MA20X11-B-PHMEB Passive House Market Effects Indicator Baseline Final Report

Final Report

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SUBMITTED TO:
Massachusetts Program Administrators and EEAC

SUBMITTED BY:
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DNV

Passive House Market Effects Baseline Study

Study Objectives

This study provided baseline measurements of market effects indicators for the multifamily Passive House Offering of the PAs' New Homes and Renovations Initiative. The indicators are meant to be remeasured periodically to track changes in the market over time and to eventually be used in quantifying the market effects from the offering.

Methodology

In-depth Interviews

The team performed in-depth interviews with market actors to support the design of the web survey questions and help the team better understand the multifamily market.

Web Survey

The team designed a web survey of participants and non-participants to collect data for many of the indicators.

Secondary Data Analysis and Indicator Measurement

The team measured baselines for several indicators using secondary data.

Key Findings

This study established baseline values for most of the indicators that the MA19R05 Passive House Program Theory and Logic Model Study recommended measuring at the launch of the redesigned program. In most cases, the evaluation team expects the baseline value to grow as program influence grows. However, we expect some to shrink. For outcomes expected to manifest in the mid-term (i.e., four to six years after program launch versus one to three years for short-term outcomes), it could be some years before the values change as expected, with ambiguous short-term movement.

Recommendations

1. Develop Cost data collection forms to determine participant costs at the measure level.
2. Before the next study measuring changes in market effects indicators, characterize the multifamily market actor population to assess the size of the market, ideally coordinating this research with similar research on the Non-residential new construction market.
3. Increase the volume of project contact information in tracking base by adding information that is currently contained in program documents.
4. Plan to update values for all indicators measured in this evaluation in late 2023.
5. Track PA-sponsored PH trainings, including the number and type of trainings and amount of participants

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Acronyms

Acronym	Definition
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BPD	Building Performance Database
CBECS	Commercial Buildings Energy Consumption Survey
CCSI	Code Compliance Support Initiative
CEC	Massachusetts Clean Energy Center
C&I	Commercial & Industrial
DOE	Department of Energy
DOER	Department of Energy Resources
ECM	Energy Conservation Measures
EIA	Energy Information Administration
EEAC	Energy Efficiency Advisory Council
EUI	Energy Usage Intensity
IDI	In-depth Interview
IECC	International Energy Code Council
ILFI	International Living Future Institute
ISP	Industry Standard Practice
LEED	Leadership in Energy and Environmental Design
MF	Multifamily
NBI	New Buildings Institute
NC	New Construction
NEI	Non-Energy Impact
NRNC	Non-Residential New Construction
NTG	Net-to-Gross
OPM	Owner Project Managers
PA	Program Administrators
PH	Passive House
PHIUS	Passive House Institute U.S.
PHI	Passive House Institute
PTLM	Program Theory and Logic Model
RNC	Residential New Construction
RFP	Request for Proposal
SD	Schematic Design
USGBC	U.S. Green Building Council's
ZNE	Zero Net Energy

Executive Summary

This report presents the findings of the *Passive House Baseline Indicators of Market Effects Study* (study number MA20X11-B-PHMEB). The Cross-Cutting Market Effects/Net-to-Gross evaluation team, led by NMR Group with support from DNV (here referred to as "the evaluation team" or "the team"), prepared this report for the Massachusetts Program Administrators (PAs)[1] and the Energy Efficiency Advisory Council (EEAC) consultants.

Goals and Objectives

The primary goal of this study was to measure the baseline indicators of market effects for the Passive House Offering for multifamily buildings, part of the PAs' Residential New Homes and Renovations Initiative. We refer to the Passive House Offering as the "Passive House program" or "PH program" throughout this report. The measurements presented are intended for use in future studies to assess progress toward the transformation of the broader multifamily market to Passive House levels of construction and to quantify the effects of the offering on the market for multifamily new construction in Massachusetts.

Background

The PH program was launched in July 2019 to generate market effects in the multifamily new construction sector. Market effects are *sustained increases in the adoption and penetration of technologies and practices resulting from market changes induced by market intervention* (i.e., the PH program), and market effects *indicators* are metrics that can be measured to help determine if market effects are occurring as expected in the target market.[2]

These indicators should be remeasured periodically to track changes in the market over time and for use in quantifying the market effects for the PH program. The *2020 MA19R05 Passive House Program Theory and Logic Model* [3] report identified the market effects outcomes from the PH program and the indicators associated with each. This evaluation attempted to establish baselines for these indicators, as appropriate.

Key Findings and Recommendations

This study established baseline values for most of the short- and medium-term indicators that the *MA19R05 Passive House Program Theory and Logic Model* report recommended measuring early in the program lifecycle. Table 1 lists the indicators that this study sought to measure, the associated outcomes, the timeframe over which the outcome is expected to manifest in the

[1] The PAs comprise Berkshire Gas, Cape Light Compact, Eversource, Eversource Gas of Massachusetts, Liberty Utilities, National Grid, and Until.
[2] https://ma-eeac.org/wp-content/uploads/Action_Plan_Measuring_Market_Effects_FINAL_2019.02.15.pdf
[3] http://ma-eeac.org/wordpress/wp-content/uploads/MA19R05_PassiveHouse_PTLM_Final_2020.06.26.pdf

market, how the indicator was operationalized (i.e., the method by which the evaluation team turned the abstract concept of the indicator into a measurable observation), and the value the evaluation team recommends for the baseline. Table 1 also documents indicators meant to be measured in this study for which we could not develop and recommend values. (In these cases, the "Baseline Value" column reads N/A). Section 4 and Appendix A list additional details about all measurements reported here, including unsuccessful measurements and measurements the evaluation team did not recommend using.

Table 1 shows the expected trajectory for the baseline value(s) of each indictor, assuming the program works in the market as theorized. In most cases, the evaluation team expects the value to grow as program influence grows. However, we expect some values to shrink. For outcomes expected to manifest in the mid-term (i.e., four to six years after program launch versus one to three years for short-term outcomes), it could be several more years before the values change as expected, with ambiguous short-term movement.[4] Note that certain indicators (most often those for short-term outcomes) are focused only on program participants. This reflects the program theory, which recognizes that these short-term indicators likely will not manifest among non-participants within three years after program launch. We outline strategies to capture the baseline measurements of the market effects indicators that were not captured in this study in Section 5.

