even if the renovation was limited to a smaller portion of the home. In the table below, we identify the measure-level values that were applied in the unrenovated portion of the home, the renovated portion of the home, or the whole home, as appropriate.

Table 64: Baseline and Upgrade Model Inputs for Renovations

Measure	Unit	Baseline: Current	Baseline: Adjusted	Baseline: ISP	Upgrade
Envelope					
Foundation	R-value	0			0
Slab	R-value	0			0
Attic	R-value/Grade (G1=Good, G2=Fair, G3=Poor)	15.2/G3	15.2/G3	Unrenovated: 15.2/G3 Renovated: 37.0*/G2	Whole home: 37.0/G1
Walls	R-value/Grade	6.7/G3	6.7/G3	Unrenovated: 6.7/G3 Renovated: 13.0/G2	Unrenovated: 6.7/G3 Renovated: 14.0/G1
Frame floor	R-value/Grade	5.0/G3			Whole home: 24.0/G1
Air sealing	ACH50	9.3			Whole home: 8.3
Duct sealing	CFM25	18.3			Whole home: 16.5
Windows	U-factor	0.30			Unrenovated: 0.30 Renovated: 0.27
Heating and Cooling					
Electric baseboard	COP	1.0			Mini-split heat pump (18 SEER/10 HSPF)**
Oil boiler	AFUE	75.0	84.0	84.0	Mini-split heat pump (18 SEER/10 HSPF)**
Gas/LP boiler	AFUE	80.0	82.0	82.0	Furnace (95 AFUE) and CAC (16 SEER)**
CAC	SEER	10.0	13.0	13.0	16.0**
Thermostat set points	ºF	Heating: 72; Cooling: 75			Heating: 72; Cooling: 75
Water Heating					
Electric tank	EF	0.93			HPWH (1.82 EF)**
Gas/LP tank	EF	0.55	0.62	0.62	Tankless (0.87)**
Lighting, Appliances, and Instant Savings Measures					
Lighting		MAM			MAM
Appliances		Ekotrope Defaults			Ekotrope Defaults
Flow rates		Standard			Low Flow

*Small renovations (500 sq. ft.): assumes contractor would not upgrade ceiling over unrenovated portion of home; large renovations (1,500 sq. ft): assumes contractor would insulate entire ceiling.
**Upgrade only applied to select models, as described in Table 62.

Table 65 describes the measure-level inputs used in the baseline and upgrade scenario energy models for additions.

Table 65: Baseline and Upgrade Model Inputs for Additions

Measure	Units	Baseline Inputs (UDRH Values)	Upgrade Inputs
Envelope			
Foundation	R-value	0	0
Slab	R-value	0	0
Frame floor	R-value/Grade	21.3/G2	30.3/G1
Attic	R-value/Grade	33.3/G2	41.0/G1
Walls	R-value/Grade	16.1/G2	21.1/G1
Air sealing	ACH50	3.6	2.9
Duct sealing	CFM25	3.8	2.6
Windows	U-factor	0.30	0.27
Heating and Cooling			
Gas/LP furnace	AFUE	93.8	95.0*
Heat pump	SEER/ HSPF	13.9/9.4	18.0/10.0*
CAC	SEER	13.9	16.0*
Thermostat set points	ºF	Heating: 72; Cooling: 75	Heating: 72; Cooling: 75
Water Heating			
Electric tank	EF	0.93	HPWH (1.82 EF)*
Gas/LP tank	EF	0.69	Tankless (0.87)*
Lighting, Appliances, and Instant Savings Measures			
Lighting		MAM	MAM
Appliances		Ekotrope Defaults	Ekotrope Defaults
Flow rates		Standard	Low Flow

*Upgrade only applied to select models, as described in Table 62.

A.6.4 Lighting

NMR calculated lighting savings separately from the energy simulation models to maintain consistency with the programs' methodology for calculating lighting savings. In the energy models, we left the efficient lighting saturation constant in the baseline and upgrade energy models, such that the energy models did not incorporate savings associated with lighting improvements.

We calculated savings assuming that all bulbs installed were LEDs, with an annual savings value of 37.1 kWh per bulb (consistent with the 2019 TRM for RNC LEDs). We assumed that in the upgrade scenario reflecting program participation, the program would upgrade all of the light bulbs in the home, even outside of the renovation or addition area. The lighting saturation value used for the existing portion of the home is from the 2018 MA Lighting Market Assessment; this value has likely improved since then and therefore these savings values may be slightly overstated.

Table 66: Data Sources for Lighting Saturation in Baseline Scenarios

Measure	Source	Value
Renovation Area		
% inefficient bulbs	2018 MA Lighting Market Assessment	31%
Bulbs/sq. ft.	2018 MA Lighting Market Assessment	0.032
Addition Area		
% inefficient bulbs	2019 MA RNC Baseline	10%
Bulbs/sq. ft.	2019 MA RNC Baseline	0.035

Table 67: Detailed Inputs for Lighting Savings

Renovation Type	Square Feet		Total Bulbs		Inefficient Bulbs		Lighting Savings per Home	
	R	A	R	A	R	A	*kWh*	*MMBtu*
Small renovation	2,000	0	64	0	20	0	736	2.5
Large renovation	2,000	0	64	0	20	0	736	2.5
Small addition	2,000	500	64	18	20	2	804	2.7
Large addition	2,000	1,000	64	35	20	4	873	3.0
Small renovation and addition	2,000	500	64	18	20	2	804	2.7
Large renovation and addition	2,000	875	64	31	20	3	856	2.9

A.6.5 Scaling Results to Population

NMR weighted the model simulation results by a number of different factors to determine both statewide potential and PA-specific potential for this market. NMR used the order of operations listed below to calculate market-wide savings potential.

- Energy models
  - Create all energy models, including baseline and upgrade scenarios (360 models total)
  - Complete model simulation runs
  - Develop per-home savings estimates by end use (heating, cooling, water heating, and lighting) based on the three baseline scenarios (current, adjusted, and ISP)
- Market size
  - Estimate the total permitted population of each core project type based on the results of the permit analysis (which included statewide and PA-specific estimates)
  - Adjust permit estimates based on the results of the homeowner and contractor survey to account for non-permitted projects
  - Reduce the market size to program-eligible projects (at least 500 sq. ft.), based on size estimates from the homeowner survey (approximately 55,500 program-eligible projects out of about 130,000 estimated total projects).
- Scaling results to state

- Apply per-home savings estimates to the statewide market size for each core project type, weighting each model proportionally based on the statewide prevalence of the following factors:
  - Project size (source: homeowner survey)
  - Project type (renovation and/or addition)
  - Climate (source: GIS mapping)
  - Heating fuel (source: U.S. Census)
- Develop statewide values that reflect all potential renovation and addition projects across the state, including municipal territories

Table 68, Table 69, and Table 70 show the statewide proportions used to scale up model level results by the above factors.

Table 68: Statewide Heating Fuel Prevalence

Heating Fuel	Statewide Prevalence
Electric	16%
Natural gas	50%
Oil	30%
Propane	4%

Table 69: Statewide Climate Location Prevalence

Climate Location	Statewide Prevalence
Amherst	30%
Lowell	50%
Barnstable	20%

Table 70: Statewide Project Size Prevalence

Project Type	Small		Large	
	%	*n*	%	*n*
Renovation only	38%	12,516	62%	20,421
Addition only	83%	11,593	17%	2,374
Renovation and addition	36%	3,094	64%	5,500

- Disaggregating results to PA territories
  - PA-level results generally follow the statewide approach (scaling per-home results up to the market), but results were weighted based on these PA-specific factors:
    - Climate (source: GIS mapping)
    - Project Type (renovation and/or addition)
    - Heating fuel (source: U.S. Census data, mapped to PA-territories using GIS)

- PA-level results are based on assumptions that each PA has the same mix of project sizes (large vs. small projects). While these may vary by PA, the sample sizes from the contractor and homeowner survey were not sufficient to develop robust estimates at the PA-level for this factor.

Table 71, Table 72, and Table 73 show PA specific proportions used to scale model results up to PA territories.

Table 71: Heating Fuel Prevalence by PA

Project Type	Electric	Natural Gas	Oil	Propane
National Grid	18%	54%	25%	3%
Eversource	21%	52%	24%	3%
Cape Light Compact	15%	48%	33%	4%
Unitil	13%	36%	47%	4%
Columbia Gas	15%	51%	31%	3%
Berkshire Gas	16%	36%	41%	7%
Liberty Utilities	10%	63%	24%	3%
Blackstone Gas	9%	33%	55%	3%

Table 72: Climate Location Prevalence by Electric PA

Project Type	Amherst	Lowell	Barnstable
National Grid	40%	60%	-
Eversource	30%	50%	20%
Cape Light Compact	-	-	100%
Unitil	-	100%	-

Table 73: Climate Location Prevalence by Gas PA

Project Type	Amherst	Lowell	Barnstable
National Grid	10%	70%	20%
Eversource	30%	50%	20%
Unitil	-	100%	-
Columbia Gas	30%	50%	20%
Berkshire Gas	100%	-	-
Liberty Utilities	-	-	100%
Blackstone Gas	100%	-	-

Appendix B Gross Technical Potential Savings – Detailed Findings

The following section details the estimated savings potential for the Massachusetts renovations and additions market based on methodology outlined in Appendix A.6. The estimates reflect the amount of annual savings that might be achieved if all of the program-eligible renovation and addition projects occurring in a typical year in Massachusetts participated in the program and were built to performance levels comparable to typical program projects. NMR created prototype energy models in the Ekotrope software to simulate different baseline and upgrade scenarios and calculate the energy savings between them. The team then scaled up the resulting savings from these models to the PA territory and to the state level using a weighted scheme for fuel, location, and scope.

B.1 Naming Conventions

Each prototype model run, as described in this section, follows the naming conventions described in Table 74, with a four-letter label identifying the project type, scope, climate location, and primary heating fuel.

Table 74: Model Run Naming Conventions

Project Type	Scope	Climate Location	Fuel
R = Renovation Only	S = Small	A = Amherst	E = Electric
A = Addition Only	L = Large	L = Lowell	G = Gas
RA = Renovation and Addition		B = Barnstable	O = Oil
			P = Propane

We first assessed savings at the prototype model level for each baseline scenario by subtracting upgrade scenario consumption values from baseline scenario consumption values. Table 75 describes the abbreviations used to identify the assessed fuels and end uses in the summary tables.

Table 75: Fuel and End-Use Naming Conventions

Abbreviation	Model Feature
Fuel	
E	Electric
G	Natural gas
O	Oil
P	Propane
HVAC	
HE	Heat (electric)
HG	Heat (natural gas)
HO	Heat (oil)
HP	Heat (propane)
C	Cooling
DHW	
WE	Domestic hot water (electric)
WG	Domestic hot water (natural gas)
WP	Domestic hot water (propane)
Lighting	
L	Lighting (electric)

B.2 Energy Consumption of Baseline Scenario Homes

The following tables present consumption values by fuel and end use for the three assessed baseline scenarios at the individual model level.[30]

Table 76: Baseline Home Consumption by Fuel (MMBTU)

Model Run	Current Baseline				Adjusted Baseline				ISP Baseline			
Fuel	E	G	O	P	E	G	O	P	E	G	O	P
RSAE	132.7	-	-	-	132.7	-	-	-	126.6	-	-	-
RSLE	129.3	-	-	-	129.3	-	-	-	123.4	-	-	-
RSBE	130.8	-	-	-	130.8	-	-	-	124.9	-	-	-
RSAG	21.8	144.6	-	-	21.8	139.2	-	-	21.8	131.7	-	-
RSLG	21.8	140.4	-	-	21.8	135.1	-	-	21.8	127.8	-	-
RSBG	21.8	142.2	-	-	21.8	136.9	-	-	21.8	129.6	-	-
RSAO	33.8	-	132.7	-	33.8	-	118.5	-	33.7	-	111.2	-
RSLO	33.6	-	128.4	-	33.6	-	114.7	-	33.5	-	107.6	-
RSBO	33.6	-	130.4	-	33.6	-	116.4	-	33.6	-	109.3	-
RSAP	21.8	-	-	144.6	21.8	-	-	139.2	21.8	-	-	131.7
RSLP	21.8	-	-	140.4	21.8	-	-	135.1	21.8	-	-	127.8
RSBP	21.8	-	-	142.2	21.8	-	-	136.9	21.8	-	-	129.6
RLAE	132.7	-	-	-	132.7	-	-	-	118.1	-	-	-
RLLE	129.3	-	-	-	129.3	-	-	-	115.2	-	-	-
RLBE	130.8	-	-	-	130.8	-	-	-	116.7	-	-	-
RLAG	21.8	144.6	-	-	21.8	139.2	-	-	21.8	121.4	-	-
RLLG	21.8	140.4	-	-	21.8	135.1	-	-	21.8	117.8	-	-
RLBG	21.8	142.2	-	-	21.8	136.9	-	-	21.8	119.7	-	-
RLAO	33.8	-	132.7	-	33.8	-	118.5	-	33.7	-	101.1	-
RLLO	33.6	-	128.4	-	33.6	-	114.7	-	33.5	-	97.9	-

[30] Baseline consumption values include lighting. However, the team calculated savings values for lighting outside of the Ekotrope modeling tool.

RLBO	33.6	-	130.4	-	33.6	-	116.4	-	33.5	-	99.7	-
RLAP	21.8	-	-	144.6	21.8	-	-	139.2	21.8	-	-	121.4
RLLP	21.8	-	-	140.4	21.8	-	-	135.1	21.8	-	-	117.8
RLBP	21.8	-	-	142.2	21.8	-	-	136.9	21.8	-	-	119.7
ASAE	148.2	-	-	-	148.2	-	-	-	148.2	-	-	-
ASLE	144.3	-	-	-	144.3	-	-	-	144.3	-	-	-
ASBE	145.8	-	-	-	145.8	-	-	-	145.8	-	-	-
ASAG	25.4	159.5	-	-	25.4	153.7	-	-	25.4	153.7	-	-
ASLG	25.4	154.6	-	-	25.4	148.9	-	-	25.4	148.9	-	-
ASBG	25.4	156.5	-	-	25.4	150.8	-	-	25.4	150.8	-	-
ASAO	39.5	-	145.7	-	39.5	-	130.1	-	39.5	-	130.1	-
ASLO	39.3	-	140.8	-	39.3	-	125.8	-	39.3	-	125.8	-
ASBO	39.3	-	142.8	-	39.3	-	127.5	-	39.3	-	127.5	-
ASAP	25.4	-	-	159.5	25.4	-	-	153.7	25.4	-	-	153.7
ASLP	25.4	-	-	154.6	25.4	-	-	148.9	25.4	-	-	148.9
ASBP	25.4	-	-	156.5	25.4	-	-	150.8	25.4	-	-	150.8
ALAE	142.4	-	-	-	141.8	-	-	-	141.8	-	-	-
ALLE	138.3	-	-	-	137.8	-	-	-	137.8	-	-	-
ALBE	138.3	-	-	-	137.8	-	-	-	137.8	-	-	-
ALAG	31.9	165.2	-	-	31.3	160.4	-	-	31.3	160.4	-	-
ALLG	31.6	160.1	-	-	31.1	155.4	-	-	31.1	155.4	-	-
ALBG	31.2	162.4	-	-	30.7	157.6	-	-	30.7	157.6	-	-
ALAO	65.1	-	103.5	-	64.5	-	92.4	-	64.5	-	92.4	-
ALLO	63.6	-	100.1	-	63.0	-	89.4	-	63.0	-	89.4	-
ALBO	62.4	-	101.6	-	61.9	-	90.7	-	61.9	-	90.7	-
ALAP	31.9	-	-	165.2	31.3	-	-	160.4	31.3	-	-	160.4
ALLP	31.6	-	-	160.1	31.1	-	-	155.4	31.1	-	-	155.4
ALBP	31.2	-	-	162.4	30.7	-	-	157.6	30.7	-	-	157.6
RASAE	140.4	-	-	-	139.7	-	-	-	134.8	-	-	-
RASLE	136.4	-	-	-	135.8	-	-	-	131.0	-	-	-
RASBE	136.7	-	-	-	136.1	-	-	-	131.4	-	-	-
RASAG	29.2	156.0	-	-	28.5	150.9	-	-	28.4	144.4	-	-
RASLG	29.0	151.2	-	-	28.3	146.1	-	-	28.2	139.9	-	-
RASBG	28.5	153.0	-	-	27.9	147.9	-	-	27.8	141.7	-	-
RASAO	54.2	-	115.5	-	53.5	-	103.1	-	52.8	-	98.0	-
RASLO	53.1	-	111.6	-	52.5	-	99.6	-	51.9	-	94.7	-
RASBO	52.2	-	113.1	-	51.7	-	101.0	-	51.1	-	96.0	-
RASAP	29.2	-	-	156.0	28.5	-	-	150.9	28.4	-	-	144.4
RASLP	29.0	-	-	151.2	28.3	-	-	146.1	28.2	-	-	139.9
RASBP	28.5	-	-	153.0	27.9	-	-	147.9	27.8	-	-	141.7
RALAE	141.7	-	-	-	141.1	-	-	-	131.7	-	-	-
RALLE	137.6	-	-	-	137.0	-	-	-	128.1	-	-	-
RALBE	137.6	-	-	-	137.1	-	-	-	128.2	-	-	-
RALAG	31.3	167.4	-	-	30.7	162.4	-	-	30.4	149.1	-	-
RALLG	31.0	162.2	-	-	30.4	157.3	-	-	30.2	144.4	-	-
RALBG	30.5	164.4	-	-	30.0	159.4	-	-	29.8	146.5	-	-
RALAO	62.4	-	106.1	-	61.8	-	94.7	-	59.9	-	85.9	-
RALLO	61.0	-	102.5	-	60.4	-	91.6	-	58.7	-	83.0	-
RALBO	59.9	-	104.0	-	59.4	-	92.9	-	57.7	-	84.3	-
RALAP	31.3	-	-	167.4	30.7	-	-	162.4	30.4	-	-	149.1
RALLP	31.0	-	-	162.2	30.4	-	-	157.3	30.2	-	-	144.4
RALBP	30.5	-	-	164.4	30.0	-	-	159.4	29.8	-	-	146.5

Table 77: Baseline Home Consumption by End Use (MMBTU)

Model Run	Current Baseline								Adjusted Baseline								ISP Baseline							
Fuel	HE	HG	HO	HP	C	WE	WG	WP	HE	HG	HO	HP	C	WE	WG	WP	HE	HG	HO	HP	C	WE	WG	WP
RSAE	99.6	-	-	-	-	11.7	-	-	99.6	-	-	-	-	11.7	-	-	93.4	-	-	-	-	11.7	-	-
RSLE	96.3	-	-	-	-	11.5	-	-	96.3	-	-	-	-	11.5	-	-	90.4	-	-	-	-	11.5	-	-
RSBE	97.8	-	-	-	-	11.5	-	-	97.8	-	-	-	-	11.5	-	-	91.8	-	-	-	-	11.5	-	-
RSAG	0.3	124.4	-	-	-	-	20.2	-	0.3	121.4	-	-	-	-	17.8	-	0.3	113.9	-	-	-	-	17.8	-
RSLG	0.3	120.4	-	-	-	-	20.0	-	0.3	117.5	-	-	-	-	17.6	-	0.3	110.2	-	-	-	-	17.6	-
RSBG	0.3	122.2	-	-	-	-	20.0	-	0.3	119.3	-	-	-	-	17.6	-	0.3	112.0	-	-	-	-	17.6	-
RSAO	0.6	-	132.7	-	-	11.7	-	-	0.6	-	118.5	-	-	11.7	-	-	0.6	-	111.2	-	-	11.7	-	-
RSLO	0.6	-	128.4	-	-	11.5	-	-	0.6	-	114.7	-	-	11.5	-	-	0.5	-	107.6	-	-	11.5	-	-
RSBO	0.6	-	130.4	-	-	11.5	-	-	0.6	-	116.4	-	-	11.5	-	-	0.6	-	109.3	-	-	11.5	-	-
RSAP	0.3	-	-	124.4	-	-	-	20.2	0.3	-	-	121.4	-	-	-	17.8	0.3	-	-	113.9	-	-	-	17.8
RSLP	0.3	-	-	120.4	-	-	-	20.0	0.3	-	-	117.5	-	-	-	17.6	0.3	-	-	110.2	-	-	-	17.6
RSBP	0.3	-	-	122.2	-	-	-	20.0	0.3	-	-	119.3	-	-	-	17.6	0.3	-	-	112.0	-	-	-	17.6
RLAE	99.6	-	-	-	-	11.7	-	-	99.6	-	-	-	-	11.7	-	-	85.0	-	-	-	-	11.7	-	-
RLLE	96.3	-	-	-	-	11.5	-	-	96.3	-	-	-	-	11.5	-	-	82.2	-	-	-	-	11.5	-	-
RLBE	97.8	-	-	-	-	11.5	-	-	97.8	-	-	-	-	11.5	-	-	83.7	-	-	-	-	11.5	-	-
RLAG	0.3	124.4	-	-	-	-	20.2	-	0.3	121.4	-	-	-	-	17.8	-	0.3	103.6	-	-	-	-	17.8	-
RLLG	0.3	120.4	-	-	-	-	20.0	-	0.3	117.5	-	-	-	-	17.6	-	0.3	100.3	-	-	-	-	17.6	-
RLBG	0.3	122.2	-	-	-	-	20.0	-	0.3	119.3	-	-	-	-	17.6	-	0.3	102.1	-	-	-	-	17.6	-
RLAO	0.6	-	132.7	-	-	11.7	-	-	0.6	-	118.5	-	-	11.7	-	-	0.5	-	101.1	-	-	11.7	-	-
RLLO	0.6	-	128.4	-	-	11.5	-	-	0.6	-	114.7	-	-	11.5	-	-	0.5	-	97.9	-	-	11.5	-	-
RLBO	0.6	-	130.4	-	-	11.5	-	-	0.6	-	116.4	-	-	11.5	-	-	0.5	-	99.7	-	-	11.5	-	-
RLAP	0.3	-	-	124.4	-	-	-	20.2	0.3	-	-	121.4	-	-	-	17.8	0.3	-	-	103.6	-	-	-	17.8
RLLP	0.3	-	-	120.4	-	-	-	20.0	0.3	-	-	117.5	-	-	-	17.6	0.3	-	-	100.3	-	-	-	17.6
RLBP	0.3	-	-	122.2	-	-	-	20.0	0.3	-	-	119.3	-	-	-	17.6	0.3	-	-	102.1	-	-	-	17.6
ASAE	109.3	-	-	-	-	13.8	-	-	109.3	-	-	-	-	13.8	-	-	109.3	-	-	-	-	13.8	-	-
ASLE	105.6	-	-	-	-	13.6	-	-	105.6	-	-	-	-	13.6	-	-	105.6	-	-	-	-	13.6	-	-
ASBE	107.1	-	-	-	-	13.6	-	-	107.1	-	-	-	-	13.6	-	-	107.1	-	-	-	-	13.6	-	-
ASAG	0.3	136.6	-	-	-	-	22.9	-	0.3	133.3	-	-	-	-	20.4	-	0.3	133.3	-	-	-	-	20.4	-
ASLG	0.3	132.0	-	-	-	-	22.6	-	0.3	128.8	-	-	-	-	20.1	-	0.3	128.8	-	-	-	-	20.1	-
ASBG	0.3	133.9	-	-	-	-	22.6	-	0.3	130.6	-	-	-	-	20.2	-	0.3	130.6	-	-	-	-	20.2	-
ASAO	0.7	-	145.7	-	-	13.8	-	-	0.7	-	130.1	-	-	13.8	-	-	0.7	-	130.1	-	-	13.8	-	-
ASLO	0.6	-	140.8	-	-	13.6	-	-	0.6	-	125.8	-	-	13.6	-	-	0.6	-	125.8	-	-	13.6	-	-
ASBO	0.6	-	142.8	-	-	13.6	-	-	0.6	-	127.5	-	-	13.6	-	-	0.6	-	127.5	-	-	13.6	-	-
ASAP	0.3	-	-	136.6	-	-	-	22.9	0.3	-	-	133.3	-	-	-	20.4	0.3	-	-	133.3	-	-	-	20.4
ASLP	0.3	-	-	132.0	-	-	-	22.6	0.3	-	-	128.8	-	-	-	20.1	0.3	-	-	128.8	-	-	-	20.1
ASBP	0.3	-	-	133.9	-	-	-	22.6	0.3	-	-	130.6	-	-	-	20.2	0.3	-	-	130.6	-	-	-	20.2
ALAE	97.3	-	-	-	3.8	13.8	-	-	97.3	-	-	-	3.2	13.8	-	-	97.3	-	-	-	3.2	13.8	-	-