Entries in Table 1 that refer to respondents are based on data collected via a web survey of market actors. "Participating respondents" are those who indicated in the survey that some or all of their multifamily projects had participated in the Passive House program, while "all respondents" include all survey respondents regardless of their stated participation status. Non-participants are respondents that have not participated in the program. These respondents are broken out into two sub-categories. "Other non-participants" are those that have worked on a multifamily project that participated in another PA-sponsored program in the 18 months prior to the launch of the program. "True non-participants" are those had not worked on any program projects in the 18 months prior to program launch. Following the table are additional recommendations and considerations for the program in preparation for tracking the indicators in the future.

[4] The program theory/logic model presented in the *Passive House Program Theory and Logic Model* identified several long-term outcomes that are generally not measured in this evaluation. This is because the program theory did not anticipate indicators of long-term outcomes to be measurable in the baseline period and did not recommend them for immediate measurement.

Recommended Indicator Baseline Values

Table 1: Summary of Measurements and Recommended Indicator Baselines

Measurement	Baseline Value	Data Source	Expected Trajectory
Short-Term Outcomes (Measurable Changes Attributable to Program Expected in 1-3 Years)			
Outcome A: High Program Awareness and Participation, Indicator 1: Rates of Program Awareness			
Proportion of **"true non-participant" respondents** who indicated they were aware of PH as a building concept.	**29%**	Survey	Increase
Rate of program awareness among **all non-participant respondents**.	**8%**	Survey	Increase
Outcome A: High Program Awareness and Participation, Indicator 2: Rates of Program Penetration			
Rates of Program Penetration. (To be operationalized in a future study.)	**N/A (see below)**	Program tracking data and U.S. Census data	N/A (long-term increase)
Outcome B: Increased Participant Understanding and Awareness of PH Certification, Practices, and Benefits, Indicator 3: Participant Understanding of PH Benefits and Challenges			
Proportion of **participating respondents** indicating they received some level of training in PH design or construction principles.	**28%**	Survey	Increase
Outcome B: Increased Participant Understanding and Awareness of PH Certification, Practices, and Benefits, Indicator 4: Participant Awareness of PH Design Principles			
Proportion of **participating respondents** indicating they received some level of training in PH design or construction principles.	**28%**	Survey	Increase
Proportion of **participating respondents** who indicated they "always" implement certain passive design principles on their projects.	**16% thermal bridge; 38% continuous insulation; 9% solar gains; 22% ventilation; 16% minimized HVAC; 6%**	Survey	Increase

Measurement	Baseline Value	Data Source	Expected Trajectory
	extremely air-tight		
Outcome B: Increased Participant Understanding and Awareness of PH Certification, Practices, and Benefits, Indicator 5: Participant Familiarity of PH Certification Processes			
Proportion of **participating respondents** who had worked on a project that was PH certified.	**16%**	Survey	Unknown (short-term) Increase (long-term)
Outcome C: Increased Adoption of Passive Design and Building Practices by Participant Market Actors, Indicator 6: Self-reported Building/Operation Practices of Participants			
Proportion of **participating respondents** that "always" tries to implement efficient practices.	**37% (PH-oriented), 40% (systems), 48% (other benefits)[a]**	Survey	Increase
Proportion of **participating respondents** that "always" succeeds in implementing efficient practices.	**12% (PH-oriented), 19% (systems), 35% (other benefits)[a]**	Survey	Increase
Proportion of **participating respondents** who said over 75% of their projects were all-electric.	**10%**	Survey	Increase
Outcome E: High Participant Satisfaction with Program, Indicator 8: Level of Participant Satisfaction with Program Support, Services, and Incentives			
The likelihood of **participating respondents** recommending the PH program using both the proportion of program promoters and the Net Promotor Score (NPS).	**61%, 45 (NPS)**	Survey	Increase
Mid-Term Outcomes (Measurable Changes Attributable to Program Expected in 4-6 Years)			
Outcome F: Increased Demand for PH Buildings in the Multifamily Market, Indicator 9: Proportion of New Buildings That Are PH Certified or Pre-certified			
Proportion of certified PH multifamily buildings in Massachusetts	**<1%**	Secondary data analysis	Increase
Proportion of pre-certified PH multifamily buildings in Massachusetts	**0%**	Secondary data analysis	Increase

Measurement	Baseline Value	Data Source	Expected Trajectory
Outcome F: Increased Demand for PH Buildings in the Multifamily Market, Indicator 10: Increased Requests for Passive Designs in RFPs			
Proportion of projects that had PH design or related language included in the RFP. (Base: **All respondents aware of PH only**)	**2%**	Survey	Increase
Outcome F: Increased Demand for PH Buildings in the Multifamily Market, Indicator 11: Increased Mentions of PH Accreditation in Advertisements and Real Estate Listings			
Proportion of developers that valued achieving high-performance standards "A great deal." (Base: **All developer or owner's project manager respondents**)	**25%**	Survey	Increase
Proportion of developers that perceived marketing advantages for achieving high-performance standards. (Base: **All developer or owner's project manager respondents**)	**42%**	Survey	Increase
Outcome G: Increased Number of PH-Certified and Skilled Market Actors, Indicator 12: Number of Market Actors with a PH Certification			
Total number of Massachusetts-based market actors with a PH certification.	**132**	Secondary data analysis	Increase
Outcome G: Increased Number of PH-Certified and Skilled Market Actors, Indicator 13: Self-Reported Levels of Skill in PH Practices (e.g., Air-Sealing, Thermal Bridge Details)			
Proportion of **all respondents** that "always" tries to implement efficient practices.	**27% (PH-oriented), 31% (systems), 35% (other benefits)**	Survey	Increase
Proportion of **all respondents** that "always" succeeds in implementing efficient practices.	**12% (PH-oriented), 16% (systems), 24% (other benefits)**	Survey	Increase
Outcome H: Increased Proportion of New Buildings That Are PH Certified or Pre-Certified, Indicator 14: Proportion of New Buildings in Massachusetts That Are PH Certified or Pre-certified			

Measurement	Baseline Value	Data Source	Expected Trajectory
Proportion of certified PH multifamily buildings in Massachusetts (same as Indicator 9)	**<1%**	Secondary data analysis	Increase
Proportion of pre-certified PH multifamily buildings in Massachusetts (same as Indicator 9)	**0%**	Secondary data analysis	Increase
Outcome I: Passive Design and Construction Practices Carried Over to Non-participant Projects, Indicator 15: Reports of Applying Knowledge/Skills for High-performance Building/Operation Learned through Program			
Proportion of **participating respondents** that reported carrying knowledge or experience gained on participating projects to their other work.	**81%**	Survey	Increase (short-term) Unknown (long-term)
Outcome K: Increased Proportion of New Buildings Which are Low EUI, Indicator 18: Proportion of buildings That Are Low EUI			
No measurement in absence of a 'low EUI' threshold value.	**N/A**		N/A
Outcome L: Increased Feasibility of Passive Design, Indicator 19: Market Actor Attitudes toward Passive Design Feasibility			
Proportion of **all respondents** who indicated it was "a little more" or "no more" difficult to execute a high-performance project than a code-compliant version of the same project	**31%**	Survey	Increase
Proportion of **all respondents** who indicated it has become easier to execute a high-performance building project since July of 2019.	**64%**	Survey	Increase
Long-Term Outcomes (Measurable Changes Attributable to Program Expected in 7-10 Years)			
Outcome T: Market Transformation, Indicator 32: Major Presence of PH Construction Observed in Neighboring States			
Proportion of PH certified multifamily buildings in Massachusetts compared to all PH certified buildings in the New England Region	**20% (buildings); 16% (units)**	Secondary data analysis	Unknown (short-term, small sample size may cause decrease) Increase (long-term)
Proportion of PH pre-certified multifamily buildings in Massachusetts compared to PH pre-certified buildings New England Region	**39% (buildings); 61% (units)**	Secondary data analysis	Unknown (short-term, small sample size may cause decrease) Increase (long-term)

Measurement	Baseline Value	Data Source	Expected Trajectory
Proportion of Certified PH Professionals in Massachusetts compared to New England Region	**54%**	Secondary data analysis	Increase

[a] *We organized specific design practices into three themes to simplify measuring this indicator: Passive House-oriented (enhanced air sealing, high levels of insulation, and designing to manage solar heat gain), systems and equipment (smaller high-efficiency HVAC systems, integrated building controls, balanced mechanical ventilation, and on-site renewables), and other benefits (indoor air quality considerations and other green building design considerations such as cool roofs, reflective exterior cladding, etc.).*

ADDITIONAL RECOMMENDATIONS AND CONSIDERATIONS

Recommendations

Develop cost data collection forms to determine participant costs at the measure level. This information will help the program, implementation, and evaluation teams understand how incremental costs change throughout the life of the program. The PAs could leverage existing data collection processes, for example by examining how the Massachusetts Clean Energy Center (CEC) captured incremental cost data from their Passive Design participant projects. The PAs could also create data collection forms through a consensus approach with program, implementation, and evaluation staff.

Before the next study measuring changes in market effects indicators, characterize the multifamily market actor population to assess the size of the market, ideally coordinating this research with similar research on the non-residential new construction (NRNC) market. This study focused on establishing indicator baselines with the PH program. A fundamental next step to accurately quantifying the market effects generated by the program is characterizing the market to understand the proportion of the market the program reaches. This information can also help identify and address possible self-selection bias in this and future web survey efforts. To help ensure accurate estimates of the proportion of the market the program reaches and improve the likelihood of successfully and defensibly quantifying market effects from the PH program, the PAs should undertake a market characterization study that focuses on estimating the population of market actors of various types (e.g., architects and mechanical, electrical, plumbing (MEP) engineers) working on multifamily new construction in Massachusetts. The PAs should complete the market characterization study before planning a follow-up study to re-measure indicators covered in this study and indicators that remain to be measured.

For market effects from Paths 1 and 2 of the NRNC program, EEAC consultants have raised a similar concern about lack of data on market actor populations and program reach in the NRNC market. Due to overlap among the market actors working on multifamily and NRNC projects, the multifamily and NRNC market characterization research should be coordinated or even conducted jointly.

In addition, program implementors may leverage this research to identify who in the market is not being reached and develop strategies to increase program coverage in the non-participant market.

The PAs could substantially increase the volume of project contact information contained in the tracking base without burdening participants by adding to the program data contact information that is already part of the project plans, specifications, and other documents that participants must submit to the program. Currently, the program tracking data supplies contact information for just two contacts per project. This makes evaluation difficult and results less reliable by preventing evaluators from conducting outreach to market actors and confirming participation status. It is the evaluation team's understanding that the reason just two contacts per project are listed in the program tracking database is to reduce the reporting burden on participants. However, a wealth of additional contact information is contained in the submittals

that participants are required to supply for each project. As program and implementation staff must go through these submittals carefully, extracting the additional contact information to add to the database should not be an excessive burden.

Plan to update values for all indicators measured in this evaluation in late 2023. In 2023, the program will enter the four-to-six-year period over which the PTLM predicts short-term outcomes will manifest in the market. It is important to reassess indicators when measurable changes are expected in the market to avoid recall issues and other factors that could impact accuracy and attribution. This timeline falls at the end of the expected short-term outcomes and the beginning of mid-term outcomes and will be a good point to determine whether unforeseen issues or market shifts may impact the ability to quantify market effects or warrant changes. The PAs have already identified late 2023 through 2024 as the likely time to execute such a study, which is in line with this recommendation. A Stage 1 plan for the study is included in the Massachusetts Three-Year Energy Efficiency Plan for 2022 – 2024. That timing would also be appropriate for assessing the outcomes and indicators not measured in this study, largely because by then a large portion of projects that initially enrolled in the PH program will be completed. As part of the study, the evaluation team should also develop an approach to quantify market effects from the program given the data on hand, the results of the market characterization study recommended above, and the results from the completed participant projects.

If PA or implementation staff are not doing so already, track PA-sponsored PH trainings, including the number and type of trainings conducted, market actor participation counts, and the number and type of certifications gained through PA-sponsorship. If possible, track which of the certified or trained market actors have also worked on a participant project would highlight the link between program sponsored training with real-world experience.

Indicator-specific Recommendations. Section 6.1 provides a summary of all recommendations, considerations, and conclusions for each specific indicator (Table 30). In most cases where the team was able to measure an indicator baseline, the recommendation is to update that same measurement during the follow-up study. Some recommendations address how to tackle unsuccessful measurements with additional data or identify potentially hard-to-interpret measurements as they evolve.

Considerations

Consider providing project teams additional incentives to deliver incremental cost estimates in addition to actual project cost data. Incremental cost evaluations are challenging to execute because acquiring cost data at the measure level can be prohibitive, and because determining the baseline measure relies on assumptions (primarily from the UDRH). Project teams are in a unique position to provide incremental cost estimates for their projects, as they likely have a baseline version of the project assessed during the feasibility study and access to specific costs. This data could feed into any evaluations that estimate incremental costs for the PH program and would also be useful in developing approaches to reduce barriers to broader market adoption of PH or similar levels of efficiency.