Model Run	Current Baseline								Adjusted Baseline								ISP Baseline							
Fuel	HE	HG	HO	HP	C	WE	WG	WP	HE	HG	HO	HP	C	WE	WG	WP	HE	HG	HO	HP	C	WE	WG	WP
ALLE	93.7	-	-	-	3.5	13.6	-	-	93.7	-	-	-	3.0	13.6	-	-	93.7	-	-	-	3.0	13.6	-	-
ALBE	94.1	-	-	-	3.0	13.6	-	-	94.1	-	-	-	2.6	13.6	-	-	94.1	-	-	-	2.6	13.6	-	-
ALAG	0.5	142.4	-	-	3.8	-	22.9	-	0.5	140.0	-	-	3.2	-	20.4	-	0.5	140.0	-	-	3.2	-	20.4	-
ALLG	0.5	137.5	-	-	3.6	-	22.6	-	0.5	135.3	-	-	3.0	-	20.1	-	0.5	135.3	-	-	3.0	-	20.1	-
ALBG	0.5	139.8	-	-	3.1	-	22.6	-	0.5	137.4	-	-	2.6	-	20.2	-	0.5	137.4	-	-	2.6	-	20.2	-
ALAO	19.9	-	103.5	-	3.8	13.8	-	-	19.9	-	92.4	-	3.2	13.8	-	-	19.9	-	92.4	-	3.2	13.8	-	-
ALLO	18.9	-	100.1	-	3.5	13.6	-	-	18.9	-	89.4	-	3.0	13.6	-	-	18.9	-	89.4	-	3.0	13.6	-	-
ALBO	18.2	-	101.6	-	3.0	13.6	-	-	18.2	-	90.7	-	2.6	13.6	-	-	18.2	-	90.7	-	2.6	13.6	-	-
ALAP	0.5	-	-	142.4	3.8	-	-	22.9	0.5	-	-	140.0	3.2	-	-	20.4	0.5	-	-	140.0	3.2	-	-	20.4
ALLP	0.5	-	-	137.5	3.6	-	-	22.6	0.5	-	-	135.3	3.0	-	-	20.1	0.5	-	-	135.3	3.0	-	-	20.1
ALBP	0.5	-	-	139.8	3.1	-	-	22.6	0.5	-	-	137.4	2.6	-	-	20.2	0.5	-	-	137.4	2.6	-	-	20.2
RASAE	97.7	-	-	-	3.8	13.8	-	-	97.7	-	-	-	3.1	13.8	-	-	92.9	-	-	-	3.0	13.8	-	-
RASLE	94.2	-	-	-	3.6	13.6	-	-	94.2	-	-	-	2.9	13.6	-	-	89.5	-	-	-	2.8	13.6	-	-
RASBE	94.9	-	-	-	3.1	13.6	-	-	94.9	-	-	-	2.5	13.6		-	90.3	-	-	-	2.4	13.6	-	-
RASAG	0.3	133.1	-	-	3.9	-	22.9	-	0.3	130.5	-	-	3.2	-	20.4	-	0.3	124.0	-	-	3.0	-	20.4	-
RASLG	0.3	128.6	-	-	3.6	-	22.6	-	0.3	126.0	-	-	3.0	-	20.1	-	0.3	119.8	-	-	2.9	-	20.1	-
RASBG	0.3	130.4	-	-	3.1	-	22.6	-	0.3	127.8	-	-	2.5	-	20.2	-	0.3	121.5	-	-	2.5	-	20.2	-
RASAO	11.5	-	115.5	-	3.8	13.8	-	-	11.5	-	103.1	-	3.1	13.8	-	-	11.0	-	98.0	-	3.0	13.8	-	-
RASLO	10.9	-	111.6	-	3.6	13.6	-	-	10.9	-	99.6	-	2.9	13.6	-	-	10.4	-	94.7	-	2.8	13.6	-	-
RASBO	10.5	-	113.1	-	3.1	13.6	-	-	10.5	-	101.0	-	2.5	13.6	-	-	10.0	-	96.0	-	2.4	13.6	-	-
RASAP	0.3	-	-	133.1	3.9	-	-	22.9	0.3	-	-	130.5	3.2	-	-	20.4	0.3	-	-	124.0	3.0	-	-	20.4
RASLP	0.3	-	-	128.6	3.6	-	-	22.6	0.3	-	-	126.0	3.0	-	-	20.1	0.3	-	-	119.8	2.9	-	-	20.1
RASBP	0.3	-	-	130.4	3.1	-	-	22.6	0.3	-	-	127.8	2.5	-	-	20.2	0.3	-	-	121.5	2.5	-	-	20.2
RALAE	97.1	-	-	-	3.9	13.8	-	-	97.1	-	-	-	3.2	13.8	-	-	88.0	-	-	-	3.0	13.8	-	-
RALLE	93.5	-	-	-	3.6	13.6	-	-	93.5	-	-	-	3.0	13.6	-	-	84.7	-	-	-	2.8	13.6	-	-
RALBE	93.9	-	-	-	3.1	13.6	-	-	93.9	-	-	-	2.6	13.6	-	-	85.2	-	-	-	2.4	13.6	-	-
RALAG	0.4	144.6	-	-	3.9	-	22.9	-	0.4	142.0	-	-	3.3	-	20.4	-	0.4	128.7	-	-	3.0	-	20.4	-
RALLG	0.4	139.6	-	-	3.6	-	22.6	-	0.4	137.2	-	-	3.1	-	20.1	-	0.4	124.3	-	-	2.9	-	20.1	-
RALBG	0.4	141.7	-	-	3.2	-	22.6	-	0.4	139.2	-	-	2.6	-	20.2	-	0.4	126.3	-	-	2.5	-	20.2	-
RALAO	17.8	-	106.1	-	3.9	13.8	-	-	17.8	-	94.7	-	3.2	13.8	-	-	16.2	-	85.9	-	3.0	13.8	-	-
RALLO	16.9	-	102.5	-	3.6	13.6	-	-	16.9	-	91.6	-	3.0	13.6	-	-	15.3	-	83.0	-	2.8	13.6	-	-
RALBO	16.2	-	104.0	-	3.1	13.6	-	-	16.2	-	92.9	-	2.6	13.6	-	-	14.7	-	84.3	-	2.4	13.6	-	-
RALAP	0.4	-	-	144.6	3.9	-	-	22.9	0.4	-	-	142.0	3.3	-	-	20.4	0.4	-	-	128.7	3.0	-	-	20.4
RALLP	0.4	-	-	139.6	3.6	-	-	22.6	0.4	-	-	137.2	3.1	-	-	20.1	0.4	-	-	124.3	2.9	-	-	20.1
RALBP	0.4	-	-	141.7	3.2	-	-	22.6	0.4	-	-	139.2	2.6	-	-	20.2	0.4	-	-	126.3	2.5	-	-	20.2

B.3 Energy Consumption of Upgrade Scenario Homes

The following tables present consumption values for the upgrade scenario models, as if the homes had participated in the program.[31] Because this study created energy models for three different baseline scenarios, NMR also developed two upgrade scenario models for each model variant: one upgrade model that could be compared directly to the program's current baseline model, and one with tweaks to the mechanical systems such that it could be compared to the adjusted and ISP baseline models.

Table 78: Upgrade Scenario Home Consumption by Fuel (MMBTU)

Model Run	Upgrade to Current Baseline				Upgrade to Adjusted and ISP Baselines			
Fuel	**E***	**G**	**O**	**P**	**E***	**G**	**O**	**P**
RSAE	110.7	-	-	-	110.7	-	-	-
RSLE	107.9	-	-	-	107.9	-	-	-
RSBE	108.9	-	-	-	108.9	-	-	-
RSAG	21.8	117.0	-	-	21.8	112.3	-	-
RSLG	21.8	113.5	-	-	21.8	108.8	-	-
RSBG	21.8	114.7	-	-	21.8	110.1	-	-
RSAO	33.2	-	103.9	-	33.2	-	92.8	-
RSLO	33.0	-	100.4	-	33.0	-	89.6	-
RSBO	33.1	-	101.7	-	33.1	-	90.8	-
RSAP	21.8	-	-	117.0	21.8	-	-	112.3
RSLP	21.8	-	-	113.5	21.8	-	-	108.8
RSBP	21.8	-	-	114.7	21.8	-	-	110.1
RLAE	104.3	-	-	-	104.3	-	-	-
RLLE	101.7	-	-	-	101.7	-	-	-
RLBE	102.7	-	-	-	102.7	-	-	-
RLAG	21.7	109.0	-	-	21.7	104.5	-	-
RLLG	21.7	105.8	-	-	21.7	101.3	-	-
RLBG	21.7	107.1	-	-	21.7	102.6	-	-
RLAO	33.2	-	95.4	-	33.2	-	85.2	-
RLLO	33.0	-	92.2	-	33.0	-	82.3	-
RLBO	33.0	-	93.6	-	33.0	-	83.5	-
RLAP	21.7	-	-	109.0	21.7	-	-	104.5
RLLP	21.7	-	-	105.8	21.7	-	-	101.3
RLBP	21.7	-	-	107.1	21.7	-	-	102.6
ASAE	144.3	-	-	-	144.3	-	-	-
ASLE	140.5	-	-	-	140.5	-	-	-
ASBE	142.0	-	-	-	142.0	-	-	-
ASAG	25.4	154.7	-	-	25.4	149.0	-	-
ASLG	25.4	149.9	-	-	25.4	144.4	-	-
ASBG	25.4	151.8	-	-	25.4	146.2	-	-
ASAO	38.9	-	141.3	-	38.9	-	126.2	-
ASLO	38.7	-	136.6	-	38.7	-	121.9	-
ASBO	38.8	-	138.5	-	38.8	-	123.7	-
ASAP	25.4	-	-	154.7	25.4	-	-	149.0
ASLP	25.4	-	-	149.9	25.4	-	-	144.4

[31] Upgrade scenario consumption values from Ekotrope energy models include consumption associated with lighting use, but are held constant from the baseline scenarios. The team calculated savings values for lighting outside of the Ekotrope modeling tool.

Model Run	Upgrade to Current Baseline				Upgrade to Adjusted and ISP Baselines			
Fuel	E*	G	O	P	E*	G	O	P
ASBP	25.4	-	-	151.8	25.4	-	-	146.2
ALAE	129.9	-	-	-	129.3	-	-	-
ALLE	126.1	-	-	-	125.6	-	-	-
ALBE	126.1	-	-	-	125.6	-	-	-
ALAG	31.7	149.4	-	-	31.1	147.1	-	-
ALLG	31.4	144.6	-	-	30.9	142.4	-	-
ALBG	31.0	146.6	-	-	30.5	144.4	-	-
ALAO	56.2	-	98.7	-	55.6	-	88.1	-
ALLO	54.9	-	95.4	-	54.3	-	85.2	-
ALBO	53.7	-	96.9	-	53.3	-	86.5	-
ALAP	31.7	-	-	149.4	31.1	-	-	147.1
ALLP	31.4	-	-	144.6	30.9	-	-	142.4
ALBP	31.0	-	-	146.6	30.5	-	-	144.4
RASAE	117.7	-	-	-	117.0	-	-	-
RASLE	114.4	-	-	-	113.7	-	-	-
RASBE	114.2	-	-	-	113.7	-	-	-
RASAG	29.1	125.4	-	-	28.4	120.9	-	-
RASLG	28.8	121.4	-	-	28.2	117.0	-	-
RASBG	28.3	122.5	-	-	27.8	118.0	-	-
RASAO	50.6	-	89.8	-	50.0	-	80.2	-
RASLO	49.7	-	86.6	-	49.1	-	77.3	-
RASBO	48.9	-	87.5	-	48.4	-	78.1	-
RASAP	29.1	-	-	125.4	28.4	-	-	120.9
RASLP	28.8	-	-	121.4	28.2	-	-	117.0
RASBP	28.3	-	-	122.5	27.8	-	-	118.0
RALAE	78.2	-	-	-	78.2	-	-	-
RALLE	75.6	-	-	-	75.6	-	-	-
RALBE	73.5	-	-	-	73.5	-	-	-
RALAG	32.1	135.3	-	-	32.1	135.3	-	-
RALLG	31.8	129.4	-	-	31.8	129.4	-	-
RALBG	31.5	131.5	-	-	31.5	131.5	-	-
RALAO	78.2	-	-	-	78.2	-	-	-
RALLO	75.6	-	-	-	75.6	-	-	-
RALBO	73.5	-	-	-	73.5	-	-	-
RALAP	32.1	-	-	135.3	32.1	-	-	135.3
RALLP	31.8	-	-	129.4	31.8	-	-	129.4
RALBP	31.5	-	-	131.5	31.5	-	-	131.5

*Includes lighting consumption, which has been held constant from baseline scenario models. The team calculated lighting savings outside of Ekotrope modeling tool.

Table 79: Upgrade Scenario Home Consumption by End Use (MMBTU)*

Model Run	Upgrade to Current Baseline								Upgrade to Adjusted and ISP Baseline							
Fuel	**HE**	**HG**	**HO**	**HP**	**C**	**WE**	**WG**	**WP**	**HE**	**HG**	**HO**	**HP**	**C**	**WE**	**WG**	**WP**
RSAE	77.9	-	-	-	-	11.2	-	-	77.9	-	-	-	-	11.2	-	-
RSLE	75.3	-	-	-	-	11.0	-	-	75.3	-	-	-	-	11.0	-	-
RSBE	76.2	-	-	-	-	11.1	-	-	76.2	-	-	-	-	11.1	-	-
RSAG	0.2	97.4	-	-	-	-	19.6	-	0.2	95.1	-	-	-	-	17.3	-
RSLG	0.2	94.1	-	-	-	-	19.4	-	0.2	91.8	-	-	-	-	17.1	-
RSBG	0.2	95.3	-	-	-	-	19.4	-	0.2	93.0	-	-	-	-	17.1	-
RSAO	0.5	-	103.9	-	-	11.2	-	-	0.5	-	92.8	-	-	11.2	-	-
RSLO	0.5	-	100.4	-	-	11.0	-	-	0.5	-	89.6	-	-	11.0	-	-
RSBO	0.5	-	101.7	-	-	11.1	-	-	0.5	-	90.8	-	-	11.1	-	-
RSAP	0.2	-	-	97.4	-	-	-	19.6	0.2	-	-	95.1	-	-	-	17.3
RSLP	0.2	-	-	94.1	-	-	-	19.4	0.2	-	-	91.8	-	-	-	17.1
RSBP	0.2	-	-	95.3	-	-	-	19.4	0.2	-	-	93.0	-	-	-	17.1
RLAE	71.5	-	-	-	-	11.2	-	-	71.5	-	-	-	-	11.2	-	-
RLLE	69.1	-	-	-	-	11.0	-	-	69.1	-	-	-	-	11.0	-	-
RLBE	70.2	-	-	-	-	11.1	-	-	70.2	-	-	-	-	11.1	-	-
RLAG	0.2	89.4	-	-	-	-	19.6	-	0.2	87.2	-	-	-	-	17.3	-
RLLG	0.2	86.4	-	-	-	-	19.4	-	0.2	84.3	-	-	-	-	17.1	-
RLBG	0.2	87.7	-	-	-	-	19.4	-	0.2	85.6	-	-	-	-	17.1	-
RLAO	0.4	-	95.4	-	-	11.2	-	-	0.4	-	85.2	-	-	11.2	-	-
RLLO	0.4	-	92.2	-	-	11.0	-	-	0.4	-	82.3	-	-	11.0	-	-
RLBO	0.4	-	93.6	-	-	11.1	-	-	0.4	-	83.5	-	-	11.1	-	-
RLAP	0.2	-	-	89.4	-	-	-	19.6	0.2	-	-	87.2	-	-	-	17.3
RLLP	0.2	-	-	86.4	-	-	-	19.4	0.2	-	-	84.3	-	-	-	17.1
RLBP	0.2	-	-	87.7	-	-	-	19.4	0.2	-	-	85.6	-	-	-	17.1
ASAE	106.0	-	-	-	-	13.3	-	-	106.0		-	-	-	13.3	-	-
ASLE	102.4	-	-	-	-	13.1	-	-	102.4	-	-	-	-	13.1	-	-
ASBE	103.9	-	-	-	-	13.1	-	-	103.9	-	-	-	-	13.1	-	-
ASAG	0.3	132.5	-	-	-	-	22.2	-	0.3	129.3	-	-	-	-	19.7	-
ASLG	0.3	128.0	-	-	-	-	21.9	-	0.3	124.9	-	-	-	-	19.5	-
ASBG	0.3	129.9	-	-	-	-	22.0	-	0.3	126.7	-	-	-	-	19.5	-
ASAO	0.6	-	141.3	-	-	13.3	-	-	0.6	-	126.2	-	-	13.3	-	-
ASLO	0.6	-	136.6	-	-	13.1	-	-	0.6	-	121.9	-	-	13.1	-	-
ASBO	0.6	-	138.5	-	-	13.1	-	-	0.6	-	123.7	-	-	13.1	-	-
ASAP	0.3	-	-	132.5	-	-	-	22.2	0.3	-	--	129.3	-	-	-	19.7
ASLP	0.3	-	-	128.0	-	-	-	21.9	0.3	-	-	124.9	-	-	-	19.5
ASBP	0.3	-	-	129.9	-	-	-	22.0	0.3	-	-	126.7	-	-	-	19.5
ALAE	92.0	-	-	-	3.6	6.8	-	-	92.0	-	-	-	3.0	6.8	-	-
ALLE	88.6	-	-	-	3.3	6.7	-	-	88.6	-	-	-	2.8	6.7	-	-
ALBE	89.0	-	-	-	2.9	6.7	-	-	89.0	-	-	-	2.4	6.7	-	-
ALAG	0.5	133.9	-	-	3.7	-	15.4	-	0.5	131.7	-	-	3.1	-	15.4	-
ALLG	0.4	129.4	-	-	3.4	-	15.2	-	0.4	127.2	-	-	2.9	-	15.2	-
ALBG	0.4	131.4	-	-	3.0	-	15.2	-	0.4	129.2	-	-	2.5	-	15.2	-
ALAO	18.3	-	98.7	-	3.6	6.8	-	-	18.3	-	88.1	-	3.0	6.8	-	-
ALLO	17.3	-	95.4	-	3.3	6.7	-	-	17.3	-	85.2	-	2.8	6.7	-	-
ALBO	16.6	-	96.9	-	2.9	6.7	-	-	16.6	-	86.5	-	2.4	6.7	-	-
ALAP	0.5	-	-	133.9	3.7	-	-	15.4	0.5	-	-	131.7	3.1	-	-	15.4
ALLP	0.4	-	-	129.4	3.4	-	-	15.2	0.4	-	-	127.2	2.9	-	-	15.2
ALBP	0.4	-	-	131.4	3.0	-	-	15.2	0.4	-	-	129.2	2.5	-	-	15.2
RASAE	75.7	-	-	-	3.7	13.3	-	-	75.7	-	-	-	3.0	13.3	-	-

Model Run	Upgrade to Current Baseline								Upgrade to Adjusted and ISP Baseline							
Fuel	**HE**	**HG**	**HO**	**HP**	**C**	**WE**	**WG**	**WP**	**HE**	**HG**	**HO**	**HP**	**C**	**WE**	**WG**	**WP**
RASLE	72.8	-	-	-	3.5	13.1	-	-	72.8	-	-	-	2.8	13.1	-	-
RASBE	73.1	-	-	-	3.0	13.1	-	-	73.1	-	-	-	2.4	13.1	-	-
RASAG	0.3	103.3	-	-	3.8	-	22.2	-	0.3	101.2	-	-	3.1	-	19.7	-
RASLG	0.2	99.5	-	-	3.5	-	21.9	-	0.2	97.5	-	-	2.9	-	19.5	-
RASBG	0.2	100.6	-	-	3.0	-	22.0	-	0.2	98.6	-	-	2.5	-	19.5	-
RASAO	8.6	-	89.8	-	3.7	13.3	-	-	8.6	-	80.2	-	3.0	13.3	-	-
RASLO	8.2	-	86.6	-	3.5	13.1	-	-	8.2	-	77.3	-	2.8	13.1	-	-
RASBO	7.8	-	87.5	-	3.0	13.1	-	-	7.8	-	78.1	-	2.4	13.1	-	-
RASAP	0.3	-	-	103.3	3.8	-	-	22.2	0.3	-	-	101.2	3.1	-	-	19.7
RASLP	0.2	-	-	99.5	3.5	-	-	21.9	0.2	-	-	97.5	2.9	-	-	19.5
RASBP	0.2	-	-	100.6	3.0	-	-	22.0	0.2	-	-	98.6	2.5	-	-	19.5
RALAE	42.4	-	-	-	2.0	6.8	-	-	42.4	-	-	-	2.0	6.8	-	-
RALLE	40.1	-			1.9	6.7	-	-	40.1	-	-	-	1.9	6.7	-	-
RALBE	38.2	-	--	-	1.7	6.7	-	-	38.2	-	-	-	1.7	6.7	-	-
RALAG	2.2	119.8	-	-	2.9	-	15.4	-	2.2	119.8	-	-	2.9	-	15.4	-
RALLG	2.1	114.2	-	-	2.7	-	15.2	-	2.1	114.2	-	-	2.7	-	15.2	-
RALBG	2.2	116.3	-	-	2.4	-	15.2	-	2.2	116.3	-	-	2.4	-	15.2	-
RALAO	42.4	-	-	-	2.0	6.8	-	-	42.4	-	-	-	2.0	6.8	-	-
RALLO	40.1	--	-	-	1.9	6.7	-	-	40.1	-	-	-	1.9	6.7	-	-
RALBO	38.2	-	-	-	1.7	6.7	-	-	38.2	-	-	-	1.7	6.7	-	-
RALAP	2.2	-	-	119.8	2.9	-	-	15.4	2.2	-	-	119.8	2.9	-	-	15.4
RALLP	2.1	-	-	114.2	2.7	-	-	15.2	2.1	-	-	114.2	2.7	-	-	15.2
RALBP	2.2	-	-	116.3	2.4	-	-	15.2	2.2	-	-	116.3	2.4	-	-	15.2

*Excludes lighting consumption. Lighting savings were calculated outside of Ekotrope modeling tool.

B.4 Energy Savings of Individual Home Prototypes

The following tables present the savings for the modeled prototype homes. Because we modeled three different baseline scenarios, there are three different savings values presented for each model.