PA staff should reassess all aspects of the PH PTLM for any necessary adjustments now that the program has been in operation for a few years. The MA19R05 Passive House

Program Theory and Logic Model was established in 2020, and nearly three years have passed since the program entered the market. The team understands that PTLMs are meant to be living documents and that circumstances change once a program design moves from theory to practice. Failing to make necessary adjustments to program theory and indicator measurement plans before the execution of the next study that measures indicators could lock the program into an approach and a group of metrics that might not best reflect its impact.

While continuing to target multifamily project owners and developers with general education and outreach, the PAs should consider also providing non-developer market actors with tools and strategies that could help them to encourage project decision-makers to achieve greater levels of efficiency. Respondents aware of Passive House indicated that the project owner or developer was the primary driver behind the decision to pursue incentives through the PH program. They noted that other project stakeholders, such as the project team or sustainability consultants, can also drive this decision. If the program is not doing so already, the PAs should consider providing market actors with tools and strategies to help them sell project developers and owners on PH or other high-performance projects.

Consider conducting brief exit interviews or surveys with participants that drop out of the program to better understand which costs were too high and to inform program efforts to overcome those cost barriers. Respondents indicated that the number one reason for their project dropping out of the PH program was due to the incremental cost associated with achieving PH or similar levels of efficiency (Table 41).

The memo presented in Appendix D provides additional considerations for program and implementation staff. At a high level, these considerations are to:

1. Document and expand PA efforts to influence project RFPs to include language about incorporating PH or similar levels of efficiency in the project,[5] and track mentions of this language and impacted projects.
2. Consider offering training to appraisers to help them develop expertise in valuing high-performance buildings and other sustainability features. Having trained appraisers available in the market should help the construction financing of projects pursuing PH levels of efficiency. The program already targets real estate agents as a part of the workforce development component. The program could research whether any training or certification in valuation of high-performance buildings is currently offered to appraisers by any entity. The PAs could support and provide input if training is offered. If not, the PAs could develop and offer training.
3. Reduce barriers for low-rise multifamily projects to enroll in the PH program. For example, Home Energy Rating System (HERS) raters that operate in the low-rise multifamily market can more effectively encourage future participation in the program if they are trained to communicate the value and incentive structure of the PH program to market actors.

[5] This could include PH or similar levels of efficiency requirement, requirements to include PH core design principles, PH certification or pre-certification requirements, explicit inclusion of other high-performance design and construction practices, selection bonuses for project teams that include PH (or related high-performance strategies) in their responses, and teams that apply integrated project delivery strategies.

4. Determine which, if any, of the remaining market segments in Massachusetts can support programmatic offerings to achieve PH levels of efficiency. These market segments may include retrofits or renovations in the single-family, multifamily, and commercial markets as well as new construction for single-family homes and prefabricated homes.
5. Review the initial PH participant projects to identify whether equipment not currently covered in the User-defined Reference Home (UDRH) is commonly used and whether it warrants inclusion. Consider the impacts of design strategies such as managing solar gains and eliminating thermal bridging.

METHODOLOGY

The evaluation team measured indicator baselines via a web survey of participating and non-participating market actors and a review and analysis of program data and several secondary data sources.

Using a sample frame of contacts from program tracking data and ConstructConnect® data for Massachusetts,[6] the market actor web survey targeted 100 completes among participating and non-participating owners and practitioners in the multifamily market. To help ensure the effectiveness of the web survey questions and help the evaluation team better understand the makeup of the multifamily market, the team first performed ten in-depth interviews (IDIs) with participant and non-participant market actors. Because the survey was fielded two years after the PH program launch, the team designed the questions to be retrospective to before July 2019, when the PH program started.

We received 123 responses for a response rate of approximately 5%. Of these, 40 were screened out due to lack of experience in the multifamily market between 2018 and June 2019 or had completed too few questions. The survey yielded 83 useable responses, 71 fully complete and 12 partially complete, with partial responses included.

Program Data and Secondary Data Analysis

The team used secondary and program data to measure the baselines for each market effects indicator that could be measured through secondary data analysis at this time.

The team requested program participant tracking data and energy models for both the PH and Multifamily Housing Retrofit (MFHR) programs.[7] At the time of the data request, energy model and consumption data for PH program participants were not yet available. The team leveraged public data sources such as U.S. Census data to estimate program penetration in the Massachusetts market. We used data from the Passive House Institute U.S. (PHIUS) and Passive House Institute (PHI) databases of certified projects and professionals to estimate the number of

[6] https://www.constructconnect.com/
ConstructConnect also owns CMD Group, a source of new construction square footage data frequently used by NMR in evaluations.

[7] Due to the limited participation in the low-rise multifamily sector, the team did not request MFLR data, though data from other RNC-specific evaluations were leveraged to inform program penetration into the low-rise market.

certified PH buildings and market actors before July 2019. We also obtained relevant information from previous Massachusetts evaluation reports, such as the MA19R05 Passive House Assessment and literature review, and the (MA20X05-B-RNCNTG) Low-Rise Residential NTG Study.[8, 9]

Approaches for Market Effects Indicators Not Yet Ready for Measurement

Certain longer-terms indicators were not yet ready for a baseline measurement due to unavailable data or because it was too early in the program lifecycle to measure market level impacts. For each of these indicators, the team researched and recommended ways to measure the baselines in a future study. The assessments include potential sources of data, context around the measurement approach or approaches, potential research activities, and an estimate of when to measure the baseline for each indicator.

KEY LIMITATIONS AND SOURCES OF UNCERTAINTY

Potential for self-selection bias and limitations of self-reported data. While outreach materials avoided mentioning "high-performance buildings" to prevent alienating respondents for whom that term did not resonate, there is still potential for self-selection bias among survey respondents. Program participants or other market actors involved in high-performance designs or with interest in new and emerging building or design practices may be more willing than others to share information about their work and methods in a survey. In addition, relying on self-reported survey data can encourage socially desirable responding. However, where possible, the survey was designed to avoid inherent problems in self-assessments by asking questions designed to measure knowledge.

Recall Issues. To establish baselines prior to the launch of the PH program, the retrospective period precedes 2019. Therefore, any questions with a retrospective framing are asking respondents to think back to a period that ended between two and three years before the fielding of the survey in summer and fall of 2021. This creates the potential for recall issues that can affect the accuracy of self-report data included in the survey. This can be avoided in future measurements of market effects indicators.

The results are a snapshot of a moment in time. The PH program requires project participation from early in the design phase, well before construction has started. These projects usually have long timelines before occupancy, resulting in final as-built project data and energy model results unavailable until project completion, which can be several years after initial enrollment in the PH program. This information can be used to provide additional support for indicators of market effects, especially those related to specific PH practices. The program requirements also include monitoring actual energy consumption upon completion. (This data may not yield reliable energy consumption data until after at least one year of occupancy.)

[8] http://ma-eeac.org/wordpress/wp-content/uploads/MA19R05_PassiveHouse_LitReview_Final_2019.07.17.pdf
[9] A public reference for the Low-Rise RNC NTG study was not available at the time of drafting this report.

Section 1 Introduction

This report presents the findings of the *Passive House Baseline Indicators of Market Effects Study* (study number MA20X11-B-PHMEB). The Cross-Cutting Market Effects/Net-to-Gross evaluation team, led by NMR Group with support from DNV (here referred to as "the evaluation team" or "the team"), prepared this report for the Massachusetts Program Administrators (PAs)[10] and the Energy Efficiency Advisory Council (EEAC) consultants.

1.1 Study Goals and Objectives

This study primarily sought to measure the baseline indicators of market effects in the multifamily new construction market from the Passive House Offering of the PAs' Residential New Homes and Renovations Initiative.[11] This study also aimed to develop methods that could be replicated for each indicator. The measurements presented here are intended for use in future studies to assess progress toward the transformation of the broader multifamily market to Passive House levels of construction and to quantify the effects of the offering on the market for multifamily new construction in Massachusetts. [12]

For ease of reading, we refer to the Residential New Homes and Renovations Initiative as the "Residential New Construction program" or the "RNC" Program. The Passive House Offering is referred to as "Passive House program" or "PH program."

1.2 Passive House Program Background

The PH program was launched in July 2019 with the purpose of generating market effects in the multifamily new construction sector. Market effects are *sustained increases in the adoption and penetration of technologies and practices resulting from market changes induced by market intervention*[13]. (i.e., the PH program), and market effects *indicators* are metrics that can be measured to help determine if market effects are occurring as expected in the target market.

Passive House ("PH") is a design and construction concept that achieves extremely low space conditioning loads by emphasizing core design principles such as a well-insulated building

[10] The PAs comprise Berkshire Gas, Cape Light Compact, Eversource, Eversource Gas of Massachusetts, Liberty Utilities, National Grid, and Until.

[11] The New Homes and Renovations initiative is an umbrella effort that provides incentives for energy-efficiency residential new construction. It includes programs targeted at various market segments including single-family homes, low- and high-rise multifamily, and residential renovations and additions. The Passive House Offering is a subset of the multifamily offerings and includes multifamily buildings with five or more units.

[12] The development of a market effects quantification approach was not included in the scope of this study. The team has already delivered a stage 1 plan to the PAs to remeasure the indicators assessed in this evaluation, measure additional indicators for which baseline values could not be established here due to timing, and develop a market effects quantification approach. This study is planned to enter the field in fall of 2023 and be completed in fall of 2024.

[13] NMR Group, Inc. 2019. "Action Plan for Measuring Market Effects." Massachusetts Energy Efficiency Program Administrators. https://ma-eeac.org/wp-content/uploads/Action_Plan_Measuring_Market_Effects_FINAL_2019.02.15.pdf

envelope with minimal air leakage and thermal bridging, optimized window performance, optimized solar and internal gains, balanced heat and moisture recovery ventilation, and minimized Heating, Ventilation, and Air Conditioning (HVAC) systems. There are two PH building certification systems the program leverages as part of the incentive and training structure: Passive House Institute (PHI) and Passive House Institute U.S. (PHIUS). The PH program provides incentives to project teams for feasibility assessments, energy modeling subsidies, PH pre-certification, PH certification, and net performance bonuses based on the modeled energy savings, whether the project achieves certification or not.[14,15] It also includes trainings and technical support for various market actors pursuing PH projects. The PH program seeks to impact the broader multifamily market by making passive design more commonplace and, eventually, an industry-standard practice.

The PH Offering falls under the umbrella of the RNC Program, which includes two general pathways for multifamily construction: the Multifamily High-Rise (MFHR) pathway and the Multifamily Low-Rise (MFLR) pathway. The traditional MFHR path includes multifamily buildings four stories or higher and buildings with centralized HVAC systems. The traditional MFLR pathway includes multifamily buildings three stories or lower. (This pathway also includes single-family homes, which are out of the scope of this study.) The PH program was initially focused on high-rise multifamily projects. In January 2020, the PH program updated participant requirements to take a more holistic approach to the residential multifamily market by including all multifamily buildings with five or more units. However, in the 16 months from the start of the program until the evaluation team requested program data, participating projects were almost entirely high-rise.[16]

The program participant mix includes both affordable housing and market-rate developments. The amount of market rate participants has exceeded both program and implementation staff initial expectations. The program tracking data indicates that 52% of enrolled projects are market rate and 48% are affordable housing projects.

1.3 Research Approach

The Program Theory and Logic Model (PTLM) developed in the study *2020 MA19R05 Passive House Program Theory and Logic Model* identified the market effects outcomes expected from the program and the indicators that should be measured to quantify and track progress toward outcomes.[17] This study operationalized (i.e., turned an abstract concept into measurable observations) and measured certain indicators using a combination of primary data collected through a web-based survey of multifamily industry professionals that work in Massachusetts ("market actors") and through analysis of secondary data. The market actors targeted by the

[14] https://www.masssave.com/saving/residential-rebates/passive-house-incentives
[15] Pre-certification refers to the design of the building that meets PH standards and PH certification refers to the constructed building meeting the PH standards. A building can achieve pre-certification and not achieve full certification.
[16] The program participant data request indicated only one PH project that falls under the low-rise multifamily designation.
[17] http://ma-eeac.org/wordpress/wp-content/uploads/MA19R05_PassiveHouse_PTLM_Final_2020.06.26.pdf

survey included architects, engineers, builders, HVAC installers, other subcontractors, and project owners and developers.

1.3.1 Indicators Measured in This Study

For each of the market effects indicators identified in the PH PTLM, Table 2 shows whether and how it was measured in this study. The PTLM includes some expected medium- and long-term outcomes unlikely to happen this early in the life of the program. Instead of measuring these indicators, the evaluation team identified a suitable approach to capture the baseline measurement and a likely timeline for measurement. Throughout the report, we refer to the outcomes and indicators using the numbering presented in the table.