Table 80: Model-Level Savings by Fuel (MMBTU)

Model Run	Current Baseline				Adjusted Baseline				ISP Baseline			
Fuel	E	G	O	P	E	G	O	P	E	G	O	P
RSAE	22.0	-	-	-	22.0	-	-	-	15.9	--	-	-
RSLE	21.5	-	-	-	21.5	-	-	-	15.5	-	-	-
RSBE	22.0	-	-	-	22.0	-	-	-	16.0	-	-	-
RSAG	-	27.6	-	-	-	26.9	-	-	-	19.4	-	-
RSLG	-	26.9	-	-	-	26.2	-	-	-	19.0	-	-
RSBG	-	27.5	-	-	-	26.8	-	-	-	19.6	-	-
RSAO	0.6	-	28.8	-	0.6	-	25.7	-	0.5	-	18.4	-
RSLO	0.5	-	28.1	-	0.5	-	25.1	-	0.5	-	18.0	-
RSBO	0.5	-	28.7	-	0.5	-	25.7	-	0.5	-	18.6	-
RSAP	-	-	-	27.6	-	-	-	26.9	-	-	-	19.4
RSLP	-	-	-	26.9	-	-	-	26.2	-	-	-	19.0
RSBP	-	-	-	27.5	-	-	-	26.8	-	-	-	19.6
RLAE	28.5	-	-	-	28.5	-	-	-	13.9	-	-	-
RLLE	27.7	-	-	-	27.7	-	-	-	13.6	-	-	-
RLBE	28.1	-	-	-	28.1	-	-	-	14.0	-	-	-
RLAG	0.1	35.6	-	-	0.1	34.7	-	-	-	16.9	-	-
RLLG	0.1	34.6	-	-	0.1	33.7	-	-	-	16.5	-	-
RLBG	0.1	35.1	-	-	0.1	34.3	-	-	-	17.1	-	-
RLAO	0.6	-	37.3	-	0.6	-	33.3	-	0.5	-	16.0	-
RLLO	0.6	-	36.3	-	0.6	-	32.4	-	0.5	-	15.6	-
RLBO	0.6	-	36.8	-	0.6	-	32.9	-	0.5	-	16.1	-
RLAP	0.1	-	-	35.6	0.1	-	-	34.7	-	-	--	16.9
RLLP	0.1	-	-	34.6	0.1	-	-	33.7	-	-	-	16.5
RLBP	0.1	-	-	35.1	0.1	-	-	34.3	-	-	-	17.1
ASAE	3.9	-	-	-	3.9	-	-	--	3.9	-	-	-
ASLE	3.7	-	-	-	3.7	-	-	-	3.7	-	-	-
ASBE	3.8	-	-	-	3.8	-	-	-	3.8	-	-	-
ASAG	-	4.8	-	-	-	4.7	-	-	-	4.7	-	-
ASLG	-	4.7	-	-	-	4.6	-	-	-	4.6	-	-
ASBG	-	4.7	-	-	-	4.6	-	-	-	4.6	-	-
ASAO	0.6	-	4.4	-	0.6	-	3.9	-	0.6	-	3.9	-
ASLO	0.6	-	4.3	-	0.6	-	3.8	-	0.6	-	3.8	-
ASBO	0.6	-	4.3	-	0.6	-	3.9	-	0.6	-	3.9	-
ASAP	-	-	-	4.8	-	-	--	4.7	-	-	-	4.7
ASLP	-	-	-	4.7	-	-	-	4.6	-	-	-	4.6
ASBP	-	-	-	4.7	-	-	-	4.6	-	-	-	4.6
ALAE	12.5	-	-	-	12.5	-	-	-	12.5	-	-	-
ALLE	12.2	-	-	-	12.2	-	-	-	12.2	-	-	-
ALBE	12.2	-	-	-	12.2	-	-	-	12.2	-	-	-
ALAG	0.2	15.9	-	-	0.2	13.3	-	-	0.2	13.3	-	-
ALLG	0.2	15.5	-	-	0.2	13.0	-	-	0.2	13.0	-	-
ALBG	0.2	15.7	-	-	0.2	13.2	-	-	0.2	13.2	-	-
ALAO	8.9	-	4.8	-	8.9	-	4.3	-	8.9	-	4.3	-
ALLO	8.7	-	4.7	-	8.7	-	4.2	-	8.7	-	4.2	-

Model Run	Current Baseline				Adjusted Baseline				ISP Baseline			
Fuel	E	G	O	P	E	G	O	P	E	G	O	P
ALBO	8.7	-	4.8	-	8.7	-	4.3	-	8.7	-	4.3	-
ALAP	0.2	-	-	15.9	0.2	-	-	13.3	0.2	-	-	13.3
ALLP	0.2	-	-	15.5	0.2	-	-	13.0	0.2	-	-	13.0
ALBP	0.2	-	-	15.7	0.2	-	-	13.2	0.2	-	-	13.2
RASAE	22.7	-	-	-	22.7	-	-	-	17.8	-	-	-
RASLE	22.1	-	-	-	22.1	-	-	-	17.3	-	-	-
RASBE	22.4	-	-	-	22.4	-	-	-	17.7	-	-	-
RASAG	0.2	30.6	-	-	0.2	30.0	-	-	-	23.5	-	-
RASLG	0.1	29.8	-	-	0.1	29.2	-	-	-	22.9	-	-
RASBG	0.1	30.5	-	-	0.1	29.9	-	-	-	23.6	-	-
RASAO	3.6	-	25.6	-	3.6	-	22.9	-	2.9	-	17.8	-
RASLO	3.4	-	25.0	-	3.4	-	22.3	-	2.8	-	17.4	-
RASBO	3.3	-	25.6	-	3.3	-	22.9	-	2.7	-	17.9	-
RASAP	0.2	-	-	30.6	0.2	-	-	30.0	-	-	-	23.5
RASLP	0.1	-	-	29.8	0.1	-	-	29.2	-	-	-	22.9
RASBP	0.1	-	-	30.5	0.1	-	-	29.9	-	-	-	23.6
RALAE	63.5	-	-	-	62.9	-	-	-	53.6	-	-	-
RALLE	62.0	-	-	-	61.4	-	-	-	52.5	-	-	-
RALBE	64.1	-	-	-	63.6	-	-	-	54.7	-	-	-
RALAG	-0.8	32.2	-	-	-1.4	27.1	-	-	-1.7	13.8	-	-
RALLG	-0.8	32.8	-	-	-1.4	27.9	-	-	-1.6	15.1	-	-
RALBG	-0.9	32.8	-	-	-1.5	27.9	-	-	-1.7	14.9		-
RALAO	-15.7	-	106.1	-	-16.4	-	94.7	-	-18.3	-	85.9	-
RALLO	-14.6	-	102.5	-	-15.2	-	91.6	-	-16.9	-	83.0	-
RALBO	-13.6	-	104.0	-	-14.1	-	92.9	-	-15.8	-	84.3	-
RALAP	-0.8	-	-	32.2	-1.4	-	--	27.1	-1.7	-	--	13.8
RALLP	-0.8	-	-	32.8	-1.4	-	-	27.9	-1.6	-	-	15.1
RALBP	-0.9	-	-	32.8	-1.5	-	-	27.9	-1.7	-	-	14.9

Table 81: Model-Level Savings by End Use (MMBTU)

Model Run	Current Baseline								Adjusted Baseline								ISP Baseline								Lighting (All)
End Use	HE	HG	HO	HP	C	WE	WG	WP	HE	HG	HO	HP	C	WE	WG	WP	HE	HG	HO	HP	C	WE	WG	WP	L
RSAE	21.6	-	-	-	-	0.5	-	-	21.6	-	-	-	-	0.5	-	-	15.5	-	-	-	-	0.5	-	-	2.5
RSLE	21.1	-	-	-	-	0.5	-	-	21.1	-	-	-	-	0.5	-	-	15.1	-	-	-	-	0.5	-	-	2.5
RSBE	21.6	-	-	-	-	0.4	-	-	21.6	-	-	-	-	0.4	-	-	15.6	-	-	-	-	0.4	-	-	2.5
RSAG	0.1	27.0	-	-	-	-	0.6	-	0.1	26.3	-	-	-	-	0.6	-	-	18.8	-	-	-	-	0.6	-	2.5
RSLG	0.1	26.3	-	-	-	-	0.6	-	0.1	25.7	-	-	-	-	0.6	-	-	18.4	-	-	-	-	0.6	-	2.5
RSBG	0.1	26.9	-	-	-	-	0.6	-	0.1	26.3	-	-	-	-	0.5	-	-	19.0	-	-	-	-	0.5	-	2.5
RSAO	0.1	-	28.8	-	-	0.5	-	-	0.1	-	25.7	-	-	0.5	-	-	0.1	-	18.4	-	-	0.5	-	-	2.5
RSLO	0.1	-	28.1	-	-	0.5	-	-	0.1	-	25.1	-	-	0.5	-	-	0.1	-	18.0	-	-	0.5	-	-	2.5
RSBO	0.1	-	28.7	-	-	0.4	-	-	0.1	-	25.7	-	-	0.4	-	-	0.1	-	18.6	-	-	0.4	-	-	2.5
RSAP	0.1	-	-	27.0	-	-	-	0.6	0.1	-	-	26.3	-	-	-	0.6	-	-	-	18.8	-	-	-	0.6	2.5
RSLP	0.1	-	-	26.3	-	-	-	0.6	0.1	-	-	25.7	-	-	-	0.6	-	-	-	18.4	-	-	-	0.6	2.5
RSBP	0.1	-	-	26.9	-	-	-	0.6	0.1	-	-	26.3	-	-	-	0.5	-	-	-	19.0	-	-	-	0.5	2.5
RLAE	28.0	-	-	-	-	0.5	-	-	28.0	-	-	-	-	0.5	-	-	13.4	-	-	-	-	0.5	-	-	2.5
RLLE	27.2	-	-	-	-	0.5	-	-	27.2	-	-		-	0.5	-	-	13.1	-	-	-	-	0.5	-	-	2.5
RLBE	27.6	-	-	-	-	0.5	-	-	27.6	-	-		-	0.5	-	-	13.6	-	-	-	-	0.5	-	-	2.5
RLAG	0.1	35.0	-	-	-	-	0.6	-	0.1	34.2	-		-	-	0.6	-	-	16.4	-	-	-	-	0.6	-	2.5
RLLG	0.1	34.0	-	-	-	-	0.6	-	0.1	33.2	-		-	-	0.6	-	-	16.0	-	-	-	-	0.5	-	2.5
RLBG	0.1	34.5	-	-	-	-	0.6	-	0.1	33.7	-		-	-	0.5	-	-	16.5	-	-	-	-	0.5	-	2.5
RLAO	0.2	-	37.3	-	-	0.5	-	-	0.2	-	33.3		-	0.5	-	-	0.1	-	16.0	-	-	0.5	-	-	2.5
RLLO	0.2	-	36.3	-	-	0.5	-	-	0.2	-	32.4		-	0.5	-	-	0.1	-	15.6	-	-	0.5	-	-	2.5
RLBO	0.2	-	36.8	-	-	0.5	-	-	0.2	-	32.9		-	0.5	-	-	0.1	-	16.1	-	-	0.5	-	-	2.5
RLAP	0.1	-	-	35.0	-	-	-	0.6	0.1	-	-	34.2	-	-	-	0.6	-	-	-	16.4	-	-	-	0.6	2.5
RLLP	0.1	-	-	34.0	-	-	-	0.6	0.1	-	-	33.2	-	-	-	0.6	-	-	-	16.0	-	-	-	0.5	2.5
RLBP	0.1	-	-	34.5	-	-	-	0.6	0.1	-	-	33.7	-	-	-	0.5	-	-	-	16.5	-	-	-	0.5	2.5
ASAE	3.3	-	-	-	-	0.6	-	-	3.3	-	-	-	-	0.6	-	-	3.3	-	-	-	-	0.6	-	-	2.7
ASLE	3.2	-	-	-	-	0.5	-	-	3.2	-	-	-	-	0.5	-	-	3.2	-	-	-	-	0.5	-	-	2.7
ASBE	3.2	-	-	-	-	0.5	-	-	3.2	-	-	-	-	0.5	-	-	3.2	-	-	-	-	0.5	-	-	2.7
ASAG	-	4.1	-	-	-	-	0.7	-	-	4.0	-	-	-	-	0.7	-	-	4.0	-	-	-	-	0.7	-	2.7
ASLG	-	4.0	-	-	-	-	0.7	-	-	3.9	-	-	-		0.6	-	-	3.9	-	-	-	-	0.6	-	2.7
ASBG	-	4.1	-	-	--	-	0.7	-	-	4.0	-	-	-		0.6	-	-	4.0	-	-	-	-	0.6	-	2.7
ASAO	-	-	4.4	-		0.6	-	-	-	-	3.9	-	-	0.6	-	-	-	-	3.9	-	-	0.6	-	-	2.7
ASLO	-	-	4.3	-	-	0.5	-	-	-	-	3.8	-	-	0.5	-	-	-	-	3.8	-	-	0.5	-	-	2.7
ASBO	-	-	4.3	-	-	0.5	-	-	-	-	3.9	-	-	0.5	--	-	-	-	3.9	-	-	0.5	-	-	2.7
ASAP	-	-	-	4.1	-	-	-	0.7	-	-	-	4.0	-	-	-	0.7	-	-	-	4.0	-	-	-	0.7	2.7
ASLP	-	-	-	4.0	-	-	-	0.7	-	-	-	3.9	-	-	-	0.6	-	-	-	3.9	-	-	-	0.6	2.7
ASBP	-	-	-	4.1	-	-	-	0.7	-	-	-	4.0	-	-	-	0.6	-	-	-	4.0	-	-	-	0.6	2.7
ALAE	5.3	-	-	--	0.2	7.0	-	-	5.3	-	-	-	0.2	7.0	-	-	5.3	-	-	-	0.2	7.0	-	-	3.0
ALLE	5.1	-	-	-	0.2	6.9	-	-	5.1	-	-	-	0.2	6.9	-	-	5.1	-	-	-	0.2	6.9	-	-	3.0
ALBE	5.1	-	-	-	0.2	6.9	-	-	5.1	-	-	-	0.2	6.9	-	-	5.1	-	-	-	0.2	6.9	-	-	3.0

NMR Group, Inc.

Model Run	Current Baseline								Adjusted Baseline								ISP Baseline								Lighting (All)
End Use	HE	HG	HO	HP	C	WE	WG	WP	HE	HG	HO	HP	C	WE	WG	WP	HE	HG	HO	HP	C	WE	WG	WP	L
ALAG	-	8.5	-	-	0.2	-	7.4	-	-	8.4	-	-	0.2	-	5.0	-	-	8.4	-	-	0.2	-	5.0	-	3.0
ALLG	-	8.1	-	-	0.2	-	7.4	-	-	8.0	-	-	0.1	-	4.9		-	8.0	-	-	0.1	-	4.9	-	3.0
ALBG	-	8.3	-	-	0.1	-	7.4	-	-	8.2	-	-	0.1	-	5.0	-	-	8.2	-	-	0.1	-	5.0	-	3.0
ALAO	1.7	-	4.8	-	0.2	7.0	-	-	1.7	-	4.3	-	0.2	7.0	-	-	1.7	-	4.3	-	0.2	7.0	-	-	3.0
ALLO	1.6	-	4.7	-	0.2	6.9	-	-	1.6	-	4.2	-	0.2	6.9	-	-	1.6	-	4.2	-	0.2	6.9	-	-	3.0
ALBO	1.6	-	4.8	-	0.2	6.9	-	-	1.6	-	4.3	-	0.2	6.9	-	-	1.6	-	4.3	-	0.2	6.9	-	-	3.0
ALAP	-	-	-	8.5	0.2	-	-	7.4	-	-	-	8.4	0.2	-	-	5.0	-	-	-	8.4	0.2	-	-	5.0	3.0
ALLP	-	-	-	8.1	0.2	-	-	7.4	-	-	-	8.0	0.1	-	-	4.9	-	-	-	8.0	0.1	-	-	4.9	3.0
ALBP	-	-	-	8.3	0.1	-	-	7.4	-	-	-	8.2	0.1	-	-	5.0	-	-	-	8.2	0.1	-	-	5.0	3.0
RASAE	22.0	-	-	-	0.1	0.6	-	-	22.0	-	-	-	0.1	0.6	-	-	17.2	-	-	-	-	0.6	-	-	2.7
RASLE	21.4	-	-	-	0.1	0.5	-	-	21.4	-	-	-	0.1	0.5	-	-	16.7	-	-	-	-	0.5	-	-	2.7
RASBE	21.8	-	-	-	0.1	0.5	-	-	21.8	-	-	-	0.1	0.5	-	-	17.1	-	-	-	-	0.5	-	-	2.7
RASAG	0.1	29.9	-	-	0.1	-	0.7	-	0.1	29.3	-	-	0.1	-	0.7	-	0.1	22.8	-	-	-	-	0.7	-	2.7
RASLG	0.1	29.1	-	-	0.1	-	0.7	-	0.1	28.5	-	-	0.1	-	0.6	-	0.1	22.3	-	-	-	-	0.6	-	2.7
RASBG	0.1	29.8		-	0.1	-	0.7	-	0.1	29.2	-	-	0.1	-	0.7	-	0.1	23.0	-	-	-	-	0.7	-	2.7
RASAO	2.9	-	25.6	-	0.1	0.6	-	-	2.9	-	22.9	-	0.1	0.6	-	-	2.3	-	17.8	-	-	0.6	-	-	2.7
RASLO	2.8	-	25.0	-	0.1	0.5	-	-	2.8	-	22.3	-	0.1	0.5	-	-	2.2	-	17.4	-	-	0.5	-	-	2.7
RASBO	2.7	-	25.6	-	0.1	0.5	-	-	2.7	-	22.9	-	0.1	0.5	-	-	2.2	-	17.9	-	-	0.5	-	-	2.7
RASAP	0.1	-	-	29.9	0.1	-	-	0.7	0.1	-	-	29.3	0.1	-	-	0.7	0.1	-	-	22.8	-	-	-	0.7	2.7
RASLP	0.1	-	-	29.1	0.1	-	-	0.7	0.1	-	-	28.5	0.1	-	-	0.6	0.1	-	-	22.3	-	-	-	0.6	2.7
RASBP	0.1	-	-	29.8	0.1	-	-	0.7	0.1	-	-	29.2	0.1	-	-	0.7	0.1	-	-	23.0	-	-	-	0.7	2.7
RALAE	54.7	-	-	-	1.8	7.0	-	-	54.7	-	-	-	1.2	7.0	-	-	45.6	-	-	-	0.9	7.0	-	-	2.9
RALLE	53.4	-	-	-	1.7	6.9	-	-	53.4	-	-	-	1.1	6.9	-	-	44.7	-	-	-	0.9	6.9	-	-	2.9
RALBE	55.7	-	-	-	1.5	6.9	-	-	55.7	-	-	-	0.9	6.9	-	-	47.0	-	-	-	0.8	6.9	-	-	2.9
RALAG	-1.8	24.8	-	-	1.0	-	7.4	-	-1.8	22.2	-	-	0.4	-	5.0	-	-1.8	8.9	-	-	0.1	-	5.0	-	2.9
RALLG	-1.7	25.4	-	-	0.9	-	7.4	-	-1.7	23.0	-	-	0.3	-	4.9	-	-1.7	10.1	-	-	0.1	-	4.9	-	2.9
RALBG	-1.7	25.4	-	-	0.8	-	7.4	-	-1.7	22.9	-	-	0.3	-	5.0	-	-1.8	10.0	-	-	0.1	-	5.0	-	2.9
RALAO	-24.5	-	106.1	-	1.8	7.0	-	-	-24.5	-	94.7	-	1.2	7.0	-	-	-26.2	-	85.9	-	0.9	7.0	-	-	2.9
RALLO	-23.1	-	102.5	-	1.7	6.9	-	-	-23.1	-	91.6	-	1.1	6.9	-	-	-24.7	-	83.0	-	0.9	6.9	-	-	2.9
RALBO	-22.0	-	104.0	-	1.5	6.9	-	-	-22.0	-	92.9	-	0.9	6.9	-	-	-23.5	-	84.3	-	0.8	6.9	-	-	2.9
RALAP	-1.8	-	-	24.8	1.0	-	-	7.4	-1.8	-	-	22.2	0.4	-	-	5.0	-1.8	-	-	8.9	0.1	-	-	5.0	2.9
RALLP	-1.7	-	-	25.4	0.9	-	-	7.4	-1.7	-	-	23.0	0.3	-	-	4.9	-1.7	-	-	10.1	0.1	-	-	4.9	2.9
RALBP	-1.7	-	-	25.4	0.8	-	-	7.4	-1.7	-	-	22.9	0.3	-	-	5.0	-1.8	-	-	10.0	0.1	-	-	5.0	2.9

B.5 AVERAGE SAVINGS PER PROJECT

Table 82 presents mean savings values from the 72 prototype models, including how savings using the program's current baseline would be affected by switching to one of the two alternative baselines considered in this study. These values represent unweighted averages from the prototype models only, before scaling or weighting by any factors. On average, switching to the adjusted baseline, described in Appendix A.6, which mostly involved baselines with mechanical systems that were improved over the pre-existing conditions, would result in each of these prototype homes achieving about 93% of their current savings. Shifting to the ISP baseline, which assumes contractors would bring their projects up to *typical* building practices, would yield only two-thirds (67%) of the current savings levels.

Oil savings may be somewhat overstated because, in models where the HVAC system was being upgraded, we assumed the upgrade would entail switching to a ductless mini-split ASHP system, as opposed to an incrementally more efficient oil system. Models with fuel-switching resulted in negative electric savings due to the new electric heating and cooling system.

Table 82: Average Savings Per Prototype Project by Fuel (MMBTU)

Fuel	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Electric	9.0	8.9	99%	7.3	81%
Natural gas	6.1	5.7	93%	3.8	63%
Oil	8.5	7.6	89%	6.0	71%
Propane	6.1	5.7	93%	3.8	63%
Total	**29.6**	**27.8**	**93%**	**18.3**	**68%**

Table 83 presents the mean per-project savings, but with statewide weights for heating fuel, climate location, project type, and project scope applied. These values represent average project values after weighting them to represent the relative prevalence of different project types across the state.

Table 83: Weighted Savings Per Project by Fuel (MMBTU)

Fuel	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Electric	6.3	6.3	99%	4.9	78%
Natural gas	12.8	12.2	96%	7.4	58%
Oil	9.8	8.8	89%	6.1	62%
Propane	1.0	1.0	96%	0.6	58%
Total	**30.0**	**28.2**	**94%**	**19.0**	**63%**

Table 84 presents the same weighted mean savings values by end use. Reducing heating consumption is the largest driver of savings. The ISP baseline assumes that contractors would have improved the envelope and, in some cases, the mechanical systems, even without the program, yielding substantially lower heating savings for this scenario than the program's current baseline (42% lower). Regardless of the baseline scenario, domestic hot water savings are far lower than heating on average and are driven by installing more efficient systems and low flow fixtures. Cooling savings are minimal in all scenarios, partially due to generally low cooling loads, but also because some prototype homes were designed without cooling. This assessment assumes lighting savings are consistent regardless of baseline scenario, given that the program upgrades lighting throughout the home. This level of lighting upgrade would not occur in a typical renovation or addition project.

Table 84: Average Savings by End Use (MMBTU)

End Use	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Heat					
Electric	2.9	2.9	100%	1.6	55%
Natural gas	12.0	11.6	97%	6.8	56%
Oil	9.8	8.8	89%	6.1	62%
Propane	1.0	0.9	97%	0.5	56%
Heat Total	**25.7**	**24.3**	**94%**	**15.0**	**58%**
Domestic Hot Water					
Electric	0.6	0.6	100%	0.6	100%
Natural gas	0.8	0.6	76%	0.6	76%
Propane	0.1	0.1	76%	0.1	76%
DHW Total	**1.5**	**1.3**	**87%**	**1.3**	**86%**
Other Electric					
Cooling	0.1	0.1	57%	0.1	38%
Lighting	2.6	2.6	100%	2.6	100%
Other Total	**2.7**	**2.7**	**98%**	**2.7**	**97%**
Total					
Project Total	**30.0**	**28.2**	**94%**	**19.0**	**63%**

Figure 15 graphically depicts the information shown in Table 84, above. Shorter bars indicate the reduced home-level savings associated with the more efficient baseline scenarios.