The icons in Table 2 represent the following information:

- In the first column, "Staff and Implementor IDI," this icon indicates that program and implementation staff discussed the indicator during interviews.
- ✓ In any of the middle three columns, this icon indicates that the study attempted to establish a baseline for the indicator using the data source(s) checked.
- In the last column, "Methodology Assessment Only in this Study," this icon indicates a medium- and long- term indicator for which the evaluation team only identified an appropriate approach to capturing the baseline measurement and a likely timeline for measurement.

Table 2: Market Effects Indicator Measurements by Evaluation Activity

#	Outcome	Indicator of Outcome	Evaluation Activity				
			Staff and Implementor IDI	Market Actor IDI	Market Actor Web Survey	Program and Secondary Data Analysis	Methodology Assessment Only in this Study
Short-term (1 to 3 years)							
A	High program awareness and participation	1: Rates of program awareness		✓	✓		
		2: Rates of program penetration [a]	🔍	✓		✓	
B	Increased participant understanding and awareness of PH certification, practices, and benefits	3: Participant understanding of PH benefits and challenges			✓		
		4: Participant awareness of PH design principles	🔍	✓	✓		
		5: Participant awareness of PH certification processes		✓	✓		
C	Increased adoption of passive design and building practices by participant market actors	6: Self-reported building/operation practices of participants		✓	✓		
D	Verified and enhanced program energy savings	7: Participant energy usage compared to model estimates, traditional RNC participants, baseline results, and billing data					🔍
E	High participant satisfaction with program	8: Level of participant satisfaction with program support, services, and incentives			✓		
Mid-term (4 to 6 years)							
F	Increased demand for PH buildings in the multifamily market overall	9: Proportion of new buildings that are PH certified or pre-certified				✓	
		10: Increased requests for passive designs in RFPs	🔍	✓	✓		

#	Outcome	Indicator of Outcome	Evaluation Activity				
			Staff and Implementor IDI	Market Actor IDI	Market Actor Web Survey	Program and Secondary Data Analysis	Methodology Assessment Only in this Study
		11: Increased mentions of PH accreditation in advertisements and real estate listings		✓	✓		
G	Increased number of PH-certified and skilled market actors	12: Number of market actors with a PH certification				✓	
		13: Self-reported levels of skill in PH practices (e.g., air-sealing, thermal bridge detail)		✓	✓		
H	Increased proportion of new buildings that are PH certified or pre-certified	14: Proportion of new buildings in MA that are PH certified or pre-certified				✓	
I	Passive design and construction practices carried over to non-participant projects	15: Reports of applying knowledge/skills for high-performance bldg./operation learned through program		✓	✓		
		16: Baseline market assessments and reports that characterize changes in the MF market			✓		
J	High owner and occupant satisfaction	17: Level of participant satisfaction with owners and occupants experience in participant buildings					🔍
K	Increased proportion of new buildings that are low Energy Usage Intensity (EUI)	18: Proportion of buildings that are low EUI (or extremely efficient) [a]		✓	✓		
L	Increased feasibility of passive design	19: Market actor attitudes toward passive design feasibility		✓	✓		

#	Outcome	Indicator of Outcome	Evaluation Activity				
			Staff and Implementor IDI	Market Actor IDI	Market Actor Web Survey	Program and Secondary Data Analysis	Methodology Assessment Only in this Study
		20: Incremental cost decreases relative to past PH program participants and ISP construction					
M	Emissions reductions	21: Reduced lifetime emissions from participant buildings compared to traditional program and non-program buildings (i.e., operational savings, fuel selection, material selection)					
N	Positive NEI experienced in participant buildings	22: The value of positive NEIs experienced as a result of the PH Offering					
O	Development of additional PH Offerings	23: The number of PH Offerings expands into other market sectors in Massachusetts					
Long-term (7 to 10 years)							
P	Advances in building codes and regulations	24: Changes in building codes (e.g., inclusion of PH and Zero Net Energy [ZNE] stretch codes)					
		25: Perceptions of program influence					
Q	Persistent energy savings in market overall	26: Reductions in EUI in new multifamily buildings					
		27: Perceptions of program influence					
		28: Observed lower energy consumption and peak demand from participant projects					

#	Outcome	Indicator of Outcome	Evaluation Activity				
			Staff and Implementor IDI	Market Actor IDI	Market Actor Web Survey	Program and Secondary Data Analysis	Methodology Assessment Only in this Study
R	Increased NEIs in the overall multifamily new construction market	29: Increased NEIs experienced in broader multifamily market					🔍
S	Savings from non-regulated loads and non-traditional measures	30: Increased number of claimable measures included in the user-defined reference home (UDRH) for PH Offering	🔍				🔍
T	Market Transformation	31: A majority of short-, medium- and long-term outcomes are measured and there is a major presence of PH in broader multifamily market					🔍
		32: Major presence of PH construction observed in neighboring states				✓	

✓ indicates that research activity informed a baseline measurement for an indicator.

🔍 indicates that these indicators were discussed during program and implementation staff IDIs, or a methodology assessment took place, but a measurement was not captured.

[a] Indicates that the evaluation team attempted to operationalize the indicator but did not establish a baseline value.

Section 2 Methodology

This section describes the data sources and collection methods the evaluation team used to measure baselines for market effects indicators operationalized in this study. These included a web survey of participant and non-participant market actors as well as secondary data.

2.1 Interviews with Program and Implementation Staff

The evaluation team first conducted two interviews, one with PA program staff and one with implementation contractor staff. These interviews had the following objectives:

- Determine the availability and extent of the program tracking data.
- Provide general context on project profiles within the PH program (e.g., size, scale, fuel-types on premise).
- Provide general context on incentive milestones and project goals (i.e., the number of feasibility studies that move to energy modeling and pre-certification steps, or whether projects pursue PH certification or net-performance bonus incentives).
- Understand the PH program's current state relative to the MFHR and LR programs and the broader multifamily new construction market in Massachusetts.
- Identify potential for additional program pathways in other market segments that incentivize PH or similar projects within Massachusetts and any efforts that contribute to PH programs in other jurisdictions.
- Identify whether current or future program plans are intended to impact long-term outcomes or indicators, such as anticipated efforts to change building codes and potential adjustments to measures included in claimed savings (i.e., additional measures incorporated into the user-defined reference home).

2.2 Interviews with Market Actors

To help ensure the effectiveness of the web survey questions and help the evaluation team better understand the makeup of the multifamily market, the team conducted ten open-ended, discovery-oriented in-depth interviews (IDIs) with two groups of MFHR industry professionals ("market actors"): participants in the PH program and non-participants, which included owners, developers, and sustainability consultants. We derived the sample for the market actor IDIs from three sources: 1) a sample frame originally used for the MA19R05 Passive House Assessment, 2) market actor names and contacts provided by the PAs and implementation staff, and 3) contact information found in tracking data for the PH and MFHR programs. We recruited interviewees by email and phone, offering a $100 incentive check for participation.