Figure 15: Savings Using Alternative Baselines Relative to Current Baseline (Average per Home)

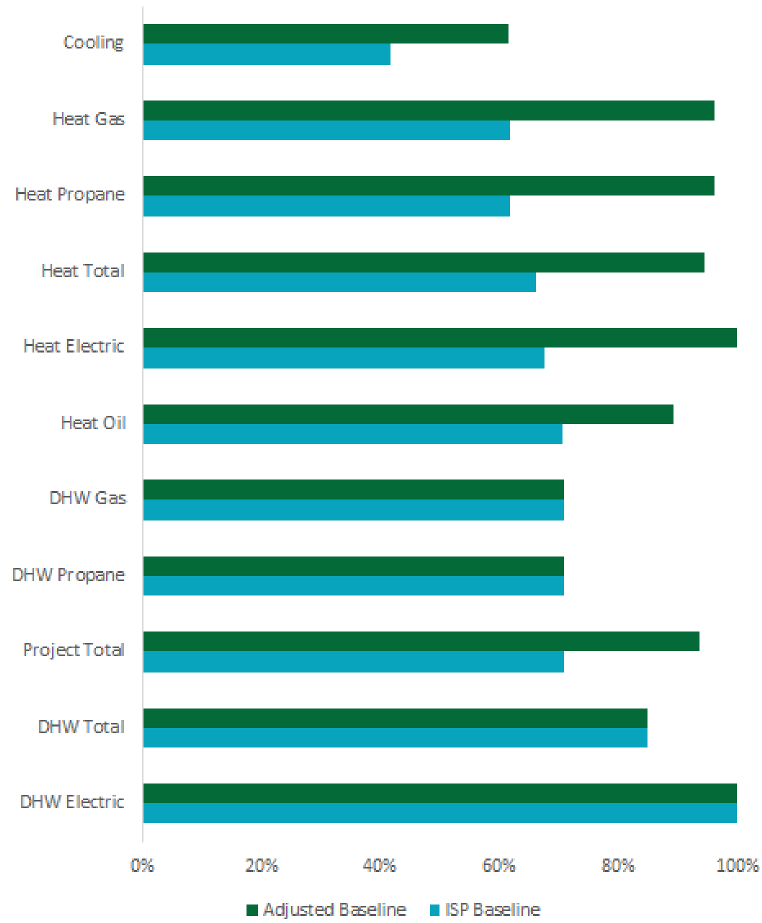


Table 85 presents the average weighted savings by project type for the modeled projects. Addition-only projects achieve the lowest savings, on average, given that addition projects are being compared to relatively efficient UDRH standards in all baseline scenarios. Logically, projects with the largest scopes – that include a renovation and addition – achieve the highest average savings, but they are more expensive projects and represent a smaller portion of the market. Adopting the ISP baseline would yield substantially lower savings for renovation projects, on average (57% of current savings for renovation-only and 70% of renovation and addition projects).

Table 85: Average Savings by Renovation Type (MMBTU)

Fuel	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Renovation Only					
Electric	6.8	6.8	100%	5.0	73%
Natural gas	16.0	15.6	98%	8.8	55%
Oil	10.1	9.0	89%	5.0	50%
Propane	1.3	1.2	98%	0.7	55%
Total	**34.2**	**32.7**	**96%**	**19.6**	**57%**
Addition Only					
Electric	4.2	4.2	100%	4.2	100%
Natural gas	3.3	3.0	92%	3.0	92%
Oil	1.3	1.2	89%	1.2	89%
Propane	0.3	0.2	92%	0.2	92%
Total	**9.1**	**8.7**	**95%**	**8.7**	**95%**
Renovation and Addition					
Electric	7.9	7.5	95%	5.8	73%
Natural gas	15.9	14.2	89%	8.9	56%
Oil	22.7	20.3	89%	18.0	80%
Propane	1.3	1.1	89%	0.7	56%
Total	**47.7**	**43.1**	**90%**	**33.4**	**70%**

B.6 Statewide Savings

Table 86 and Figure 16 show statewide potential savings by fuel. Natural gas represents the highest potential savings opportunity (in MMBTUs) under the current baseline scenario. Were the program to use the more efficient ISP baseline, savings from oil reductions would represent the highest opportunity. Oil savings are high in all baseline scenarios, partly based on the modeling assumption that oil HVAC systems would be replaced by heat pumps. Switching to the adjusted baseline would reduce the statewide potential savings to 94% of the potential savings under the current program baseline and savings would drop to 60% under the ISP scenario.

Table 86: Statewide Potential Savings by Fuel (MMBTU)

Fuel	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Electric	352,440	349,186	99%	274,173	78%
Natural gas	712,713	681,163	96%	411,251	58%
Oil	546,535	487,978	89%	337,631	62%
Propane	57,016	54,493	96%	32,900	58%
Total	**1,668,704***	**1,572,820**	**94%**	**1,055,955**	**63%**

*This number is slightly lower than the total by end use in the table below due to small lighting interactive effects in the energy models.

Figure 16: Statewide Potential Savings by Fuel (MMBTU)

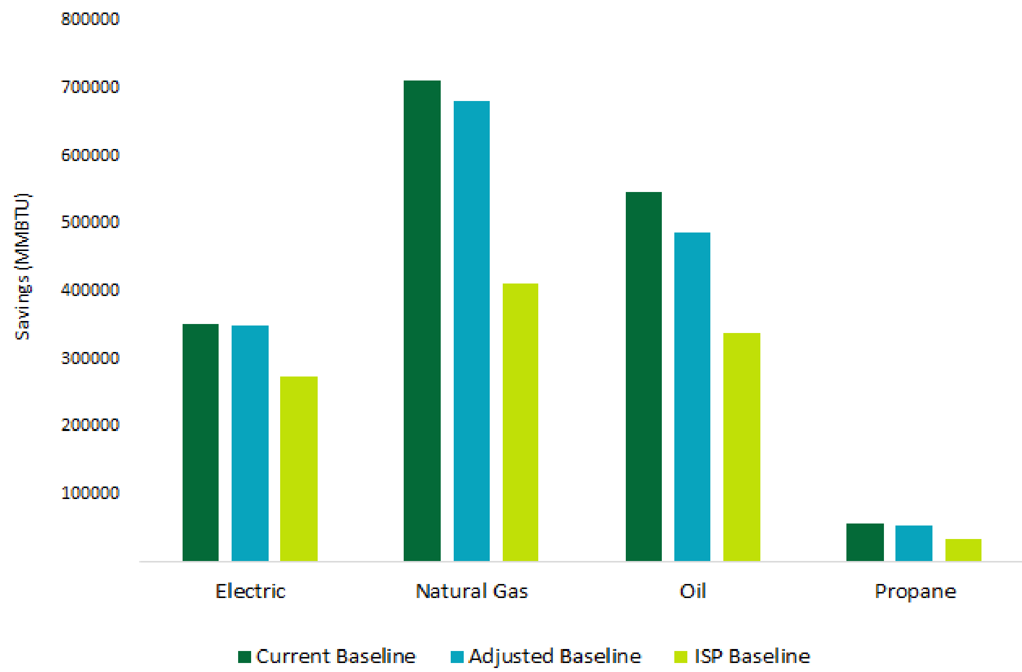


Table 87 presents the statewide potential statewide savings by end use. Reducing heating use represents the vast majority of potential savings (86% of statewide savings in the current and adjusted baseline scenarios and 79% in the ISP baseline scenario). Lighting represents no more than 14% of savings in the three baseline scenarios, water heating represents no more than 7%, and cooling savings represent less than 1%.

Table 87: Statewide Potential Savings by End Use (MMBTU)

End Use	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Heat					
Electric	162,984	162,984	100%	89,430	55%
Natural gas	668,879	647,707	97%	377,840	56%
Oil	546,535	487,978	89%	337,631	62%
Propane	53,510	51,817	97%	30,227	56%
Heat Total	**1,431,908**	**1,350,485**	**94%**	**835,128**	**58%**
Domestic Hot Water					
Electric	35,807	35,807	100%	35,801	100%
Natural gas	43,834	33,456	76%	33,411	76%
Propane	3,505	2,676	76%	2,673	76%
DHW Total	**83,147**	**71,939**	**86%**	**71,885**	**86%**
Other Electric					
Cooling	7,6188,57	4,364	57%	2,911	38%
Lighting	146,547	146,547	100%	146,547	100%
Other Total	**154,164**	**150,910**	**98%**	**149,457**	**97%**
Project Total	**1,669,219**	**1,573,335**	**94%**	**1,056,470**	**63%**

Table 88 presents these statewide savings results by project type. Renovation-only projects represent the largest savings potential, given that they are the most prevalent type of project in the state. Renovation and addition projects represent the highest savings per home, but are the least common project type, so they do not represent the highest statewide potential. Addition-only projects have the lowest potential savings associated with them, given the higher efficiency baseline (UDRH) to which these projects are being compared.

Table 88: Statewide Potential Savings by Project Type (MMBTU)

Fuel	Current Baseline	Adjusted Baseline	% of Current	ISP Baseline	% of Current
Renovation Only					
Electric	225,684	225,684	100%	165,532	73%
Natural gas	530,201	517,062	98%	292,683	55%
Oil	333,160	297,464	89%	166,064	50%
Propane	42,415	41,365	98%	23,415	55%
Total	**1,131,460**	**1,081,576**	**96%**	**647,694**	**57%**
Addition Only					
Electric	59,099	59,082	100%	59,082	100%
Natural gas	46,078	42,287	92%	42,287	92%
Oil	18,424	16,450	89%	16,450	89%
Propane	3,686	3,382	92%	3,382	92%
Total	**127,287**	**121,202**	**95%**	**121,202**	**95%**
Renovation and Addition					
Electric	67,656	64,419	95%	49,558	73%
Natural gas	136,434	121,813	89%	76,281	56%
Oil	194,952	174,065	89%	155,118	80%
Propane	10,915	9,745	85%	6,102	56%
Total	**409,957**	**370,042**	**90%**	**287,059**	**70%**

B.7 Savings by PA Territory

The following tables show savings by PA territory. The total savings values do not match statewide savings, as they exclude municipal electric and gas territories and areas with no gas service. Oil and propane savings are each shown in two tables, each representing the same total savings values, first distributed across the PA's electric territories and then across their gas territories.

Table 89: Potential Electric Savings by PA Territory (MMBTU)

Electric PA	Current Baseline	Adjusted Baseline	ISP Baseline
Eversource	163,913	162,653	124,839
National Grid	159,766	158,371	123,460
Cape Light Compact	16,884	16,729	13,359
Unitil	2,878	2,847	2,251

Table 90: Potential Gas Savings by PA Territory (MMBTU)

Gas PA	Current Baseline	Adjusted Baseline	ISP Baseline
National Grid	314,283	300,272	181,798
Eversource	147,286	140,871	84,743
Columbia Gas	124,007	118,474	71,809
Berkshire Gas	17,722	16,940	10,134
Liberty	13,267	12,678	7,756
Unitil	6,362	6,080	3,671
Blackstone	2,842	2,716	1,626

Table 91: Potential Oil Savings by Electric PA Territory (MMBTU)

Electric PA	Current Baseline	Adjusted Baseline	ISP Baseline
National Grid	190,334	169,941	117,316
Eversource	171,377	153,015	105,492
Cape Light Compact	30,067	26,846	19,026
Unitil	7,947	7,095	4,903

Table 92: Potential Oil Savings by Gas PA Territory (MMBTU)

Gas PA	Current Baseline	Adjusted Baseline	ISP Baseline
National Grid	186,147	166,203	115,327
Eversource	86,492	77,225	53,132
Columbia Gas	96,218	85,909	59,587
Berkshire Gas	25,939	23,160	15,963
Liberty	10,293	9,191	6,415
Unitil	10,588	9,454	6,533
Blackstone	6,099	5,446	3,760

Table 93: Potential Propane Savings by Electric PA Territory (MMBTU)

Electric PA	Current Baseline	Adjusted Baseline	ISP Baseline
National Grid	17,914	17,121	10,323
Eversource	16,784	16,049	9,657
Cape Light Compact	2,795	2,666	1,638
Unitil	531	507	306

Table 94: Potential Propane Savings by Gas PA Territory (MMBTU)

Gas PA	Current Baseline	Adjusted Baseline	ISP Baseline
National Grid	17,460	16,682	10,100
Eversource	8,497	8,127	4,889
Columbia Gas	7,294	6,969	4,224
Berkshire Gas	3,446	3,294	1,971
Liberty	780	746	456
Unitil	707	676	408
Blackstone	258	247	145

Appendix C Market Size – Detailed Findings

The following section provides additional details from the market size analysis, based on methodology outlined in Appendix A.1.

C.1 Market Size Estimates by PA

In addition to the statewide estimates provided in Section 3.1, the team estimated the number of permits obtained in each of the Massachusetts PAs' service territories. Estimates are provided separately for the number of projects occurring in the PAs' respective electric and gas service territories (i.e., the permit counts across the two following tables are not cumulative).

C.1.1 Market Size Estimates by PA – Electric Service Territory

Table 95 shows an estimate of the 2017 renovation and addition permits by PA electric service territory. Approximately four out of five (82%) of the renovation and addition permits were in National Grid or Eversource electric service territory. Thirteen percent of permits were in jurisdictions with municipal electric providers.

Table 95: 2017 Renovation and Addition Permit Estimates by PA Electric Territory*

	Renovation	Addition	Renovation and Addition	Total
National Grid	33,456	12,860	5,165	51,481
Eversource	31,638	10,758	4,822	47,218
Cape Light Compact	3,742	1,577	678	5,997
Unitil	751	274	117	1,142
Municipal electric	10,256	4,011	1,672	15,940
Total	**79,843**	**29,480**	**12,454**	**121,778**

*Note that ten municipalities are served by two different electric PAs. In these cases, the team split the estimated permit counts in half between the two electric PAs.

C.1.1 Market Size Estimates by PA – Gas Service Territory

Table 96 shows estimates of renovation and addition permit counts by PA gas service territory. National Grid gas service territory covered 41% of such permits. Fourteen percent of renovation and addition permits were located in territories without gas service.

Table 96: 2017 Renovation and Addition Permit Estimates by PA Gas Territory*

	Renovation	Addition	Renovation and Addition	Total
National Grid	32,559	12,310	5,186	50,054
Eversource	16,078	5,457	2,403	23,937
Columbia Gas	13,510	5,463	2,129	21,102
Berkshire Gas	2,732	981	424	4,137
Liberty	1,441	560	227	2,229
Unitil	1,000	366	156	1,521
Blackstone Gas	476	174	75	726
Municipal gas	883	346	126	1,355
No gas service	11,165	3,824	1,729	16,718
Total	**79,843**	**29,480**	**12,454**	**121,778**

*Note that nine municipalities are served by two different gas PAs. In these cases, the team split the estimated permit counts in half between the two gas PAs.

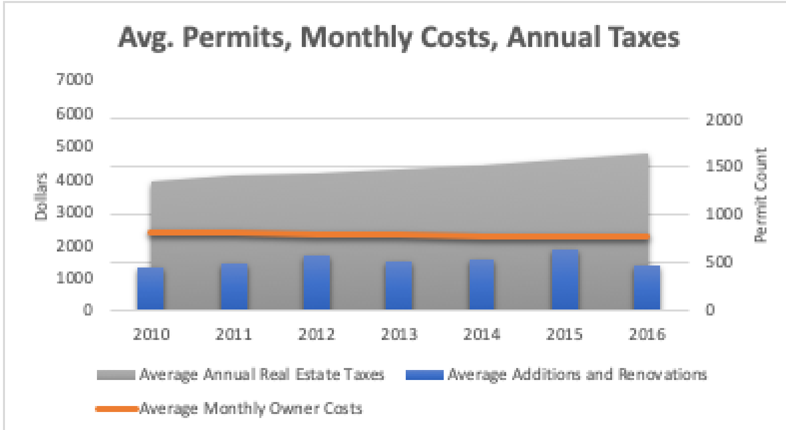
C.1 Permit Activity and Real Estate Economic Indicators

The permit analysis is based on permit records for a single year, but the team explored permit trends for seven municipalities with comprehensive permit data available for the 2010 to 2016 period. NMR compared their permit records over this period to real estate-based economic variables from the U.S. Census[32] for those municipalities to determine if the state of the economy, in particular the housing market, has an effect on the size of the renovations and additions market.

The results of this analysis are shown in Figure 17. As shown, when comparing the average number of permits to the average real estate taxes and homeowner costs for these seven towns, there does not appear to be a strong relationship between these real estate economic variables and the size of this market. As a result, we feel the permit analysis results in a reasonable approximation of what the market size might be moving forward.

[32] These data were pulled from the U.S. Census American Fact Finder website. https://factfinder.census.gov/

Figure 17: Annual Permit Counts Compared to Real Estate Economics



Appendix D Additional Findings from Contractor and Homeowner Surveys and HVAC Contractor IDIs

This appendix includes additional findings from the general contractor web survey, HVAC contractor IDIs, and homeowner web survey.[33]

D.1 Respondent Backgrounds

This section includes background details about the general contractors, HVAC contractors, and homeowners who participated in the respective survey, interview, or focus group efforts included in this study.

D.1.1 Firmographics and Renovation/Addition Experience

Table 97 shows the main line of work of those who responded to the general contractor web survey, with three-fourths (75%) primarily focused on remodeling and/or additions.

Table 97: Main Line of Work – General Contractor Survey

Main Line of Work	Percent (n=77)
Remodeling/additions	75%
New construction	19%
Handyman	4%
Other	1%

Table 98 shows the percent of the HVAC contractors' business that is associated with residential and non-residential buildings. On average, over two-thirds of their work (77%) was performed in residential buildings.

Table 98: Building Type Where Worked Performed – HVAC Contractor IDIs

Type of Work	Average	Median	Range
Residential buildings (n=10)	77%	85%	20 to 99%
Non-residential buildings (n=7)	23%	15%	1 to 80%

As seen in Table 99, on average, close to one-half (47%) of HVAC contractors' residential projects include renovations and close to one-fifth (19%) include additions.

Table 99: Average Percent of Residential Renovation and Addition Projects – HVAC Contractor IDIs

Project Type	Average	Median	Range
Renovations (n=10)	47%	45%	10 to 90%

[33] The focus groups are reported on separately, with only selected focus group findings included in this section for comparison or context. See Appendix E.

Additions (n=10)	19%	20%	5 to 35%

During the recruiting process for the focus groups, respondents provided details about the estimated number of single-family renovation projects, addition projects, and projects with both renovations and additions that they had worked on in the past year. The respondents' average number of projects are shown in Table 100.

Table 100: Average Number of Residential Renovation and Addition Projects – Focus Groups

Location of Focus Group	Number of Attendees	Avg. # of Renovations in Last 12 Months	Avg. # of Additions in Last 12 Months	Avg. # of Renovations & Additions in Last 12 Months
Cape	6	9	2	2
Metro/West-Boston	3	15	1	2
Boston/North Shore	7	7	3	3
Worcester	4	14	5	2
Western MA	4	13	3	2
Total/Average	**24**	**12**	**3**	**2**

Over one-half of homeowners (54%) indicated that the approximate total cost of the addition or renovation work done on their home fell at or below $50,000 (Table 101).[34]

Table 101: Approximate Total Cost of the Work Done – Homeowner Survey

Project Cost	Renovation Only (n=148)	Addition Only (n=26)	Renovation and Addition (n=33)	Total (n=207)
Less than $2,000	1%	4%	0%	1%
$2,000 to $5,000	10%	0%	3%	8%
$5,001 to $10,000	11%	4%	6%	10%
$10,001 to $20,000	18%	15%	0%	15%
$20,001 to $50,000	21%	27%	12%	20%
$50,001 to $100,000	14%	19%	15%	14%
More than $100,000	18%	31%	58%	26%
Don't know	7%	0%	6%	6%

As seen in Table 102, of those homeowners who used a handyman or a contractor, nearly all used them for most or all off the work (average rating of 4.6 on a scale of 1 to 5, where 1 is "Hardly any of the work" and 5 is "All of the work").

[34] Total cost includes all labor and materials.

Table 102: Portion of Work Completed by Contractor – Homeowner Survey

Rating	Renovation Only (n=148)	Addition Only (n=26)	Renovation and Addition (n=33)	Total (n=207)
1 "Hardly any of the work"	--	--	--	--
2	2%	--	3%	2%
3	7%	12%	10%	8%
4	20%	8%	17%	17%
5 "All of the work"	72%	80%	70%	72%
Mean	*4.6*	*4.7*	*4.5*	*4.6*

Over one-fourth of focus group participants (29%) felt positively about their experiences with the RNC program, and, conversely, the same percentage felt neutral about their experiences with the heating, cooling, and demand hot water rebates (Table 103).

Table 103: Experiences with Related Programs – Focus Groups

Experience with Programs	Experience with RNC Program (n=24)	Experience with Heating, Cooling, and DHW Rebates (n=24)
Positive	29%	67%
Neutral	50%	29%
Never heard of program	21%	4%

Most general contractor renovation and addition projects occurred in Middlesex (25%) or Suffolk (21%) counties (Table 104).

Table 104: Areas of Work – General Contractor Survey

(Multiple Response)

County	Renovations (n=67)	Additions (n=32)	Total (n=77)*
Barnstable	18%	9%	16%
Berkshire	4%	3%	4%
Bristol	4%	3%	5%
Dukes	1%	0%	1%
Essex	9%	16%	12%
Franklin	1%	3%	3%
Hampden	12%	13%	12%
Hampshire	9%	6%	9%
Middlesex	22%	31%	25%
Nantucket	1%	6%	3%
Norfolk	16%	13%	17%
Plymouth	15%	6%	13%
Suffolk	19%	3%	21%
Worcester	12%	19%	17%

*This column is associated with the percent of respondents who worked in each county regardless of whether they did renovation or additions.

Most HVAC contractors who were interviewed as part of the IDIs work around Boston, the greater Boston area, or metro west (Table 105).

Table 105: Areas of Work – HVAC Contractor IDIs

(Multiple Response)

Area	Count (n=10)
Boston	3
Greater Boston Area	3
Metro West	3
Worcester County	2
Cape	1
Hampden County	1
Franklin County	1
Hampshire Count	1
Western MA	1

Most homeowner renovation and addition projects occurred in Middlesex (37%) or Suffolk (16%) counties (Table 106).

Table 106: County Where Project was Completed – Homeowner Survey

County	Renovation Only (n=148)	Addition Only (n=26)	Renovation and Addition (n=33)	Total (n=207)
Barnstable	3%	4%	6%	3%
Bristol	7%	4%	3%	6%
Essex	7%	12%	0%	7%
Hampden	5%	4%	3%	4%
Hampshire	3%	8%	6%	4%
Middlesex	35%	42%	42%	37%
Norfolk	11%	4%	15%	11%
Plymouth	4%	4%	3%	4%
Suffolk	18%	12%	9%	16%
Worcester	5%	8%	12%	7%

More than half of the focus group participants had experience working with HERS raters, infrared cameras, and HRVs and ERVs (Table 107).

Table 107: Range of Experiences – Focus Groups

Experience	Experience with HERS Raters (n=24)	Experience with Infrared Cameras (n=24)	Experience with HRV & ERVs (n=24)
Worked with them	54%	54%	63%
Heard of them	46%	46%	33%
Never heard of them	0%	0%	4%

D.1.2 Knowledge and Training Related to Efficiency

As seen in Table 108, over three-fifths of general contractors (65%) said they were knowledgeable or very knowledgeable about the energy efficiency of the materials or equipment they install in their projects (using a scale of 1 to 5, where 1 is "Not knowledgeable" and 5 is "Very knowledgeable").

Table 108: Knowledge of the Energy Efficiency of the Materials/Equipment Installed – General Contractor Survey

Rating	Percent (n=77)
1 "Not knowledgeable"	0%
2	3%
3	31%
4	44%
5 "Very knowledgeable"	21%
Not applicable	1%
Mean	*3.84*

Close to one-half of general contractors (47%) had not attended any trainings on energy efficiency in the past five years (Table 109). Of those that had, continuing education code training for their license was the most commonly mentioned training.

Table 109: Trainings on Energy Efficiency Attended – General Contractor Survey
(Multiple Response)

Trainings	Percent (n=73)
Classroom trainings or presentations sponsored by Mass Save Energy Code Technical Support	10%
Webinars sponsored by Mass Save Energy Code Technical Support	8%
Building Performance Institute (BPI) trainings	15%
Continuing education code training for license	23%
Other	10%
Have not attended any trainings	47%

Most general contractors indicated that they did not hold any certifications related to energy efficiency (Table 110).