We conducted the first seven interviews before the web survey was drafted to gather data to inform the survey questions. These interviews covered topics such as program awareness,

market actor perception of high-efficiency building practices, potential sources to identify market actor samples for the web survey, data sources for projects outside of the purview of the program, and how market actors in the multifamily market segment define "high-performance" multifamily buildings. After drafting and programming the web survey, the evaluation team conducted the final three IDIs. The interviewees tested the survey while on the phone with a team member, providing feedback on question design, definitions of key terms, and overall experience in real-time. The team integrated feedback from these three interviews before fielding the final survey to the entire sample.[18]

2.3 Market Actor Web Survey

Fielded in the summer and fall of 2021, the web survey targeted 100 completes among a sample frame of multifamily industry professionals including project owners and developers, architects, engineers, builders, HVAC installers, and other subcontractors.

2.3.1 Sample Development

Since the goal of the PH program is to influence and transform the entire market, not just program participants, the survey sample frame was developed to include all possible market actors with experience in the multifamily new construction market. The sample frame comprised contact information from three sources:

1. a small number of market actors experienced in the multifamily market from previous evaluation,
2. the PH and MFHR program tracking data sets, and
3. ConstructConnect® data for Massachusetts.[19]

ConstructConnect is a market intelligence service that tracks data for ongoing and planned new construction and infrastructure projects. Their database includes new construction projects in the bidding, design, or construction phases; the companies known to be involved on those projects; and contact information for employees at those companies. Only companies identified in the ConstructConnect data as active on recent multifamily projects in Massachusetts were included in the sample frame. The ConstructConnect data primarily consisted of industry professionals such as architects, engineers, builder, HVAC installers, and other subcontractors. The data also included some limited information about project owners and developers.

This section details the methods used to measure the baseline market effects indicators and the rationale behind each choice. The primary source of measurement was a web survey of participant and non-participant market actors. The evaluation team also measured baselines for several other indicators using secondary data. In addition, the evaluation team provides

[18] Note that these three initial survey responses are included in the final results presented in this report, as no substantive changes to questions resulted from market actor feedback. Most feedback was suggestions for clarifying question wording to be more relatable to the multifamily construction industry.

[19] https://www.constructconnect.com/
ConstructConnect also owns CMD Group, a source of new construction square footage data frequently used by NMR in evaluations.

assessments on how and when to measure market effects indicators unable to be measured during the study's timeframe.

2.3.2 Sample Stratification

Since the team was not able to accurately characterize the number of market actors involved in the multifamily market, we did not specify targets by market actor type. We expected to find that some market actors had worked on both participating and non-participating projects, or with projects that participated in other PA-sponsored programs, such as the MFHR or MFLR programs. The evaluation team monitored responses with the goal of obtaining roughly 50 participants and 50 non-participants.

The team considered as program participants those market actors who reported that they had participated or were participating in the PH program as individuals. We considered as non-participants all market actors who said they had not engaged with the PH program specifically, whether they reported participation in other PA-sponsored programs or not. We further subdivided non-participants into those who had not participated in the PH program but had participated in other PA-sponsored programs versus those market actors who had not participated in any PA-sponsored program.

2.3.3 Recruitment and Response Rate

The evaluation team recruited for the survey by email with phone follow-ups as needed to meet the target sample size. The email offered prospective respondents a $50 electronic gift card as an incentive.

After cleaning the data to remove duplicates and screening out companies that did not appear to work on relevant new construction projects, the team was left with 962 email addresses from all sample sources. Of these, 130 emails bounced, resulting in a usable sample frame of 832 email addresses. Due to low initial response rates, the team supplemented the sample with ConstructConnect data slated for the concurrent Non-Residential New Construction Market Effects Baseline study (study number MA20X12-B-NRNCMEB) but had not been used. The additional sample included 2,015 emails, of which 324 bounced. Thus, the complete usable sample frame tallied 2,523 emails. We sent up to five emails per contact and called over 200 market actors before ultimately pulling the survey from the field.

We received 123 responses for a response rate of approximately 5%. Of these, 40 were screened out due to lack of experience in the multifamily market between 2018 and June 2019 or had completed too few questions to be considered non-respondents. The survey yielded 83 useable responses, 71 fully complete and 12 partially complete, with partial responses included. Section 3.1 provides more data on the types of market actors who responded to the survey as well as their participation status.

2.4 Program Data and Secondary Data Analysis

The team used secondary and program data to measure the baselines for each market effects indicator that could be measured through secondary data analysis at this time.

The team requested program participant tracking data and energy models for both the PH and MFHR programs.[20] At the time of the data request, energy model and consumption data for PH program participants were not yet available. The team leveraged public data sources such as U.S. Census data to estimate program penetration in the Massachusetts market. We used data from the PHIUS and PHI databases of certified projects and professionals to estimate the number of certified PH buildings and certified PH market actors before July 2019. We also obtained relevant information from previous Massachusetts evaluation reports, such as the MA19R05 Passive House Assessment and literature review, and the (MA20X05-B-RNCNTG) Low-Rise Residential NTG Study.[21, 22]

2.4.1 Market Effects Indicator Assessments

Certain longer-terms indicators were not yet ready for a baseline measurement due to unavailable data or because it was too early in the program lifecycle to measure market level impacts. For each of these indicators, the team researched and recommended ways to measure the baselines in a future study. The assessments include potential sources of data, context around the measurement approach or approaches, potential research activities, and an estimate of when to measure the baseline for each indicator. These assessments and the strategies to measure the remaining indicators are covered in detail in Section 5.

2.5 Key Limitations and Sources of Uncertainty

Potential for self-selection bias and limitations of self-reported data. While outreach materials avoided mentioning "high-performance buildings" to prevent alienating respondents for whom that term did not resonate, there is still potential for self-selection bias among survey respondents. Program participants or other market actors involved in high-performance designs or with interest in new and emerging building or design practices may be more willing than others to take a survey that asks them to share information about their work and methods. In addition, relying on self-reported survey data encourages socially desirable responding. However, where possible, the survey was designed to avoid inherent problems in self-assessments by asking questions designed to measure knowledge.