Table 110: Energy-Efficiency Certificates Held – General Contractor Survey
(Multiple Response)

Certifications	Percent (n=19)
Builder license	5%
Certified HERS rater	5%
Home improvement license	5%
LEED certification	5%
No certifications	79%
Required certification to keep Construction Supervisor License (CSL)	5%

D.2 Mechanical Systems

This section provides additional detail about the HVAC and water heating systems affected by renovation and addition projects.

D.2.1 Installation of New Mechanical Systems

Table 111 shows the frequency with which HVAC contractors' residential renovations and additions projects include new heating, cooling, or water heating measures. HVAC contractors reported installing similar percentages of new heating, cooling, or water heating measures across their renovations and additions projects (69% and 67%, respectively).

One HVAC contractor who installed these new measures 50% of the time said, "It varies; sometimes [I am] just adding pieces to the existing unit." Another HVAC contractor who installed these new measures only 3% of the time said it is usually just for bathrooms or kitchen situations.

Table 111: Projects with New Heating, Cooling, or Water Heating Measures Installed – HVAC Contractor IDIs

New Measures	Average	Median	Range
Renovations(n=10)	69%	88%	3 to 100%
Additions (n=10)	67%	75%	20 to 100%

Table 112 shows that the most common types of heating equipment installed by HVAC contractors in their residential renovation and addition projects were heat pumps (mentioned by six and eight respondents, respectively), with an average efficiency of 10.3 HSPF for renovations and 10.0 HSPF for additions. The most common types of equipment replaced in renovations projects were less efficient furnaces (six responses), followed by less efficient boilers (four responses), electric baseboard (one response), and electric heat or steam (one response).

Table 112: Most Common Heating Types Installed – HVAC Contractor IDIs

<table>
<tr><th>Heating Type</th><th>Project Type</th><th>Count of Respondents</th><th>Fuel</th><th>Efficiency - Average</th><th>Efficiency - Range</th></tr>
<tr><td rowspan="2">Heat pump</td><td>Renovation</td><td>6</td><td rowspan="2">Electric</td><td>10.3* HSPF</td><td>10 to 11 HSPF</td></tr>
<tr><td>addition</td><td>8</td><td>10.0 HSPF**</td><td>9.6 to 10.9 HSPF</td></tr>
<tr><td rowspan="2">Furnace</td><td>Renovation</td><td>4</td><td rowspan="2">Gas</td><td>95.7 AFUE</td><td>95 to 97% AFUE</td></tr>
<tr><td>addition</td><td>2</td><td>93.5% AFUE</td><td>92% and 95%+ AFUE</td></tr>
</table>

*One respondent did not provide a response about the efficiency and one did not know the efficiency.
**Three respondents did not know the efficiency.

Table 113 shows the most common types of cooling equipment installed by HVAC contractors in their residential renovation and addition projects. Heat pumps were the most commonly reported type across both renovations and additions projects (mentioned by five and nine respondents, respectively), with an average efficiency of 19.0 SEER for renovations and 20.8 for additions. The most common types of equipment replaced in renovations projects were central ACs (five responses), followed by nothing (three responses), and room AC units (one response).

Table 113: Most Common Cooling Types Installed – HVAC Contractor IDIs

Cooling Type	Project Type	Count of Respondents	Fuel	Efficiency - Average	Efficiency - Range
Heat Pump	Renovation	5	Electric	19.0 SEER	17 to 20+ SEER**
	addition	9		20.8*	17 to 26 SEER
Central AC	Renovation	4	Electric	13 SEER*	13 SEER
	addition	1		13 SEER	13 SEER

*One respondent did not know the efficiency.
**One respondent did not provide a response about the efficiency and one did not now.
***One respondent did not know the type of equipment replaced.

Table 114 shows the most common type of heat pumps that the HVAC contractors reported installing, as well as the rooms/conditions that they think are most suitable for their installation. Ductless mini-splits were the most common type (all ten respondents), followed by conventional air source heat pumps (five mentions). Four HVAC contractors thought that ductless mini-splits were suitable for all rooms, and three thought that conventional air source heat pumps were most suitable if ductwork was needed or if it was already in the home.

Table 114: Heat Pumps Installed and Suitable Conditions – HVAC Contractor IDIs

(Multiple Response)

Type	Count (n=10)	Most Suitable Conditions/Rooms
Ductless mini-splits	10	All rooms (4), bedrooms (2), wide open areas/rooms (2), living rooms (1), when furnace backup exists (1), when forced hot water and no duct work (1), in additions (1), if there are cold/hot spots in home (1)
Conventional air source heat pumps	5	If ductwork is needed or is already there (3), when there is oil or propane (1), not in the attic (1)
Heat pump water heaters	3	Basement (2), sufficient room around the unit (2), open area (1), temp in room stays above 50 F year-round (1)
Ducted heat pumps	2	Cold climates
Ductless hyper heat pumps	1	Cold climates
Ground source heat pumps	1	All rooms (1)
Unitary	1	Supplying duct work to whole house (1)

D.2.2 Altering Existing vs. Adding New HVAC and Water Heating Systems

Table 115 shows that HVAC contractors rarely expand the distribution systems for existing heating or cooling equipment to meet the needs of additions (12% on average). One HVAC contractor said, “It is very rare to do this. We honestly walk away from the job for this reason. [We] try to offer the newest technology and go with what customer can afford.” Similarly, another respondent said, “It is not very often. Most of the time we’re doing mini-splits, sometimes we might expand ductwork.”

Table 115: Expanding Distribution System of Existing HVAC to Serve Additions – HVAC Contractor IDIs

Expansion of Heating or Cooling	Average	Median	Range
Additions (n=10)	12%	10%	5 to 20%

HVAC contractors described the type of work that they perform when they need to expand the heating or cooling system distribution systems to meet space conditioning requirements for an addition (Table 116). Adding ductwork was the most commonly mentioned type of work performed (seven respondents), followed by adding baseboard radiators (five respondents).

Table 116: How Existing System Was Expanded to Serve an Addition – HVAC Contractor IDIs

(Multiple Response)

Type of Work	Count (n=10)
Ductwork	7
Baseboard	5
Plumbing lines	2
Change R22 to 10a	1
Ductless mini-split	1
Mechanical damper	1

Table 117 shows that, on average, HVAC contractors report altering existing equipment as part of their renovations one-third (33%) of the time. Two respondents said that they never do this, with one of those two describing that they usually just replaced old or broken equipment, meaning that they just replace like-for-like instead of making upgrades or alterations.

Table 117: Projects Where Alterations Are Made to Existing Equipment as Part of Renovation Projects – HVAC Contractor IDIs

Alterations	Average	Median	Range
Renovations (n=10)	33%	20%	0 to 97%

HVAC contractors described the type of work they typically perform when they need to alter existing equipment as part of their renovation projects (Table 118). Ductwork was the most commonly mentioned type of work performed.

Table 118: Work Performed When Altering Existing Equipment in Renovations – HVAC Contractor IDIs

(Multiple Response)

Type of Work	Count (n=8)
Duct work	7
Adding cooling coil to furnace	1
Extending baseboard	1
Ductless heating/cooling	1
Water heating	1
Heating for kitchen	1

D.3 Duct Work and Air Sealing

General contractors who incorporate duct work into their renovation or addition projects provided granular detail about their typical practices (Table 119). They most often mentioned sealing ducts to meet code requirements in renovation projects (46%) and installing new ducts in additions projects (73%). Interestingly, about one-quarter (26%) said that their typical renovation practices would only involve fixing clearly broken or disconnected ducts, which likely represents an opportunity for additional improvements.

Table 119: Typical Duct Work Practices – General Contractor Survey

(Multiple Response)

Duct Work Practice	Renovations (n=32)	Additions (n=22)
Install new ducts	31%	73%
Seal ducts to meet code requirements	46%	64%
Seal ducts to exceed code requirements	20%	27%
Only fix clearly broken/disconnected ducts	26%	9%
Seal only gaping holes	9%	5%
Seal readily accessible holes	14%	14%
Seal tiny holes	11%	14%
Seal with classic duct tape	0%	5%
Seal with foil or butyl tape	26%	23%
Seal holes with mastic	11%	14%
Seal ducts for leakage	14%	27%
Leave ducts alone	6%	0%

General contractors who indicated they have done air sealing as part of their renovation and addition projects described how often they had performed blower door tests on those projects in the last year (Table 120). Close to one-fourth (22%) of contractors performing renovations said they do so at least half the time, while over one-third (34%) of contractors performing additions said they do so at least half the time.

Table 120: Frequency of Blower Door Tests – General Contractor Survey

Frequency	Renovations (n=36)	Additions (n=24)
Always	8%	17%
More than half the time	3%	0%
About half the time	11%	17%
Less than half the time	17%	8%
Never	58%	46%
Don’t know	3%	4%

D.4 CHANGES TO PROJECT SCOPES

HVAC contractor projects rarely expand the original scope of work agreed to with the customer to include additional energy-efficiency related improvements (Table 121). Adding heat pumps or using ventilation to improve air quality were the most frequently mentioned types of work that might fall into this category, but respondents said this occurs rarely (three respondents each).

One of the two HVAC contractors who said this never occurs specified this is the case because "if we are renovating, we use what is there. We meet six times before the job starts." The other respondent also indicated that they agree up front on the work to be done and that projects never go beyond the original scope.

Table 121: How Often Projects Go Beyond Original Scope to Include Additional Energy-Efficiency Improvements – HVAC Contractor IDIs

Beyond Original Scope	Count (n=10)
Some of the time	1
Not very often/rarely	7
Never	2

A similar proportion of homeowners performing renovations said they did the work in other areas of their home because they were already doing the renovation as those that said they did not do work in other areas.

Homeowners performing additions were less likely than those performing renovations to indicate they did additional work in other areas of their home because they were already doing the renovation or addition project (Table 122).

Table 122: Whether Additional Work was Completed Because of Renovation – Homeowner Survey

Additional Work Done Because Renovation was Happening	Renovations (n=68)	Additions (n=19)
Yes	47%	36%
No	49%	55%
Don't know	4%	9%

D.5 PERMITTING

In the general contractor web survey, respondents reported that they obtained permits with slightly less frequency for their renovation projects (88%) than for addition projects (97%) (Table 123). Almost all ten of the interviewed HVAC contractors reported pulling permits for their renovations and additions projects (97% and 96% of the time, respectively).

Table 123: Obtained Building Permits – General Contractor Survey and HVAC Contractor IDIs

Average Percent of Permits Obtained	Renovations	Additions
General contractor survey (n=67 for renovations and n=32 for additions)	88%	97%
HVAC contractor IDIs (n=10 for both renovations and additions)	97%	96%

Contractors participating in the focus groups mostly indicated pulling permits for all their projects, though some were willing to skip the permitting process for a limited number of projects in unusual cases, such as those that were under a time crunch, were for clients with whom they had a strong relationship, or in some cases knew the project was unlikely to be noticed by a building inspector, but indicated that there are a small percentage of unlicensed contractors they expect do not pull permits.

As seen in Table 124, homeowners estimated that permits were pulled with less frequency than the contractors (84% on average for the homeowner's most recent projects).

Table 124: Whether Permits were Pulled for Work Completed – Homeowner Survey

Permits	Renovations (n=148)	Additions (n=26)	Renovation and Addition (n=33)	Total (n=207)
Yes	82%	92%	88%	84%
No	3%	4%	3%	3%
Don't know	15%	4%	9%	13%

General contractors who pulled permits less than 100% of the time most often said they did not do so because the size and scope of the project did not require it (Table 125). Similarly, an HVAC contractor who indicated he used permits most of the time said there is typically already a permit in place by the time he is involved in a project, or that he will usually not pull a permit for a minor alteration.

Table 125: Reasons Permits were Not Pulled – General Contractor Survey

Reasons	Percent (n=22)
The size and scope of the project did not require one	86%
The homeowner requested the project not have a permit	9%
Inspections would cause delays	5%
Scope grew beyond original permit	5%

The handful of homeowners who said permits were not pulled for their projects provided a variety of reasons for why this was the case (Table 126).

Table 126: Reasons for not Pulling a Permit – Homeowner Survey

Reasons	Renovations or Additions (n=7)
Friend did the work	1
May have been done without knowledge or did not need permit	1
Not involved with permitting decision	1
Project was not big enough	1
Was not told by contractor	1
Don't know	2

D.6 Efficiency Considerations

This subsection provides details about the efficiency considerations associated with renovation and addition projects from the perspectives of the homeowners and contractors.

D.6.1 Efficiency vs. Other Considerations

Homeowners and general contractors provided feedback about whether efficiency is a primary consideration in the decision-making process for these projects and how it compares to other key considerations. Table 127 shows that general contractors prioritize high-quality materials, providing features that meet homeowners' long-term needs, and making the home more attractive when developing a bid for a renovation or addition project (ratings were provided on a scale of 1 to 5, where 1 means "Not at all important" and 5 means "Very important"). Providing the absolute lowest cost is not as high of priority in most cases, as contractors seemed more focused on demonstrating the overall value proposition for their work.

Table 127: Importance of Considerations when Bidding on a Project – General Contractor Survey

(n=77)

Considerations	Rating					Mean
	1 "Not at all important"	2	3	4	5 "Very important"	
Providing lowest price possible	18%	21%	47%	8%	6%	2.64
Providing the highest quality materials	0%	1%	13%	29%	57%	4.42
Providing features that meet the homeowner's needs over the long run	1%	0%	3%	22%	74%	4.68
Making the home more attractive	1%	1%	6%	26%	65%	4.52
Making the home more energy efficient	1%	4%	21%	40%	34%	4.01

Table 128 presents a similar set of results as Table 127, but from the homeowner's perspective. It appears that homeowners prioritize energy efficiency slightly more than general contractors, although both prioritize long-term needs, high-quality materials, and making the home more attractive or sellable. Similar to the general contractors, getting the work done for the lowest price possible is less important when compared to other considerations.

Table 128: Importance of Considerations when Planning Project – Homeowner Survey
(n=207)

Importance of Considerations	Rating							Mean
	1 "Not at all important"	2	3	4	5 "Very important"	Don't Know	N/A	
Getting the work done for the lowest price possible	3%	8%	31%	29%	25%	2%	1%	3.79
Using high-quality materials and equipment	0%	0%	6%	34%	56%	2%	1%	4.56
Providing features that meet my needs for this home over the long run	0%	0%	5%	14%	78%	1%	0%	4.77
Making the home more attractive, comfortable, and sellable	0%	2%	7%	30%	58%	2%	0%	4.52
Making the home more energy efficient since I was having a lot of work done	1%	4%	15%	25%	46%	4%	4%	4.39
Making the home more energy efficient since that will save a lot of money over the long run	0%	4%	17%	19%	55%	3%	2%	4.4

Contractors attending the focus groups indicated that homeowners like to invest in materials and items that they can see. As a result, if there is budget remaining for a project, it is more likely to be allocated towards something aesthetically pleasing, rather than towards energy efficiency. Additionally, projects that bring a space up to modern code standards would represent a significant increase in efficiency already, thereby pleasing the customer without going to extreme lengths (and costs) to promote extra efficiency. Please refer to Appendix E for more details.

D.6.2 Awareness and Importance of Efficiency

General contractors provided feedback about homeowners' awareness of energy efficiency (Table 129) and how often they suggest energy-efficient features to homeowners (Table 130). They provided mixed results regarding homeowners' awareness of efficiency, while nearly one-half (43%) of contractors suggested that they make energy-efficient suggestions to clients on every project.

Table 129: Client Awareness of Energy Efficiency – General Contractor Survey

Clients Awareness	Renovations (n=65)	Additions (n=31)
All of them	6%	10%
More than half	25%	32%
About half	32%	23%
Less than half	34%	29%
None	3%	6%

Table 130: How Often Contractors Suggest Energy-Efficient Features to Clients – General Contractor Survey

Frequency of Suggestions	Percent (n=77)
Every project I work on	43%
More than one-half of the work I do	17%
About one-half of the work I do	17%
Less than one-half of the work I do	16%
Never	4%
Does not apply to my work	4%

Table 131 shows that homeowners report making energy efficiency a primary consideration more than one-fourth (28%) of the time, while it is a moderate or secondary consideration over one-half (57%) of the time. Only 7% suggested that energy efficiency is never a consideration.

Table 131: Homeowners Ranking of Energy Efficiency – Homeowner Survey

Consideration	Renovations (n=148)	Additions (n=26)	Renovation and Addition (n=33)	Total (n=207)
Primary consideration	28%	27%	33%	29%
Moderate or secondary consideration	55%	62%	61%	57%
Not a consideration at all	8%	8%	0%	7%
Don't know	9%	4%	6%	8%

Some focus group participants suggested that there are homeowners who are knowledgeable about energy efficiency and that they are the drivers of any particularly energy-efficient practices being included in renovation and addition projects. Contractors said they see this affect windows and HVAC equipment more than insulation measures. However, most focus group participants thought that they – the contractors – were the drivers of energy efficiency in most circumstances as their recommendations and general practices drove the outcome of the project. Please refer to Appendix E for more details.

As seen in Table 132, on average, HVAC contractors estimate that over five-sixths (84%) of renovations and additions homeowners would opt for higher efficiency options, though a wide range of responses were provided (between 50% and 100%). One HVAC contractor said that 100% of homeowners will choose efficiency when a rebate is available and 25% will choose it without a rebate. Another respondent said that "some just want to replace, but most want to save energy."

Table 132: Homeowners Who Opt for More Energy-Efficient Options – HVAC Contractor IDIs

Opt for Efficiency	Average	Median	Range
Renovations and additions (n=10)	84%	90%	50 to 100%

Table 133 shows that most HVAC contractors rate energy efficiency as important or very important to both their renovations and additions clients (using a scale of 1 to 5, where 1 means "Not at all important" and 5 means "Very important").

When asked to provide the reasoning behind their ratings, many HVAC contractors said there is more interest from their clients in being green, efficient, and less wasteful (four respondents). Others who gave a rating of 4 or 5 said that improving comfort is important to their clients (one respondent), as is reducing bills over the long-term (one respondent), and wanting to do it right the first time (on respondent).

One of the respondents said, "Some people are looking for what's going to cost less, others are looking for efficiency. What helps is the Mass Save rebates so they have more incentive to upgrade." Another HVAC contractor said a quick return on investment is a concern for some customers, noting that "especially on the AC side, it's very tough to get money back in Massachusetts because there are so few seasons where [the client] is using AC. On the gas side, a lot of times you need to change the flue type to get to 90% or above so it becomes a money issue for many people."

Table 133: Importance of Energy Efficiency to Clients – HVAC Contractor IDIs

Rating	Renovations (n=10)	Additions (n=10)
1 "Not at all important"	--	--
2	--	--
3	1	1
4	4	3
5 "Very important"	5	6
Mean	*4.4*	*4.5*

Most HVAC contractors (eight out of ten) said that energy efficiency is not any more or less important to their renovations and additions clients than other residential customer segments, such as single-family new construction or multifamily new construction. One respondent said that efficiency is more important to new construction because they have a longer-term vision in mind compared to addition or renovation customers who may not want to incur additional costs or are more comfortable with their current situation. Another respondent said that efficiency is more important to their renovations and additions customers than other groups because of their concerns about saving space and money.

D.6.3 Barriers to Efficiency

Three-fifths (60%) of general contractors who responded to the web survey suggested that homeowner budgets were one of the primary barriers preventing above-code measures from being installed in all of their renovations and additions projects (Table 134).

Table 134: Barriers that Prevent Above Code Measures from Being Installed – General Contractor Survey
(Multiple Response)

Barriers	Percent (n=43)
Budget	60%
Scope of project	21%
Older homes	7%
Customer interest	5%
Existing conditions	5%
Not a requirement	5%
Time constraints	5%
Air leakage from other areas of building	2%
Education	2%
HERS expense	2%
No barriers	5%

Similarly, over one-half (55%) of homeowners reported that it would be too expensive to make their home more energy efficient (Table 135).

Table 135: Barriers to Making Home more Energy Efficient – Homeowner Survey
(Multiple Response)

Barriers	Renovations or Additions (n=172)
It would be too expensive to make my home more energy efficient	55%
I do not know what to do to make my home more energy efficient	26%
I do not know who to hire to make my home more energy efficient	12%
It would be too disruptive to my life, family, or home	12%
I'm not likely to stay in my home long enough to recoup money spent on energy-efficiency upgrades through lower bills	16%
Energy efficiency is not a priority for me	2%
Home is already pretty efficient	6%
Not ready to make more changes yet	3%
Doing work in stages	2%
Work covered prior to move-in	2%
Other	5%

Like the general contractors responding to the web surveys and the HVAC contractors, the contractors participating in the focus groups indicated that cost was the key barrier, with nearly all contractors mentioning it. When asked to elaborate on what was driving high costs, most pointed to the cost of materials, specifically spray foam insulation. A smaller number also mentioned labor cost and stated that building to higher efficiency usually took more time. The already high cost of construction was also mentioned by some contractors as a barrier to achieving higher level of efficiency. They said that since costs across all aspects of construction have been going up, energy-efficiency measures are often the first to be cut from tight budgets.

The other barriers identified by focus group contractors were small project size, homeowner demand, age of the home, how long the occupant expects to stay in the home, return on investment, and project priorities. Some contractors also mentioned it can be challenging to even meet code with projects that have small wall and ceiling cavities in existing homes. Please refer to Appendix E for more details.

Table 136 shows the extra cost, on average, that HVAC contractors estimated is associated with installing a more efficient system over a standard system. Respondents provided a wide range of extra cost estimates, from as little as $200 extra to as much as $8,000 extra. Most respondents said this additional expense was dependent on the scope of the work. One respondent said that "high-efficiency equipment compared to not efficient is very close dollar-wise (a few hundred dollars more). If it has to be a wall mount installation [for example], there could be different cost, [but it is a] couple hundred dollars more on average."

Two HVAC contractors provided their estimates in percentages rather than in dollar values, with one indicating that efficient system installations would add about 10% to the cost of both their renovations and additions projects, and the other indicating that efficiency would add about 30% to the cost of renovations and additions projects. One respondent did not answer the question because he said they only install efficient systems.

Table 136: Extra Cost to Install a More Efficient System Over Standard – HVAC Contractor IDIs

Extra Cost	Average	Median	Range
Renovations (n=7)*	$1,833	$1,500	$200 to $8000
Additions (n=7)*	$1,750	$1,500	$200 to $5000

*Seven rather than ten respondents, as one respondent did not answer the question and two provided percentage estimates rather than dollar values.

Similar to some of the HVAC contractor feedback, over two-fifths (43%) of general contractors who responded to the web survey indicated that renovations and addition projects that significantly exceed code may cost 10-25% more (Table 137).

Table 137: Additional Cost of Projects that Significantly Exceed Code – General Contractor Survey

Additional Cost	Percent (n=77)
Would not cost more	1%
1 to less than 10% more	17%
10 to 25% more	43%
26 to 50% more	14%
More than 50% cost increase	1%
Don't know	23%

D.6.4 Drivers to Efficiency

Table 138 shows what HVAC contractors think typically leads to the installation of high-efficiency heating, cooling, or water heating equipment in renovation and addition projects. One-half of HVAC contractors indicated that it is typically a mix of contractor recommendations and customer interest. One HVAC contractor said that it is rare for a customer to call up with a specific interest in efficiency. Others indicated that customers typically call them when they hear about a rebate or incentive, or when they want to save money over the long run or save space.

Table 138: What Leads to High-Efficiency Projects Occurring – HVAC Contractor IDIs

Reasons	Count (n=10)	Customer Reasons for Showing Interest
Mix of contractor recommendation and customer interest	5	Desire to save money in the long run (2), Customer awareness about rebates/incentives (1)
Contractor recommendations	4	--
Customer interest	1	Desire to save money in the long run (1), Customer awareness about rebates/incentives (1), Space considerations (1)

HVAC contractors reported recommending high-efficiency equipment to their customers or to their general contractors on almost all (92%) of their projects (Table 139). All ten HVAC contractors indicated that they make this recommendation of higher efficiency equipment at the beginning of their projects.

Table 139: How Often HVAC Contractors Recommend High-Efficiency Equipment Installations – HVAC Contractor IDIs

Recommend Efficiency	Average	Median	Range
Renovations (n=10)	92%	100%	50 to 100%
Additions (n=10)	92%	100%	50 to 100%

HVAC contractors most often indicated that high-efficiency installations are more likely to occur if customers show interest in efficiency or if they have the budget available (Table 140). Three of the ten respondents said there are not necessarily any specific circumstances that make installing high-efficiency more favorable.

Table 140: Circumstances that Make Installing High-Efficiency More Likely – HVAC Contractor IDIs

(Multiple Response)

Circumstances	Renovations (n=10)	Additions (n=10)
If customer shows interest	2	2
Enough space to run proper flue	--	1
If home is built tighter	1	1
If room is suitable	1	1
Would not do efficiency in an attic	1	1
Depends on cost/budget	3	--
Depends on existing set-up	2	--
Not necessarily specific circumstances	3	3

HVAC contractors most often indicated that high-efficiency installations would be prevented if there was an added expense or if there was not enough space (Table 141).

Table 141: Circumstances that May Prevent the Installation of High-Efficiency – HVAC Contractor IDIs

(Multiple Response)

Circumstances	Renovations (n=10)	Additions (n=10)
Added expense	7	7
Not enough space	2	2
Customer does not request	1	1
If rebate not available	1	1
If potential for the unit to not function effectively	1	1
Sometimes impossible (no explanation)	--	1

HVAC contractors most often said that increasing customer awareness and incentives were ways to increase the likelihood that renovation and addition projects will include high-efficiency equipment (Table 142).

Table 142: Ways to Increase Likelihood that Projects Include High-Efficiency – HVAC Contractor IDIs

(Multiple Response)

Ways to Increase Likelihood	Renovations and Additions (n=10)
Customer awareness	6
Incentives	5
Loans	4
Contractor training	3
Things already being done	1

HVAC contractors discussed how improvements in the overall efficiency of a home can either reduce the size of the HVAC system needed or allow the existing system to meet the needs of the expanded conditioned space (Table 143). Seven of ten HVAC contractors said this has been a factor in at least some of their projects; they described some of the circumstances where this has been a factor, with two mentions related to downsizing oversized equipment, especially if insulation increased the efficiency of the space.

Four HVAC contractors said they are typically the ones to bring this opportunity up to architects, homeowners, or contractors; two said the general contractor or architect brought it up to them; and one said it can be a mix of both.

Table 143: Circumstances Where Improvements in Efficiency can Reduce HVAC Needs or Allow Existing System to Meet Needs of Expanded Space – HVAC Contractor IDIs

(Multiple Response)

Circumstances	Renovations and Additions (n=10)
All jobs	1
Add heat pumps in some situations to decrease wear on the boiler	1
Additions might be able to use the existing equipment if it's oversized	1
Downsizing from oversized equipment	1
May need to size up if the existing equipment can't accommodate addition	1
Perform Manual J to calculate what will be needed	1
Sometimes insulation increases the efficiency and then you have to downsize equipment	1
Has not been a factor in my projects	3

D.6.5 Rebates and Incentives

Over one-half (53%) of general contractors had either personally received a rebate or an incentive or had helped a customer receive one for energy-efficient measures by Mass Save or any other utility programs (Table 144).

Table 144: Familiarity with Mass Save Rebates and Incentives – General Contractor Survey

Familiarity	Percent (n=77)
Have not heard of any such incentives	3%
Have heard of them but have not dealt with these programs as a part of my job	44%
Have personally received an incentive	22%
Have helped a customer get a rebate/incentive	31%

As seen in Table 145 and Table 146, more HVAC contractors than general contractors estimated that their residential renovation or addition clients participated in efficiency programs to receive rebates or incentives in the past year. One of the HVAC contractors said that they push for their customers to apply to the Mass Save program.

Table 145: Whether Client Participated in Efficiency Programs – General Contractor Survey

Participation	Renovations (n=66)	Additions (n=31)
Yes	21%	32%
No	50%	35%
Don't know	29%	32%

Table 146: Percent of Client Participating in Efficiency Programs – HVAC Contractor IDIs

Participation	Average	Median	Range
Renovations and Additions (n=9)*	76%	80%	40 to 100%

*One of the ten respondents did not know the answer.

In contrast to the general contractor and HVAC contractor findings, under two-fifths of homeowners (37%) said they had received an audit through Mass Save and installed some measures with or without receiving rebates or incentives (Table 147).

Table 147: Familiarity with Mass Save Rebates and Incentives – Homeowner Survey

Familiarity with Mass Save Incentives	Renovations (n=148)	Additions (n=26)	Renovation and Addition (n=33)	Total (n=207)
Have not heard of any such incentives	9%	23%	9%	11%
Have heard of these incentives but have not participated in these programs	33%	31%	27%	32%
Received an energy audit through Mass Save but did not install any of the recommended measures	6%	0%	3%	5%
Received an audit, installed some measures, but did not apply for any incentives	16%	15%	12%	15%
Received an audit, installed some measures, and applied for at least one incentive.	35%	31%	48%	37%

HVAC and insulation were the most commonly incentivized measures mentioned by both general contractors, who said at least some of their renovations and additions projects received rebates or incentives in the last year, and homeowners, who received rebates or incentives (Table 148 and Table 149).

Table 148: Measures that Received Incentives – General Contractor Survey (Multiple Response)

Received Incentives	Renovations (n=14)	Additions (n=10)
Air sealing	0%	10%
Cooling	14%	10%
Gas conversion	7%	10%
Heating	57%	40%
Hot water	7%	10%
Insulation	14%	30%
Lighting	14%	0%
Thermostats	14%	0%
Windows	0%	10%
Don't know	14%	10%

Table 149: Rebates or Incentives Applied for and Received through Mass Save – Homeowner Survey

Measures Incentivized	Renovations or Additions (n=76)
Insulation	49%
HVAC	46%
Water heating	13%
Appliances	11%
Thermostats	9%
Air sealing	8%
Windows	8%
Lighting	4%
Other	20%

Table 150 shows that most HVAC contractors believe programs like Mass Save are very important to both their renovations and additions customers (average rating of 4.7 using a scale from 1 to 5, where 1 means “Not at all important” and 5 means “Very important”).

Table 150: Importance of Mass Save Program to Homeowners – HVAC Contractor IDIs

Importance of Mass Save	Average	Median	Range
Renovations and Additions (n=9)*	4.7	5	4 to 5

*One of the ten respondents did not know the answer.

Homeowners typically said that rebates, incentives, and information about energy efficiency would have been most useful to them when completing their renovation or addition projects (Table 151).

Table 151: Preferred Programs or Services Promoting Efficiency – Homeowner Survey

(Multiple Response)

Preferred Program or Services	Renovations (n=148)	Additions (n=26)	Renovation and Addition (n=33)	Total (n=207)
Rebates on energy-efficient products	27%	23%	39%	29%
Incentives covering some of the cost for the work done on homes	38%	50%	42%	40%
Financing that covers the energy-efficient upgrades	9%	19%	3%	10%
Information on what needs to be done	18%	4%	9%	15%
Help in hiring a contractor	3%	0%	3%	3%
All of the above	1%	4%	0%	1%
Code support/training	1%	0%	3%	1%
Did not specify	1%	0%	0%	0%
Information about solar	1%	0%	0%	1%
More personal funds needed	1%	0%	0%	0%

D.6.6 Examples of Above Code Practices

General contractors largely indicated that they were either fully aware or somewhat aware of the energy code requirements for the measures they installed as part of their renovation and additions projects (Table 152). However, when asked to provide examples of how their work had exceeded code, some contractors still gave examples of measures that actually did not surpass code requirements, indicating imperfect knowledge of code requirements.[35]

[35] The ISP baseline used for modeling does not incorporate any such self-reported above-code practices.

Table 152: Awareness of Energy Code Requirements – General Contractor Survey

Measures		Fully Aware	Somewhat Aware	Unaware	Don't Know
Wall insulation	Additions (n=29)	100%	--	--	--
	Renovations (n=53)	89%	9%	--	2%
Heating	Additions (n=25)	93%	4%	4%	--
	Renovations (n=29)	55%	38%	3%	3%
Air conditioning	Additions (n=22)	77%	23%	--	--
	Renovations (n=29)	55%	38%	7%	--
Water heating	Additions (n=19)	74%	21%	5%	--
	Renovations (n=24)	50%	38%	8%	4%
Ventilation	Additions (n=19)	68%	16%	16%	--
	Renovations (n=30)	63%	37%	--	--
Air sealing	Additions (n=22)	68%	23%	9%	--
Duct work	Additions (n=21)	76%	24%	--	--
	Renovations (n=31)	52%	39%	10%	--
Windows	Additions (n=26)	96%	4%	--	--
	Renovations (n=50)	84%	12%	4%	--
Lighting	Additions (n=26)	69%	23%	8%	--
	Renovations (n=43)	47%	44%	9%	--
Appliances	Additions (n=18)	72%	28%	--	--
	Renovations (n=26)	46%	46%	4%	4%

Many of the contractors participating in the focus groups said that meeting the energy code, especially in a renovation, was hard enough, never mind exceeding code. Many said that they do not think there is enough benefit to adding higher R-values than required by code as Massachusetts code requirements are already quite high. Contractors also said that insulating to R-values above energy code is not practical or cost-effective for these projects – particularly for renovations – because they would only be upgrading a small portion of the home, while the rest of the home remains uninsulated or poorly insulated.

NMR asked general contractors who indicated that they installed above-code measures to give specific examples of how particular measures they installed exceeded energy code (Table 153 to Table 162). Some of the descriptions provided were vague, and others actually are not signs of above-code performance, indicating some knowledge gaps.

Table 153: Examples of Measure More Efficient than Code – Wall Insulation – General Contractor Survey

(Multiple Response)

Examples	Renovations (n=28)	Additions (n=17)
Cellulose	0%	6%
Closed cell foam insulation	4%	18%
Dense pack cellulose insulation	4%	0%
Exceeds code / more efficient	0%	12%
Foam board	4%	0%
Improved insulation / R-value	54%	24%
Improved R-value to R-15	4%	12%
Improved R-value to R-21	7%	18%
Plastic	4%	6%
Rockwool insulation	32%	0%
Spray foam	0%	6%

One general contractor who installed wall insulation in their additions said, “We always look to overshoot code R-values by a couple of points.” Two general contractors who installed wall insulation in their renovations provided feedback, with one indicating that they “always fill exterior wall bays completely with spray foam to add to the R value regardless of code requirement” and the other noting that they “replace old insulation with newer, higher R-value insulation” and “use foam in several cases.”

Table 154: Examples of Measure More Efficient than Code – Heating – General Contractor Survey

(Multiple Response)

Examples	Renovations (n=12)	Additions (n=15)
Exceeds code / more efficient	42%	53%
Extending existing ductwork	0%	7%
Gas conversion	0%	7%
Heat pumps	0%	7%
Improved efficiency to 85% AFUE	8%	0%
Improved efficiency to 87% AFUE	8%	0%
Improved efficiency to 90% AFUE	8%	0%
Improved efficiency to 95% AFUE	8%	13%
Improved efficiency to 96% AFUE	0%	7%
Improved insulation	0%	7%
Mini-split	8%	0%
Radiant floor heating	8%	0%
Replacing forced air with radiant heat	8%	7%

One general contractor who installed heating equipment in their additions said, “Both recent addition jobs involved bathrooms with radiant heat replacing forced air and on separate zones. The main bedroom space heat[ing] involved [a] simple extension of existing ducting.”

Table 155: Examples of Measure More Efficient than Code – Cooling – General Contractor Survey

(Multiple Response)

Examples	Renovations (n=11)	Additions (n=10)
Geothermal system	0%	10%
Heat pumps	0%	10%
Exceeds code / more efficient	55%	60%
Improved efficiency to 13 SEER +	9%	0%
Improved efficiency to 15 SEER	0%	20%
Mini-split	27%	0%

Table 156: Examples of Measure More Efficient than Code – Water Heating – General Contractor Survey

(Multiple Response)

Examples	Renovations (n=10)	Additions (n=11)
Closed combustion efficiency	10%	0%
Exceeds code / more efficient	10%	64%
Improved efficiency to 0.82 EF	0%	9%
Improved efficiency to 0.9 EF	10%	0%
Improved recovery efficiency	0%	9%
Switched to heat pump water heater	10%	0%
Switched to tankless	10%	0%
Upgraded to ENERGY STAR	0%	9%

Table 157: Examples of Measure More Efficient than Code – Ventilation – General Contractor Survey

(Multiple Response)

Examples	Renovations (n=7)	Additions (n=6)
Added ERV	--	1
Added exhaust fans	--	1
Airflow measurements	--	1
Improved cooling	1	1
Exceeds code / more efficient	4	2
Improved indoor air quality	--	1
Timer controls	1	--
Upgraded thermostat	1	--

Table 158: Examples of Measure More Efficient than Code – Air Sealing – General Contractor Survey*

(Multiple Response)

Examples	Additions (n=8)
Add silicone outside of framing before insulating	1
Blower door test	1
Improved air infiltration	2
Exceeds code / more efficient	2
Spray foam	2

*We purposefully did not ask this question of respondents who had done air sealing in renovations projects.

One general contractor who installed air sealing in their additions said, “Even though we weren't required by code to perform testing, we have been incorporating improved air sealing practices with all projects.”

Table 159: Examples of Measure More Efficient than Code – Duct Work – General Contractor Survey

(Multiple Response)

Examples	Renovations (n=9)	Additions (n=7)
Duct testing	--	1
Exceeds code / more efficient	1	1
Improved insulation	4	1
Improved R-value to R-12	--	1
More thorough sealing	2	2
Shorter duct runs	1	--
Tighter house	2	--
Updated ducts	1	--
Upgraded existing ducts	--	1

One general contractor who performed duct work as part of their renovations said, “The HVAC contractor is in charge of code, but we make sure all ductwork is insulated where it needs to be."

Table 160: Examples of Measure More Efficient than Code – Windows – General Contractor Survey

(Multiple Response)

Examples	Renovations (n=27)	Additions (n=15)
Exceeds code	7%	0%
Improved seal	4%	0%
Improved u-value to 0.03+	0%	7%
Improved u-value to 0.10	0%	7%
Improved u-value to 0.25	4%	0%
Improved u-value to 0.27	15%	7%
Improved u-value to 0.28	0%	7%
Low E 272 glass	0%	7%
More efficient glazing	0%	7%
Spray foam	0%	7%
Triple pane glass	7%	7%
Upgraded to more efficient windows / improved u-value	63%	53%

Table 161: Examples of Measure More Efficient than Code – Lighting – General Contractor Survey

(Multiple Response)

Examples	Renovations (n=20)	Additions (n=14)
Controls	0%	7%
Energy-efficient lighting / fixtures	25%	29%
Exceeds code / more efficient	0%	7%
LEDs	75%	64%
Timers	5%	0%

One general contractor who installed lighting in their additions said, “More efficient fixtures replaced uninsulated, incandescent ones.” Another contractor who installed lighting in their renovations said, “We use LED recessed trims and/or bulbs whenever possible.”

Table 162: Examples of Measure More Efficient than Code – Appliances – General Contractor Survey

(Multiple Response)

Examples	Renovations (n=9)	Additions (n=5)
ENERGY STAR	1	3
Exceeds code / more efficient	8	1
Used product with longer life	--	1

D.6.6.1 Extremely High Performance Projects

As seen in Table 163, under one-third of general contractors (18% for renovations and 28% for additions) said they would consider at least some of their renovation or addition projects from the last year to be extremely efficient (meaning well above code).

Table 163: Whether Worked on Extremely Energy-Efficient Projects in Past Year – General Contractor Survey

Extremely Efficient Homes	Renovations (n=67)	Additions (n=32)
Yes	18%	28%
No	60%	50%
Don't know	22%	22%

One general contractor who said they have worked on extremely energy-efficient projects in the past year had the following to add:

> *We expanded a master bedroom and bath by adding an 8x13 single story extension to an existing bedroom. We gutted the entire bedroom and bathroom. We replaced old R11 batts with foam, installed all new LED lighting, replaced old windows with new ones, insulated select interior partition walls, sealed and foamed the rim and added new cellulose insulation to the entire house attic.*

Another general contractor described one of their highly efficient projects in the following way:

> *We are currently working on a project for Zero Energy Design. We gutted the third floor of a home in Cambridge. We replaced existing windows with top-of-the-line energy-efficient units. Per the architect's specs, we applied six inches of blown closed foam insulation to the rafter bays, 3 ½ inches in walls and then used Intello paper and corresponding tape to completely air seal the space. We then strapped the room with 2x4's and used 1 ½ inch rockwool between. We then boarded and plastered the whole space.*

As seen in Table 164, close to five-sixths of HVAC contractor projects (82%) exceeded federal minimum energy-efficiency requirements. One HVAC contractor whose projects meet federal requirements 50% of the time said that it "depends on what subs I use," and one HVAC contractor whose projects meet federal requirements 90% of the time said, "We don't typically do low efficiency, [but] sometimes some people want them."

Table 164: Installed Equipment that Exceeds Federal Minimum Efficiency Requirements – HVAC Contractor IDIs

Exceeds Requirements	Average	Median	Range
Renovations and additions (n=10)*	82%	90%	50 to 100%

*One respondent met state codes but did not know if they met Federal codes.

As seen in Table 165, homeowners often rated their home's efficiency highly, with close to one-half (48%) rating their homes as efficient or very efficient (using a scale of 1 to 5, where 1 is "Not at all energy efficient" and 5 is "Very energy efficient").

Table 165: Efficiency of Home – Homeowner Survey

Rating	Renovations (n=148)	Additions (n=26)	Renovation and Addition (n=33)	Total (n=207)
1 "Not at all efficient"	1%	0%	0%	0%
2	7%	4%	3%	6%
3	44%	38%	30%	41%
4	30%	50%	48%	36%
5 "Very efficient"	11%	8%	15%	12%
Don't know	6%	0%	3%	5%
N/A	1%	0%	0%	0%
Mean	*3.49*	*3.62*	*3.78*	*3.55*

D.6.7 Working with Contractors and HERS Raters

Close to one-half of general contractors (49%) said they had either worked with HERS raters in the past or that they often work with HERS raters (Table 166).

Table 166: Familiarity with HERS Raters – General Contractor Survey

Familiarity	Percent (n=77)
Have not heard of this term	12%
Somewhat familiar	40%
Have worked with HERS raters in the past	35%
My company often works with HERS raters	14%
I hold HERS rater certification	3%

Over one-half (55%) of general contractors working on additions said they used HERS raters for either some or all of their additions, though fewer general contractors working on renovations (just over one-fourth, or 28%) reported doing so (Table 167).

Table 167: Use of HERS Raters – General Contractor Survey

Frequency	Renovations (n=58)	Additions (n=29)
No, have not used HERS raters	69%	52%
For some projects	19%	24%
For all projects	9%	21%
Don't know	3%	3%

Most homeowners had not heard of HERS raters before being asked about it in the survey (Table 168). Of the homeowners that had worked with contractors or HERS raters, just slightly more than two-fifths (41%) said their contractor or HERS rater had suggested measures or features that would improve the energy efficiency of their home (Table 169).

Table 168: Use of HERS Rater – Homeowner Survey

Use of a HERS Rater	Renovations (n=148)	Additions (n=26)	Renovation and Addition (n=33)	Total (n=207)
Have not heard of this term before	71%	69%	67%	70%
Have heard of HERS raters, but did not use one for the work on my home	15%	19%	15%	15%
Have heard of HERS raters, but not sure if one was used to inspect and test my home	8%	8%	9%	8%
Yes, used a HERS rater to inspect and test my home	6%	4%	9%	6%

Table 169: Contractor or HERS Rater Suggestions – Homeowner Survey

Suggestions	Renovations (n=124)	Additions (n=25)	Renovation and Addition (n=30)	Total (n=179)
Yes	42%	44%	33%	41%
No	40%	40%	40%	40%
Don't know	18%	16%	27%	19%

As seen in Table 170, homeowners who had either worked with a contractor or HERS rater most often said that their HERS rater or contractor suggested they install more insulation or higher efficiency foam insulation (83%). Most homeowners said they went along with what the contractor or HERS rater suggested for some or all the measures or features discussed (Table 171), and most often reported installing more insulation or higher efficiency foam insulation (Table 172).

Table 170: Measures Recommended by Contractor or HERS Rater – Homeowner Survey

(Multiple Response)

Measures Recommended	Renovations or Additions (n=73)
Using more insulation or using a higher efficiency foam insulation	86%
Heat Recovery Ventilation (HRV)	0%
Energy Recovery Ventilation (ERV)	1%
Solar photovoltaic (PV)	3%
Blower door test	15%
Insulation	8%
HVAC	7%
Windows	7%
Lighting	5%
Other	14%

Table 171: Whether Recommended Measures were Implemented – Homeowner Survey

Implemented Suggestions	Renovations or Additions (n=73)
Yes, as suggested	71%
Yes, in part but not as fully suggested	19%
No	7%
Don't know	3%

Table 172: Which Recommended Measures Were Implemented – Homeowner Survey

(Multiple Response)

Measures Implemented	Renovations or Additions (n=66)
Using more insulation or using a higher efficiency foam insulation	85%
Heat Recovery Ventilation (HRV)	3%
Energy Recovery Ventilation (ERV)	0%
Solar photovoltaic (PV)	3%
Blower door test	14%
Insulation	8%
HVAC	8%
Windows	6%
Lighting	6%
Other	12%

Homeowners who did not follow their contractor or HERS rater suggestions about energy-efficient improvements provided a variety of reasons why, with one of the most common being cost (Table 173).

Table 173: Reason Why Contractor or HERS Rater Suggestions Not Followed – Homeowner Survey

(Multiple Response)

Reason	Renovations or Additions (n=17)
Cost	24%
Have not gotten to it yet	18%
Work is too complex	12%
Other	24%
No response	24%

As seen in Table 174, close to two-fifths (38%) of homeowners said the experience and knowledge that their contractor or HERS rater had of how to make their home as energy efficient as possible was important or very important to them when choosing them (on a scale of 1 to 5, where 1 is “Not at all important” and 5 is “Very important”).

Table 174: Importance of Contractor or HERS Rater Knowledge of Efficiency – Homeowner Survey

Rating	Renovations (n=124)	Additions (n=25)	Renovation and Addition (n=30)	Total (n=179)
1 “Not at all Important”	12%	4%	3%	9%
2	11%	0%	10%	9%
3	22%	36%	17%	23%
4	15%	20%	30%	18%
5 “Very important”	20%	20%	17%	20%
Don't know	7%	8%	10%	8%
N/A	13%	12%	13%	13%
Mean	*3.24*	*3.65*	*3.61*	*3.36*

D.6.8 Final Comments about Role of Efficiency

General contractors provided the following additional comments about the role of energy efficiency in their work, including suggestions they had for promoting the use of energy efficiency in renovations and additions (Table 175). Most commonly, general contractors mentioned informing customers of efficient options (23%), using air sealing and spray foam (15%), and using the best windows and doors available (15%).

Table 175: Additional Comments about the Role of Energy Efficiency – General Contractor Survey
(Multiple Response)

Additional Comments	Percent (n=26)
Inform customers of efficient options	23%
Air sealing/spray foam	15%
Use best windows / doors available	15%
Energy efficiency is the customer’s choice	8%
ENERGY STAR appliances	8%
Importance of insulation	8%
Increase customer education	8%
Opportunities to increase efficiency are limited on smaller jobs	8%
Upfront costs still deter many customers from choosing efficiency	8%
Other	81%

Interviewers asked HVAC contractors if there was anything else they wanted to mention about the single-family renovations and additions markets that was not discussed during the interview. Respondents provided the following feedback:

- “Markets for additions and renovations are really the same. I do not see much difference in the decisions happening.”
- “Wish people knew more about efficiency. [It] would make things more successful.”

- "[In regard to the] popularity of people doing spray foam: everyone thinks they can do it but there are some issue; it is more difficult than it seems."

Table 176 shows the changes that HVAC contractors anticipate for the renovations and additions market for single-family homes in the next five years. Three respondents do not anticipate any changes. Each of the remaining HVAC contractors provided an array of responses with two mentions related to increasing expenses/costs.

Table 176: Anticipated Changes in Next Five Years – HVAC Contractor IDIs

(Multiple Response)

Anticipated Changes	Renovations and Additions (n=10)
Added expense for electrical	1
Costs increasing, which will lead to more renters	1
Large increase especially in renovations	1
More ductless heat pumps	1
The same/need programs to continue	1
Tighter homes	1
Don't know	1
No changes	3

Homeowners provided a variety of additional comments related to their experiences with the energy-efficiency aspects of their home addition or renovation (Table 177). The most common responses related to satisfaction with work completed (9%); the cost of efficiency being too expensive (6%); the desire for more incentives, rebates, or financing options (6%); and satisfaction with the savings/efficiency achieved in their projects (6%).

Table 177: Additional Comment Related to Energy-Efficiency Issues in Renovations or Additions – Homeowner Survey

(Multiple Response)

Additional Comments	Renovations (n=148)	Additions (n=26)	Renovation and Addition (n=33)	Total (n=207)
Satisfied with work completed	9%	8%	9%	9%
Higher efficiency equipment/upgrades too expensive	5%	8%	6%	6%
More incentives/rebates/financing options	7%	4%	0%	6%
Satisfied with savings/efficiency achieved	5%	12%	6%	6%
More information needed about upgrades to make/ways to save energy	6%	4%	3%	5%
Satisfied with Mass Save experience	5%	8%	3%	5%
Made additional upgrades after this project was complete	5%	4%	3%	4%
Hope to make more improvements in future	3%	8%	3%	4%
Made all of the efficient upgrades that they could	4%	4%	3%	4%
Work completed made home more comfortable	5%	0%	3%	4%
Dissatisfied with contractor’s knowledge of efficiency/rebates/incentives/loans	3%	4%	3%	3%
Satisfied with contractor	2%	0%	6%	2%
Efficiency was not the focus of this project	3%	0%	0%	2%
Would have done more if they had more budget	2%	0%	3%	2%
Would like to have a more efficient/money-saving home	2%	0%	3%	2%
Other	14%	4%	18%	14%
Nothing more to add	34%	38%	36%	35%

E

Appendix E Focus Group Detailed Findings

To provide more in-depth detail on the renovation and addition market in Massachusetts, NMR conducted focus groups with builders, remodelers, and handymen across the state. These were designed to shed light on the scope of projects and factors that might affect scope, drivers and barriers to different energy-efficiency upgrades that might occur during a renovation or addition; factors that affect whether a permit is pulled; and what types of program interventions would have an effect on the energy efficiency of a project. Five focus groups were held, each in a different region of the state, to best represent the state and get a broader understanding of the market.

The following section details key findings we gathered from the focus groups. Findings are split out by relevance to the following research questions:

- What are the energy-related elements of renovations and additions, and how do they vary by the type and depth of renovation / addition? What opportunities do renovations and additions offer for program intervention?
- Who are the key market actors and decision makers that affect a project's efficiency? What factors affect their decision-making process in terms of energy efficiency, including cost? What proportion of builders and homeowners conducting renovation projects currently include energy efficiency as a primary consideration, a moderate or secondary consideration, or do not consider energy efficiency at all?
- What is / are the appropriate baseline(s) for the program? How do the baselines vary by type and depth of renovation? How should the PAs calculate gross savings?

Our findings are presented in tables displaying not only how many participants expressed a given sentiment, but also how many times that sentiment was mentioned during the focus groups. There were several ideas that were mentioned multiple times in response to different prompts over the course of the focus groups. Repetition suggested that these were being given more emphasis by the participants.

E.1 Scope of Projects

NMR asked several questions to characterize the scope of renovation and addition projects, with a focus on opportunities for energy-efficiency upgrades. The questions were generally grouped into separate elements, including building envelope, window replacement, and HVAC upgrades. For questions relating to the building envelope and windows, the responses were focused on renovation projects, whereas, for HVAC-related questions, they focused on additions. This is because in an addition, the building envelope and windows are always included in the scope, as opposed to a renovation, in which there is a choice to be made. Conversely, there are more choices to be made on the scope of the HVAC in an addition project than a renovation, in which it was said to be rarely part of the scope at all.

E.1.1 Building Envelope

We first asked the focus group participants whether the envelope is typically opened up during a renovation. Table 178 shows the responses on that topic. It should be noted that some participants expressed different views at different times during the focus groups, so the total number of participants listed in the table as expressing either of the opinions is higher than total overall participants.

Table 178: Building Envelope Scope

(n=24 contractors across all groups)

Envelope Scope	Participants	Mentions
Open up envelope	18	25
Avoid envelope	13	21

There was a split between contractors as to whether they typically open up the building envelope during the course of a renovation, with a more contractors leaning towards opening it up consistently.

Among contractors who indicated that they generally open up the envelope during a renovation, there were a few different reasons cited. The most common reason mentioned was that there is usually other electrical or plumbing work that will be done during the renovation, so the walls will have to be opened up anyway. This was standard among bathroom and kitchen renovations, but it was also said to be common for other room types as well. They also mentioned an increased level of confidence in the finished product as a reason to open up the envelope. By opening up walls, contractors then know what is behind them and can feel confident in how they have left the home at the completion of the project, as opposed to leaving behind potential issues for the homeowner to deal with later. Another reason was that it is simply easier to gut a section of wall than to try to preserve and work around it. They said that it is easy and cheap to put drywall back up afterward, so there is no need to avoid opening up a wall.

The opposing view expressed that they typically avoid opening up the building envelope unless it is absolutely necessary. They said that to open up walls, no matter what, increases the budget and scope of the project without a good reason. They said that there is hesitation to gut walls because they do not know what they might find behind them. If they discover a preexisting issue (rot, mold, electrical, etc.), they would then be responsible for addressing it, which can increase the scope and budget significantly. They also mentioned avoiding opening the envelope so that they would not trigger code and have to bring that section up to it.

E.1.2 Window Replacement

We asked the contractors if windows were typically part of the scope of a renovation. Table 179 shows focus group responses.

Table 179: Window Replacement Scope
(n=24 contractors across all groups)

Window Scope	Participants	Mentions
Replace windows	10	11
Leave existing windows	2	2

Most contractors indicated that windows were usually part of the scope of a renovation. The most common reason they gave for this was customer demand. Unlike other measures discussed, the contractors indicated that homeowners actively ask about windows and are interested in replacing them. Windows have an aesthetic component to them and so unlike other, less visible measures, such as insulation and HVAC systems, homeowners are willing to pay more for them and want them included in the scope of a project. Another reason given for windows being included in the scope of a project was that it is often the case that windows are older and will have to be replaced at some point, and a renovation is a good time to do it. The few contractors that disagreed cited not wanting to add to the budget of the project unnecessarily and would only bring up windows if they were old or damaged, consistent with what was mentioned related to the building shell.

E.1.3 HVAC Upgrades

We asked the focus group participants about HVAC upgrades in renovation and addition projects. There was a consensus that renovations rarely involved altering the HVAC system unless it was very old and in need of replacement anyway, and so the conversation on this topic centered around additions. Table 180 gives detail on the scope of HVAC upgrades involved in addition projects.

Table 180: Additions- HVAC Upgrade Scope
(n=24 contractors across all groups)

HVAC Upgrade	Participants	Mentions
New standalone system	19	31
Tie into existing system	10	12
No HVAC upgrade	6	7

Most contractors said that when working on an addition, they install a new system to serve that new floor area on its own. A smaller number said that they prefer to tie into the existing HVAC system and add on duct work or new baseboards to serve the new area. Some contractors indicated that no HVAC upgrades were required.

Contractors that indicated they typically install a new standalone system for an addition project mentioned a few different reasons for doing so, with the most common reason being that it is easier to treat the addition as a standalone space and condition it accordingly. This allows the contractor to avoid having to address the existing HVAC system serving the rest of the home. They also said that the existing system is usually not large enough to take on the additional heating and cooling load, and they do not want to strain the system or the duct work, which can risk decreasing the comfort of the space. Another reason cited frequently was a growing homeowner interest in ductless mini splits. Most of the contractors indicated that these are a great option that are relatively cheap and easy to install as opposed to tying into duct work or installing new ducts. There appears to be increasing awareness and interest in this technology among homeowners and contractors.

Other participants mentioned that they prefer to tie into the existing HVAC system to accommodate the addition space. They acknowledged that this is not always possible if the system is not sized to do so, but they lean towards this option over adding a completely separate system for the addition. They said that this is the easiest and cheapest option, adding on duct work or baseboards is a lot less time- and cost-intensive than putting an entirely new system in.

The small number of contractors that indicated HVAC upgrades are typically not necessary said they did not want to increase the scope and budget of the project unnecessarily by adding a new system. They also indicated that it can increase the time of the project and complicate it, since they would have to bring in a separate HVAC subcontractor for that portion.

E.1.4 Factors Affecting Scope

While discussing the scope of different elements within a renovation or addition project, focus group participants also cited different factors that affect the scope of the project overall. Table 181 lists some of the most common factors mentioned.

Table 181: Factors Affecting Project Scope
(n=24 contractors across all groups)

Scope Factor	Participants	Mentions
Budget	14	31
Homeowner attitude	11	16
Age of home	10	13
Homeowner longevity	4	4

Not surprisingly, the most common factor mentioned was the budget of the project. Contractors frequently said that as projects progress, unexpected issues arise that increase cost; homeowners must make decisions on what to cut from the scope of the project in order to stay on budget. They agreed that energy-efficiency upgrades are usually among the first things to go.

The attitude of the homeowner was also cited as affecting the scope of the project. According to contractors, some homeowners are willing to listen to their recommendations and increase the scope of a project, while others have a very specific idea in mind of what they want done. This can be related to budget, but also includes the amount of time the project will take and the level of effort involved.

Contractors also cited the age of the home as a determining factor for the scope of a renovation project. The older a home is, the larger the scope will tend to be, and homeowners are usually willing to accept this. It is easier from a contractor perspective to recommend increasing the scope of a project when many aspects of the home are old and in need of repair anyway. If a home is on the newer side, it is more likely the scope will be limited to the small area being worked on.

Finally, a small number of contractors cited homeowner longevity as a factor for the scope of a project, meaning the amount of time the homeowner was planning to occupy the home. In cases where a homeowner only plans to be in the home for three to five years, it is more difficult to recommend increasing the scope or adding energy-efficiency upgrades because they will not be there long enough to see a return on that investment. Conversely, if a homeowner is planning to stay for 20 years, they are more likely to see the value of long-term energy savings and comfort provided by energy-efficiency upgrades.

E.2 Drivers and Barriers to Energy-Efficiency Upgrades

The focus groups included discussions about the drivers and barriers to energy-efficient practices in renovation and addition projects.

E.2.1 Drivers of Energy-Efficiency Upgrades

We first asked the focus groups where the decisions to include or not include energy efficiency as part of the scope of a project came from. Table 182 shows contractor responses to what was driving these decisions.

Table 182: Drivers of Energy Efficiency in Renovations/Additions

(n=24 contractors across all groups)

Driver	Participants	Mentions
Contractor	21	56
Energy code	19	46
Homeowner	13	25

The most prevalent opinion was that contractors are driving the decision to include energy-efficient upgrades in renovation and addition projects, with the most cited reason for this being that it is the contractor bringing up this subject during initial conversations about project scope. It is ultimately the decision of the homeowner, who is paying for the project.. Another reason mentioned was that contractors thought homeowners generally are not knowledgeable or interested in the energy-efficiency-related aspects of a project. Homeowners are typically doing a renovation or addition for the aesthetics and energy efficiency is not as much of a concern; most of the time they are not even aware of the options until the contractor lays them out. They also said that homeowners rely on contractor recommendations and judgement since they are the experts in their field.

The energy code being a driver of efficiency upgrades was mentioned frequently as well. Contractors who cited this said that meeting the energy code, especially in a renovation, was hard enough as it is now. As an example specific to insulation, existing conditions often make it difficult to even fit enough insulation in cavities to meet energy code. Going above and beyond code is often not logistically possible, and, when it is, it is impractical and cost prohibitive. They also claimed that insulation up to code is typically acceptable for homeowners, and is also good enough in their opinion. They said that they do not think there is enough benefit to adding additional insulation beyond code, as it is already quite high. Particularly given the scope of renovation projects, contractors said that insulating beyond energy code is not practical or cost-effective because they would only be upgrading a small portion of the home, while the rest of the home remains uninsulated or poorly insulated.

A smaller number of contractors mentioned the homeowner as the driver of energy efficiency in a renovation or addition. The comments related to this opinion largely focused on windows and HVAC upgrade decisions rather than building envelope measures. The primary reason given here was that since energy-efficiency upgrades are so expensive, the contractor usually does not bring them up to customers, so if energy efficiency is included in a project, it is at the request of the homeowner. These contractors claimed that there are some homeowners that are knowledgeable about energy efficiency and they make it a priority on their projects, although they acknowledged that this was not the norm. They also said that there is a growing interest and understanding in the comfort and energy savings that can be achieved by dedicating more to energy-efficiency upgrades.

E.2.2 Barriers to Energy-Efficiency Upgrades

Throughout the sessions, participants identified several barriers to including energy-efficiency upgrades in a renovation or addition project. Table 183 shows the barriers identified.

Table 183: Barriers to Energy Efficiency
(n=24 contractors across all groups)

Barrier	Participants	Mentions
Budget	20	73
Project size	14	22
Homeowner demand	9	17
Return on investment	8	16
Project priorities	9	13

Budget was by far the most commonly cited barrier to energy efficiency being included as part of a renovation or addition. When asked to specify what was driving up the cost, most contractors said that it was the cost of materials as opposed to labor or other budget factors, though some comments indicated that labor and time can be factors as well. Most of these comments were specifically focused on spray foam insulation. Some mentioned that a lot of contractors are not used to incorporating techniques that increase energy efficiency into their work, which can take extra time. They also said that, for certain measures such as spray foam, you have to hire subcontractors that have the expertise to complete the work, which can add time and money to the project.

The size of the project can also be a barrier to including energy-efficiency upgrades. This was typically mentioned in the context of renovations more than additions. Contractors said that in a small bathroom or kitchen renovation, the scope is not large enough to present a significant enough opportunity to upgrade energy efficiency. They said that choosing a high-efficiency option for one small part of the home that is being altered would not make a large difference in the home overall. They also said that budget is typically tighter for smaller projects, and it is more difficult to persuade a homeowner to agree to the energy-efficiency upgrade.

Contractors indicated that homeowner demand can be a barrier to energy efficiency in a renovation project. They said that most homeowners are not knowledgeable about their options, especially for insulation or HVAC equipment. Homeowners are also often not willing to pay the upfront cost of including energy-efficiency upgrades in their renovation projects.

Even if homeowners could see the value of including energy efficiency in their renovation projects, contractors said that the return on investment was not large enough to convince them. Usually, the scope of a project is too small to have a large impact on the overall energy usage of the home, so the homeowner would likely never see a return. Contractors also said that this was a difficult thing to quantify and present to the homeowner since they cannot predict how upgrading a small portion of the home will really save in energy cost.

Finally, the contractors cited homeowner priorities as a barrier. They said that if there is any flexibility or room in a homeowner's budget, it is likely not going towards energy efficiency. Homeowners care about the aesthetics of the renovation, not necessarily how it will perform from an energy perspective. Homeowners are more willing to pay extra for things that they will see every day, not less visible measures like insulation or HVAC.

E.3 Baseline Scenarios

NMR asked participants several questions about their typical installation practices for energy-related aspects of a renovation or addition. In order to establish a baseline for the program, we asked about the type of insulation and what R-value was typically installed in various building cavities, what types of windows were installed, and what types of HVAC upgrades took place. The following subsections detail contractor responses about their typical installation practices.

E.3.1 Installed Insulation

NMR asked contractors what their typical practices were for installing insulation during a renovation or addition project. We asked about R-values, materials used, and different types of building cavities (walls, ceilings, foundation walls). Table 184 shows the most common responses.

Table 184: Installed Insulation

(n=24 contractors across all groups)

Insulation Practice	Participants	Mentions
Fiberglass batts	20	42
R value to code	19	45
Spray foam	6	10

Most contractors agreed that the most common practice is to use fiberglass batts to bring the R-value of the cavity up to code. They gave a few reasons as to why this is, with many indicating that the code is already high enough and that there is not much opportunity to go above and beyond code. They also mentioned that it is often the case that the size of the building cavities in existing homes limits the amount of insulation you can install. R-value to code was said to be the easiest and most cost-effective way to insulate building cavities during a renovation or addition.

Regarding the material choice for insulating during a renovation or addition project, most contractors said that they use fiberglass batts. They are the cheapest product to buy and are easy to install. Contractors said that, particularly in a renovation, it does not make sense to spray foam a small section of wall being opened up because it will not generate enough energy savings to justify the additional cost. It is also more difficult to install and requires an additional crew, whereas fiberglass is relatively easy to install.

Fewer contractors mentioned that they regularly use spray foam insulation in their work. They cited that it is the highest quality product and it gets you the highest R-value. They said that it also allows you to avoid air sealing the cavities since it acts in that function as well. The participants who indicated that they used spray foam did not use it consistently on every project.

About one-half of the contractors also indicated that they would use spray foam insulation if it were incentivized through the program. They said that they use it occasionally already and think that it works well, but that it is usually too expensive. The upfront cost to homeowners is currently too high and they are not willing to pay for it, even if they see the value in a better product. They claimed that if the price were to come down, they would be more likely to suggest using spray foam and think homeowners would agree to it.

E.3.2 Installed Windows

NMR asked contractors about installation practices for windows during a renovation or addition project. There were fewer responses to these questions compared to other aspects of projects. Table 185 shows the results.

Table 185: Installed Windows

(n=24 contractors across all groups)

Installed Window	Participants	Mentions
Meet code	6	6
Exceed code	5	5

Contractors that discussed window installation were split between meeting the energy code and going above and beyond code. They said that windows are something homeowners are interested in and willing to pay more for. Since there is an aesthetic component to windows, homeowners want the best product and will allocate more budget to higher quality windows. Many of the contractors indicated that it is already general practice in the market to install efficient windows, indicating there may not be significant opportunities for program intervention.

E.3.3 Installed HVAC

NMR asked contractors to specify what types of HVAC systems were commonly installed during renovation or addition projects. Conversations about HVAC upgrades typically focused on additions, since contractors indicated it was rare to have to touch the HVAC system during a renovation. Table 186 details contractor responses to HVAC upgrades.

Table 186: Installed HVAC

(n=24 contractors across all groups)

Installed HVAC	Participants	Mentions
Ductless mini-splits	11	17
Electric baseboard	7	7
Upgrade existing system	6	6
New forced air system	2	2

Ductless mini-splits were the most commonly mentioned type of HVAC system installed for addition projects. Contractors said that they are the easiest type of system to install as a standalone system when adding floor area to a home. They said that homeowners are becoming increasingly aware of this technology and are interested in installing them. They also said that many older homes do not have existing AC, so these homeowners see the benefit of adding it, with the additional benefit of heating.

A smaller number of contractors indicated that they typically install electric baseboard heating for an addition project. This is the cheapest and easiest option to heat the new space. They mentioned that, in situations where the existing system can support the addition as well as the existing space, they are still required by code to add heating to the new space. In those cases, they will simply install a small amount of electric baseboard, even if they believe it will never be used. Contractors said that electric baseboards are a particularly good option for finishing basements, as these spaces often don't require AC.

Some contractors said that they prefer to update the existing HVAC system during a renovation or addition project. They said that it is often the case that the system is old and in need of replacement anyway, so it is a good time to replace it with a high-efficiency option that is sized to serve the addition as well. They mentioned that a lot of homes have old boilers with no AC and, in those cases, homeowners are taking out the old boiler and replacing it with either a forced air system or hydro-air. Contractors also said that homeowner comfort is an added benefit here as a new system will also better serve the existing portion of the home. A small number of contractors also said that they install a new, separate furnace and central AC system for an addition, but this seemed to be rare and usually in the case of an in-law apartment.

Appendix F Program Theory and Logic Model

This appendix reprises a memo NMR presented to the PAs early in the course of this study, describing the PTLM review. The interim memo is reproduced below.

The Renovations and Additions (R&A) path of the Residential New Homes and Additions Initiative seeks to capture energy savings from a portion of the residential home market not formerly targeted by the Massachusetts PAs weatherization and new construction programs. The R&A path incentivizes energy-efficiency upgrades in renovations and additions to existing homes. Upgradable measures may include, but are not limited to, insulation, heating, cooling, hot water equipment, ventilation equipment, windows, lighting, appliances, air sealing, and duct sealing. The path can engage a wide array of builders, contractors, and homeowners (i.e., participants) whose renovation and addition projects were previously external to the scope of the PAs' various offerings.

As part of the RLPNC 18-12 study regarding Renovation and Additions Market Characterization ("R&A Study"), we are developing a formalized PTLM. The program theory is a formal description of the program's activities and what short-, medium-, and long-term outcomes it is designed to achieve. The logic model is a graphical representation of the program theory.

F.1 Program Theory

To document the current program theory, NMR reviewed program materials and spoke with program and implementation staff to better understand the program's structure and goals. We also developed preliminary indicators of progress toward the program's theorized outcomes, which are specific researchable questions that can be studied to assess the extent to which the program has achieved its desired goals. The R&A path is being designed with Resource Acquisition goals and may also incorporate Market Transformation goals. The path has the following overall goals:

- **Generate energy savings (resource acquisition).** The path will generate energy savings by directly incentivizing projects that achieve savings beyond baseline performance levels.
  - Additions are incentivized for achieving savings relative to the RNC program's UDRH.
  - Renovation projects are incentivized based on their savings relative to established baseline conditions.
- **Serve a market not currently targeted by existing efficiency programs.** The path will allow property owners seeking to undergo renovations or additions to participate in the Residential New Homes and Additions Initiative, achieving savings from measures that would not have been implemented without the program.
  - Additions have not been directly targeted by existing Mass Save programs.

  - Existing homes have historically had access to incentives for mechanical equipment and appliances, weatherization projects, and gut rehabs, but renovation projects themselves have not been targeted by current program offerings, leaving potential savings on the table.
  - Additionally, the R&A program can increase savings in the R&A market by recommending that homeowners expand the scope of the renovations and additions they already have planned or that are already underway.
- **Achieve market transformation.** The path will ideally lead toward market transformation by an increase in market actors' demand for and knowledge about energy-efficient practices. With intentional and sustained effort, the path could potentially transform both the supply and demand sides of the market.
  - The path could increase the supply of experienced, well-trained market actors who operate in this market (via educational efforts and trainings, requiring market actors to meet high performance standards, involving HERS raters in projects, etc.). Additionally, the path could drive the supply of well-trained market actors by spreading knowledge and experience to builders and contractors who operate outside of the weatherization or whole-home markets – the traditional focuses of the current Massachusetts programs. Recent RNC program evaluations in the region have indicated that builders and contractors apply energy-efficient practices learned from direct participation in or indirect contact with the RNC programs to their other, non-program projects.[36] If the program makes an intentional effort to create such carry-over, it could potentially claim savings via market transformation.
  - The path could drive consumer demand for efficiency via exposure to well-trained market actors and by increasing awareness of energy savings from high-efficiency projects.
- **Test new technologies and practices.** The path's incentives paired with the required performance verification process will assist the testing of new technologies and practices.

In achieving these goals, the R&A path faces the following challenges:

- **Lack of knowledge or interest in efficient practices.** A lack of awareness or interest in efficient practices will make program participation more difficult or unappealing to homeowners and contractors. Some market actors are unaware that there is even an opportunity to improve the efficiency of these projects.
- **Lack of knowledge or interest in the program.** A lack of awareness or interest in the R&A path or Mass Save programs in general will inhibit program participation.

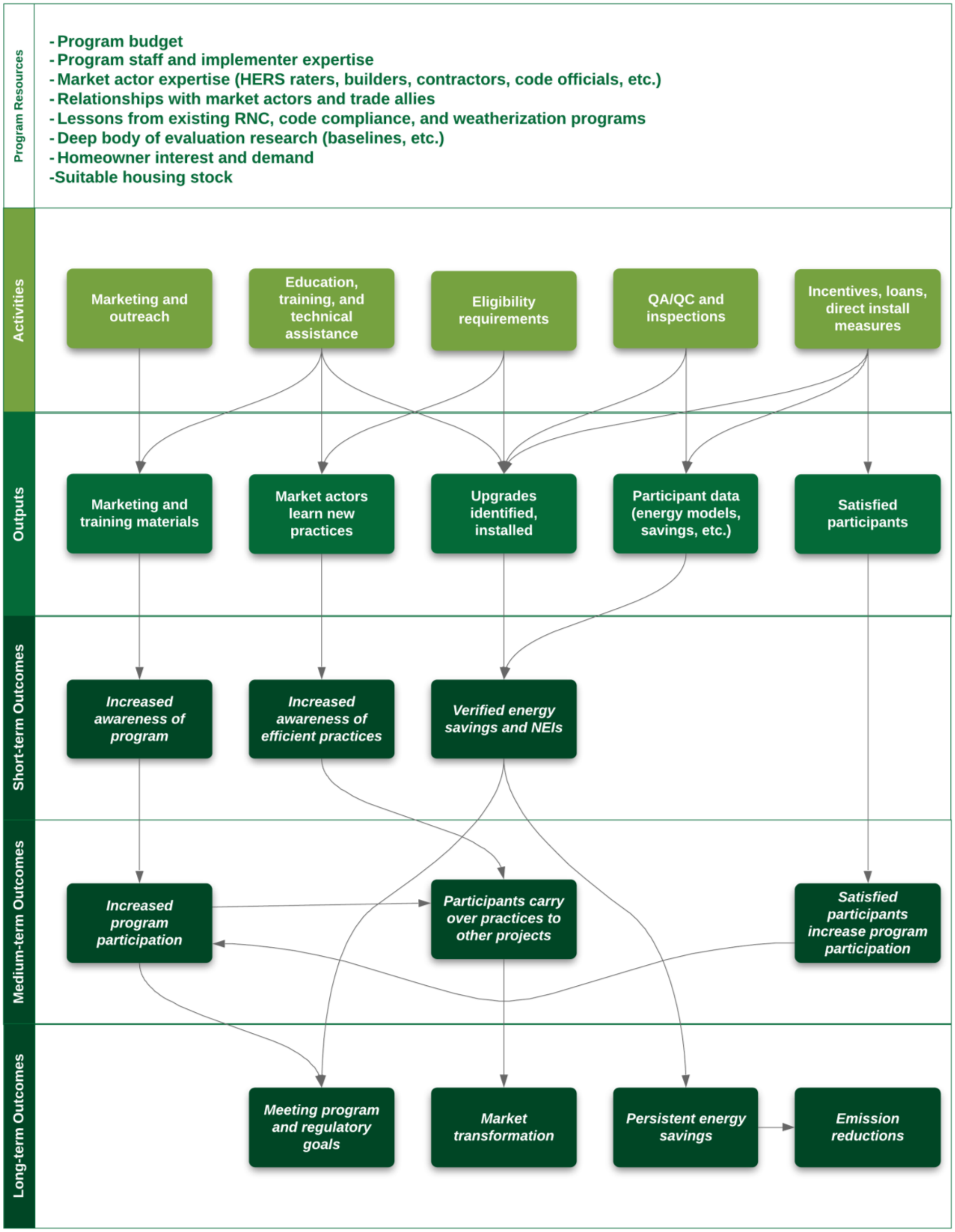
[36] http://ma-eeac.org/wordpress/wp-content/uploads/TXC_48_RNCAttribution_24AUG2018_Final.pdf; https://www.energizect.com/sites/default/files/R1707%20NTG%20Study%20for%20CT%20RNC_Final%20Report_10.5.18.pdf

- **Unclear program costs and incentive levels.** If potential participants worry that participation may add too much cost and hassle to their project, they are more likely to forgo participation.
- **Permitting requirements.** Program participants must obtain permits for their projects, subjecting them to additional requirements and inspections that some builders or contractors would rather avoid.
- **Landlord hesitance to pay for work to lower tenant costs (split incentive).** Landlords may feel they have little incentive to invest in efficiency upgrades if the associated savings only go to utility bills paid by tenants.
- **Delays in participant entry into program.** Participants do not have to enroll in the program at the earliest project planning phases, but the most substantial and cost-effective energy savings occur when projects incorporate energy efficiency into their design process from the outset. Additionally, the current program design requires a verification inspection early in the project process to inspect the quality of the insulation installation and to make recommendations on other potential improvements, including air sealing, lighting, heating, cooling, and hot water equipment. This inspection could prove impossible if a participant contacts the program too late into their project, rendering a project ineligible for participation.
- **Health and safety issues.** Health and safety issues can delay and add expense to renovation and addition projects. For example, the presence of asbestos or vermiculate insulation can prohibit the use of a blower door test to aid in air sealing.

F.2 Logic Model

Figure 18 shows the logic model for the R&A path and displays how the program activities could be traced to potential outcomes in the Massachusetts marketplace.

Figure 18: Logic Model



F.3 Components of Program Logic Model

Here, we provide more details on the program resources, activities, outputs, and expected outcomes included in the logic model.

F.3.1 Program Resources

The low-rise RNC program brings substantial existing resources to bear to implement the R&A path. The program will leverage the following existing resources:

- **Program budget.** The budget will fund implementation, incentives, and evaluation.
- **Program staff and implementer expertise.** Program staff and the program implementer have experience from the RNC program that is easily applied to the R&A path.
- **Market actor expertise.** Some market actors (e.g., builders, contractors, HERS raters, and code officials) have expertise with efficient practices and RNC program participation that can help guide R&A projects through the program and result in projects implemented outside of the program (i.e., participant and non-participant spillover).
- **Relationships with market actors and trade allies.** Relationships between program staff and market actors can help drive participation within the program and encourage similar efficiency practices to be implemented on projects completed outside of the program.
- **Lessons from existing programs.** Applying lessons learned from other programs (e.g., RNC, code compliance, and weatherization programs) can help remove barriers to participation, streamline participation, realize savings, and assist in program evaluation.
- **Deep body of supporting research.** Previous research (e.g., residential baseline studies and other market or evaluation research) can inform the R&A team's planning, implementation, and evaluation efforts.
- **Homeowner interest and demand.** There may be untapped interest in achieving savings among some homeowners and landlords that might be interested in participation, if not prevented by various barriers.
- **Suitable housing stock.** Existing homes undergoing renovations or additions provide substantial potential for energy savings and are currently not served by the RNC program. Massachusetts also has a sizeable portion of older homes in its housing stock, suitable for upgrade.

F.3.2 Key Activities

The program conducts the following key activities:

- **Marketing and outreach.** Marketing and outreach efforts are designed to spread awareness of the program to homeowners and other key market actors (e.g., builders, contractors, handymen, HERS raters, and code officials) to increase program participation and awareness of the benefits associated with implementation of energy-efficiency practices.

- **Education, training, and technical assistance.** Educational efforts, trainings, and technical assistance provided by the program staff help streamline program participation and increase market actor awareness of energy-efficient practices.
- **Eligibility requirements.** The program has established various eligibility requirements that ensure energy savings in participant projects.
- **QA/QC and inspections.** QA/QC and inspection efforts identify opportunities for efficient upgrades and verify savings.
- **Incentives, loans, and direct install measures.** Financial incentives and low-interest loans facilitate participation, thereby increasing the adoption of efficient practices. Direct installation of measures (e.g., LED light bulbs) result in immediate energy savings at limited hassle to the property owner.

F.3.3 Outputs

The program activities will result in the following outputs. Outputs represent the immediate, tangible or intangible results of program activities. For each of the outputs identified below, we suggest potential trackable indicators that could be measured to ensure that the outputs had been created or occurred, along with the data source that could provide the information necessary to inform the indicator. The indicator is the metric that gets measured. The data source describes what the program or an evaluator could use to measure the indicator.

- **Marketing and educational materials.** The program's marketing and outreach efforts produce online ads targeting homeowners showing an interest in renovations or additions, marketing materials for big box stores and lumber yards, direct communications with market actors, and engagement with market actors at industry events. The program's training and educational efforts produce training materials, including guides for how to build to high performance standards.
  - **Indicators.** Materials are created and events are held or attended.
  - **Sources for measuring indicator.** Program staff, review of created materials, confirmation that events occurred, etc.
- **Market actors learn new practices.** The eligibility requirements and technical assistance provided by the program encourage and assist market actors in learning new energy-efficient practices.
  - **Indicators.** Market actors participate in trainings that cover R&A work and report learning new practices.
  - **Sources.** Program database review, market actor surveys/ IDIs.
- **Upgrades identified and installed.** By meeting the eligibility requirements (and with the support of technical assistance and inspections), energy-efficient upgrades would be incorporated into projects.
  - **Indicators.** Number of participants and modeled energy savings.
  - **Sources.** Program database review.

- **Participant data.** The QA/QC, inspections, and incentive processing result in a participation database that includes market actor information, home data, savings estimates, and other relevant information.
  - **Indicators.** Database created and populated.
  - **Sources.** Program database review.
- **Satisfied participants.** Incentives and the installation of energy-efficient upgrades create satisfied program participants.
  - **Indicators.** Satisfaction reported by participants.
  - **Sources.** Participant surveys and IDIs.

F.3.4 Short-term Outcomes

The R&A path's activities and direct outcomes should result in the following short-term outcomes. As with the outputs identified above, we suggest potential trackable indicators of each outcome, along with data sources that could be used to provide the information necessary to measure the indicator.

- **Increased awareness of the program.** Marketing materials and efforts lead to increased awareness of the program amongst homeowners and market actors.
  - **Indicators.** Increase in reported rates of awareness of the program.
  - **Sources.** Homeowner (especially those who are entering or have recently completed R&A projects) and both participant and non-participant builder and contractor surveys and IDIs.
- **Increased awareness of efficient practices.** As market actors learn new energy-efficient practices by participating in the program, awareness of efficient practices increases.
  - **Indicators.** Increase in reported or demonstrated awareness of energy-efficient practices in the R&A market.
  - **Sources.** Market actor surveys and IDIs to assess reported awareness levels, as well as permit reviews and on-site inspections to identify projects incorporating efficient practices.
- **Verified energy savings and non-energy impacts (NEIs).** Efficiency upgrades result in energy savings that are verified by program/evaluator inspections and energy modeling; NEIs (e.g., improved health, comfort, reduced home noise) are achieved simultaneously.
  - **Indicators.** Savings demonstrated over UDRH and baseline homes. Occupants or landlords confirm the presence of NEIs.
  - **Sources.** Program database review, evaluation including on-site inspections, and surveys with occupants and landlords.

F.3.5 Mid-term Outcomes

The R&A path seeks to achieve the following medium-term outcomes:

- **Increased rates of program participation.** Increased awareness of the program paired with positive recommendations from satisfied participants lead to increased program participation.
  - **Indicators.** Increase in the rate of program participation and/or penetration.
  - **Sources.** Program database review and historical review of market penetration.
- **Participants carry over practices to other non-program projects.** After learning energy-efficient practices by participating in the program, builders and contractors apply that knowledge to other projects. This could include bringing efficient practices to projects that had builders who either elected not to or were ineligible to participate in the program. For example, some market actors might want to avoid the hassles of obtaining permits, and some projects may not meet program eligibility requirements, such as the minimum square footage thresholds.
  - **Indicators.** Participants report that they bring newly learned efficient practices to their other, non-program projects.
  - **Sources.** Builder and contractor surveys and IDIs including questions to assess baseline levels of participant and non-participant awareness of the benefits of energy-efficient practices.
- **Satisfied participants increase program participation.** Satisfied participants (homeowners, contractors, builders, etc.) recommend the program to family, colleagues, and friends and continue to participate in the future.
  - **Indicators.** Participants report encouraging others to participate. New participants report they were referred to the program by past participants. Participants report continued participation in the program.
  - **Sources.** Homeowner, builder, and contractor surveys and IDIs.

F.3.6 Long-term Outcomes

The R&A path seeks to achieve the following long-term outcomes:

- **Meeting program and regulatory goals.** The program meets its various internal and regulatory goals (e.g., participation levels, savings).
  - **Indicators.** The program outcomes compare favorably to any stated internal or external goals set for the program.
  - **Sources.** Evaluations, including comparisons of verified impacts with stated goals.

- **Market transformation.** Efficient practices are widely adopted in the R&A market.
    - **Indicators.** Increasing energy efficiency and NEIs in the R&A market.
    - **Sources.** Market actor surveys, IDIs, and baseline studies show widespread changes in practices by homeowners, builders, and contractors inside and outside the program, and also show increases in the rates of projects obtaining permits.
- **Persistent energy savings.** Energy savings generated by the program directly through program requirements or indirectly through skills learned in the program are persistent.
    - **Indicators.** Verified and evaluated savings identified as persistent.
    - **Sources.** Evaluation efforts.
- **Emission reductions.** Energy savings result in a reduction of emissions of greenhouse gases (GHG) (or other pollutants) when compared to a scenario in which the program path did not exist.
    - **Indicators.** Energy savings result in emissions reductions.
    - **Sources.** Evaluation efforts.

Appendix G Gross Savings Methodology Memo

This appendix reprises a memo NMR presented to the PAs early in the course of this study, providing recommendations for gross savings methods. The recommendations made in this memo were superseded by the overall recommendations made in the body of this report.

This memo presents the findings of Task 2 for the RLPNC 18-12 Renovations and Additions Market Characterization Study, which is to recommend a gross savings calculation methodology and appropriate baseline assumptions for the new Renovations and Additions (R&A) path within the Renovations and New Homes Initiative.

This memo describes the following:

- *Current* program design;
- *Current* program savings calculation methodology and baseline assumptions; and
- *Recommended* savings calculation methodology and baseline assumptions.

The recommended savings calculation methodology and baseline assumptions outlined in this memo reflect the current evaluation policy framework in Massachusetts. Under the current policy framework, gross savings inputs, such as baseline assumptions, are evaluable issues that may change at any point in time and are subject to retrospective application. In contrast, results pertaining to causation (i.e., net-to-gross [NTG], free-ridership, and spillover) can only be applied prospectively. For the 2019 – 2021 program cycle, prospective NTG for renovations and additions were assumed to be the same as for new construction. These factors will be up for review as part of the next program cycle (2022 to 2024 in this case). Section G.3.1 of this memo describes potential NTG issues that could be addressed in the future under a separate study.

G.1 Current Program Design

ICF, the R&A Program implementation contractor, provided the evaluation team with documents describing the current program design. Task 1 of this study built on those materials to develop a comprehensive PTLM that describe the R&A path's anticipated outcomes. The program theory describes how the goal of the R&A path is to capture energy savings from renovation and addition projects – a portion of the residential market not formerly targeted by the Massachusetts Program Administrator's weatherization and new construction programs. Ideally, this new path's efforts will drive market transformation by thoroughly influencing the behavior of key market actors, including builders, contractors, and homeowners themselves.

The R&A path is being offered under the umbrella of the Renovations and New Homes Initiative. The target customers for the R&A path include homeowners in one-to-four family residential homes and low-rise multifamily projects (three stories or less). The R&A path leverages existing RNC program infrastructure, such as the following:

- Pay-for-performance incentive structure

- Established RNC program protocols for project application, field verification, and incentive processing
- Expertise from program staff and implementers
- Experienced program vendor and established energy modeling tools
- Working advisory group of RNC experts

Projects must enroll prior to enclosing wall cavities, as the path requires a field inspection to ensure insulation installation quality. The program prefers early enrollment as that allows for the program to more heavily influence a project and achieve deeper energy savings. Currently, the program requires participant projects to obtain a building permit and to alter or affect at least 500 sq. ft. of building shell for renovations or 500 sq. ft. of conditioned floor area for additions.

The program is based on a pay-for-savings model and projects are examined using a whole-house approach. The program requires the involvement of either a Third-Party Verifier (currently this must be a HERS rater) or an ICF Account Manager. These parties are responsible for modeling the impacts of participating projects using the Ekotrope Field Tool, a version of the Ekotrope energy modeling software customized to the needs of the R&A path.[37]

The program promotes measures that are consistent with current Mass Save Program offerings. These include, but are not limited to, the following:

- Insulation, windows, and air sealing
- HVAC equipment
- Domestic hot water equipment
- Duct sealing
- Lighting and appliances
- ISMs[38]

The path uses a pay-for-savings model using the incentive structure displayed in Table 187.

Table 187: Incentive Structure

Single-Family Incentive Calculation	
A	Electric Savings (kWh) * $0.35/kWh
B	Fuel Savings (MMBtu) * $35/MMBtu
C	Percent Savings Relative to Baseline * $3,000
A+B+C	**Incentive to Participant**
$350	Incentive to Third-Party Verifier (HERS rater)

[37] https://ekotrope.com/
[38] These include low-flow showerheads and faucet aerators, smart-strips, and programmable thermostats.

G.2 Current Program Assumptions and Methodologies

The R&A path uses a performance-based modeling approach to calculate savings for participant projects. Third-party verifiers (currently these are HERS raters) are required to model the savings for all renovations and additions using Ekotrope software. The modeling software requires the creation of two energy models: the initial home prior to any renovation or addition activity, and then the final project, incorporating any additions and renovation work. Within the modeling software, the final, post-renovation/addition energy model is used to calculate savings by comparing the as-built home to a home built to baseline standards, which are based on the program's assumptions (see details on assumptions in Table 188).

The Ekotrope tool has been adapted to the program's needs such that it can use a hybrid baseline for calculating savings: the renovated portion of a home can be compared to the pre-renovation conditions, and the as-built addition can be compared to an addition built to (likely less efficient) UDRH levels. Table 188 displays the current baseline assumptions and savings calculation methodology. Our recommended updates and changes to these assumptions are detailed in Section G.3.

Table 188: Current Program Baseline Assumptions

Scenario	Baseline	Savings Calculation Method
Addition only	RNC UDRH	Compare the consumption of the home with the as-built addition to the consumption of the home as if the addition had been built to UDRH levels.
Renovation only	Pre-existing conditions	Compare the consumption of the home post-renovation to the home pre-renovation.
Renovation and addition	RNC UDRH and pre-existing conditions	Hybrid of the above methodologies. Compare the consumption of the post-renovation/addition home to a version of the home as if the addition had been built to UDRH levels and as if the home had not been renovated.
Renovations and/or additions plus other upgrades in non-renovated spaces	TBD	TBD

NMR understands that renovated portions of the existing home (i.e., alterations that do not add new conditioned floor area) will be compared to how those areas were built and configured prior to the renovation. However, in some cases, it may not be appropriate to use the pre-existing conditions as the savings baseline because those areas might have improved with a renovation project without the R&A path's influence. For example, new appliances likely would have been installed in a kitchen renovation even without program participation. In some of these cases, it may be suitable to use an early replacement baseline for calculating savings and, in other cases, it may be appropriate to use a replace-on-failure (ROF) baseline assumption. These issues are addressed in Section G.3.

G.3 RECOMMENDED BASELINE VALUES AND FUTURE NTG CONSIDERATIONS

As discussed in the previous section, the savings methodology for R&A path currently assumes that the baselines for all renovation activities are based on the pre-existing conditions of the home, while the baselines for additions are based on the low-rise RNC program UDRH.

NMR agrees with the current program assumption of using the RNC Program's UDRH as the baseline for additions. Given that additions add conditioned square footage to the home, it is reasonable to expect that, in the absence of the program, builders would install efficiency levels similar to typical single-family new construction practices. Code requires that additions must be permitted by local building departments. It is difficult to sidestep the permitting process and build an addition – a project that is often highly noticeable to neighbors – without a permit, which drives practices toward typical/code levels.

NMR believes that assuming pre-existing conditions for all renovation upgrades has the potential to overstate gross savings, in that it assumes a baseline that may be less efficient than what one would expect to see in the market. Baselines should reflect real-world conditions as much as possible to result in the best estimate of gross savings, and NTG research and adjustments can assess program influence. Table 189 highlights the complexities of gross and NTG savings issues for two renovation measures. The PAs and EEAC consultants should carefully consider and agree on which issues are related to baselines versus NTG, because otherwise it is possible to double count and over adjust savings, artificially lowering program savings. While NTG issues are not part of the current work, we anticipate a need for the PAs to engage in a renovations NTG study before the 2022 to 2024 program cycle.

Table 189: Renovation Baseline Adjustments and NTG Issue Examples

Measure	Baseline Options	NTG Questions	Considerations
Windows	Pre-existing conditions, code requirements, or ISP	Program influence (based on customer & contractor surveys, etc.)	The current baseline assumption for windows is likely to overstate gross savings as NMR assumes that the program incentives are unlikely to drive window replacements. Instead, the program is more likely to facilitate the installation of more efficient windows than otherwise would have been installed. We believe that the baseline should reflect typical practices as much as possible to most accurately estimate gross savings; future NTG research can identify program influence on window practices.
Appliances	Pre-existing conditions, federal minimum efficiency, or ISP	Program influence (based on customer & contractor surveys, etc.)	NMR assumes that most homeowners undergoing a kitchen renovation would be likely to replace appliances without the program. Given this, the current baseline assumption of pre-existing conditions is likely to overstate gross savings. We believe this issue should be addressed through an adjusted baseline assumption, which is likely to result in more accurate gross savings estimates and will simplify future NTG research.

NMR recommends the implementer of the R&A path consider adjusting their current baseline assumptions for renovation projects to avoid overstating gross savings. Specifically, we recommend the program consider adopting a blended baseline for renovation projects. The blended baseline, proposed in Table 190, suggests that the program assume pre-existing conditions for most building shell components but that the program assume a ROF baseline for mechanical equipment and appliances. We believe that this mix of baseline assumptions will result in more realistic gross savings estimates compared to the current baseline assumptions.

Table 190: Recommended Baseline Adjustments for Renovations

Measure	Current Baseline	Recommended Baseline
Insulation	Pre-existing conditions	Pre-existing conditions
Air sealing		Pre-existing conditions
Duct sealing		Pre-existing conditions
Windows		RNC UDRH
Heating equipment**		ROF from TRM
Cooling equipment**		ROF from TRM
Water heating equipment		ROF from TRM
Appliances		ROF from TRM
Instant savings measures		Applicable TRM algorithms
Lighting		Lighting market adoption model*

*NMR recommends that lighting savings be calculated using the same methodology currently used by the low-rise RNC program.
**There are ongoing conversations regarding integrated controls and their impacts on heat pump technologies. These should be monitored and considered when adjusting any baselines for this initiative.

G.3.1 NTG Considerations

To accurately calculate savings, free-ridership, and spillover for the R&A path, it will eventually be important to understand the scope of participating projects and the intentions of participants prior to their engagement with the program. Knowing what the participants planned to do *without influence from the program* will help inform a NTG assessment for the program in the future.

Table 191 shows four key scenarios that NMR has considered that would determine the extent to which the program influenced energy savings in participating projects. These scenarios can be used as a guide for future NTG research. Again, note that this study does not attempt to calculate actual program impacts – gross or net – but merely presents these issues to inform future program planning and evaluation efforts.

Table 191: R&A Scenarios

Project Type	Participant Behavior without Program	Did the Program Drive Savings?
Addition		
A homeowner is adding new conditioned square footage to their home, such as finishing a basement/attic, or expanding the footprint of their home.	The homeowner would have built a standard efficiency addition.	The program caused **all** savings beyond typical (UDRH) construction practices.
Renovation		
A homeowner is renovating some portion of their home.	**Track 1**	
	The homeowner **would not have upgraded** a given component.	The program created **all of** these savings.
	Track 2	
	The homeowner would have upgraded a given component **to some extent**.	The program created **some** of these savings.
	Track 3	
	The homeowner would have made the **same upgrade** to a given component.	The program created **no savings**.