Recall Issues. To establish baselines prior to the launch of the PH program, the retrospective period precedes 2019. Therefore, any questions with a retrospective framing are asking respondents to think back to a period that ended between two and three years before the fielding of the survey in summer and fall of 2021. This creates the potential for recall issues that can affect the accuracy of self-report data included in the survey. This issue can be avoided in future measurements of market effects indicators.

The results are a snapshot of a moment in time. The PH program requires project participation from early in the design phase, well before construction has started. These projects usually have long timelines before occupancy, resulting in final as-built project data and energy model results

[20] Due to the limited participation in the low-rise multifamily sector, the team did not request MFLR data, though data from other RNC-specific evaluations were leveraged to inform program penetration into the low-rise market.
[21] http://ma-eeac.org/wordpress/wp-content/uploads/MA19R05_PassiveHouse_LitReview_Final_2019.07.17.pdf
[22] A public reference for the Low-Rise RNC NTG study was not available at the time of drafting this report.

unavailable until project completion, which can be several years after initial enrollment in the PH program. This information can be used to provide additional support for indicators of market effects, especially those related to specific PH practices. The program requirements also include monitoring actual energy consumption upon completion. (This data may not yield reliable energy consumption data until after at least one year of occupancy.)

Section 3 Sample Characteristics

This section summarizes characteristics of the survey respondents, including their roles in the market and the types of projects they worked on in 2018 and 2019.

3.1 Program Awareness and Participation

At the time of the survey, nearly two-thirds of the 83 respondents (64%) reported being aware that the PH program existed as a distinct offering in the multifamily market before taking the survey, and more than one-third (39%) of the 83 respondents reported that at least one of their projects was a participant in the PH program. Only 24% of respondents said they had been aware of the PH program during the first six months after launch (i.e., between July and December 2019). Respondents also reported whether any of their projects participated in other Mass Save MF residential new construction programs (i.e., the MFHR program or MF buildings in the low-rise program ["MFLR program"]) in the 18 months prior to the start of the PH program (i.e., between January 2018 and June 2019). The evaluation team used this information to develop five reporting categories:

1. PH program participants,
2. total non-participants,
3. non-participants who worked on a project that participated in either the MFHR or MFLR program in the 18 months prior to the launch of the PH program (referred to as "Other non-participants"),
4. non-participants who had not worked on any program projects in the 18 months prior to the launch of the PH program (referred to as "True non-participants"), and
5. the complete sample of all respondents.

The evaluation team identified non-participants through both self-reported awareness of the PH program and program participation screening questions. The team linked 14 participant respondents back to the PH program tracking data through email addresses. These 14 respondents represent projects that account for 38% of the 6,207 enrolled units included in the PH program tracking data.

The distinction between the two non-participant subcategories shows how other PA-sponsored programs may have affected the multifamily market. Where the distinction is not relevant, such as baseline indicators focused just on participants or the overall market, we do not break out results for the non-participant subcategories.

As Table 3 shows, almost four in ten (39%) of respondents had worked on PH program-participating projects and qualified as PH participants. The balance of the sample (61%) qualified as non-participants. The evaluation team expected notable differences among non-participants who had worked on multifamily projects supported by one of the PAs' other new construction programs in the 18 months prior to the start of the PH program. Therefore, we chose to also report

results separately for the two subcategories of non-participants, "Other non-participants" and "True non-participants." The non-participants were about equally split between "Other non-participants" (27, or 53% of all the non-participants) and "True non-participants" (24, or 47% of all the non-participants).

Table 3: Respondent Categories

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Participant status	32	39%	51	61%	27	33%	24	29%	83	100%

3.2 Respondent Types and Project Details

Table 4 shows the mix of market actors that responded to the survey. Respondents were asked about *the primary role they held during projects from January 2018 to June 2019*, the 18 months before the PH program started – not their current position. Developers were the most common type of respondent. They represented one-third (33%) of survey respondents and nearly half of participant respondents (47%). This is likely due to the program tracking data including only primary and secondary project contacts. Engineers of various types, sustainability consultants, and architects together comprised over half of all respondents.

Table 4: Survey Respondent's Primary Role

Between January 2018 and June 2019

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Developer	15	47%	12	24%	11	41%	1	4%	27	33%
Engineer	3	9%	17	33%	7	26%	10	42%	20	24%
Sustainability Consultant	8	25%	5	10%	4	15%	1	4%	13	16%
Architect	3	9%	7	14%	2	7%	5	21%	10	12%
HVAC or other subcontractor	1	3%	4	8%	0	0%	4	17%	5	6%
Owners project manager	1	3%	4	8%	3	11%	1	4%	5	6%
Design/build contractor	1	3%	2	4%	0	0%	2	8%	3	4%
Total [a]	***32***	***99%***	***51***	***101%***	***27***	***100%***	***24***	***100%***	***83***	***101%***

[a] Totals may not sum to 100% due to rounding.

Respondents most commonly reported having worked on between one and ten projects between January 2018 and June 2019 (Table 5). This was consistent across participants and non-

participants (of both categories). On average, respondents worked on nine projects in the 18 months before the PH program launched.

Table 5: Respondent Project Activity

Between January 2018 and June 2019

Binned project counts (n=80)	n	%
1-10 Projects	69	86%
11-25 Projects	4	5%
26-50 Projects	4	5%
50+ Projects	3	4%
Total [a]	***80***	***100%***
Statistics		
Average	9.3	-
Median	3	-
Minimum	1	-
Maximum	110[a]	-

[a] Three outlier responses were removed due to high numbers of reported projects, including two with over 400 projects during the time period.

Over half of the projects that respondents reported working on were buildings with 50 or fewer units (Table 6). Note that it is not possible to distinguish how often respondents worked on the same projects, which projects were active in the design phase, and which projects were under construction.

Table 6: Project Counts by Residential Units

Between January 2018 and June 2019

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Fewer than 25 units	49	14%	149	54%	124	61%	25	35%	198	31%
25 to 50 units	134	38%	35	13%	23	11%	12	17%	169	27%
51 to 75 units	68	19%	17	6%	14	7%	3	4%	85	13%
76 to 99 units	36	10%	14	5%	9	4%	5	7%	50	8%
100 to 199 units	53	15%	40	15%	22	11%	18	25%	93	15%
200 to 299 units	13	4%	12	4%	6	3%	6	8%	25	4%
Over 300 units	4	1%	8	3%	6	3%	2	3%	12	2%
Total [a]	***357***	***101%***	***275***	***100%***	***204***	***100%***	***71***	***99%***	***632***	***100%***

[a] Totals may not sum to 100% due to rounding.

Respondents estimated the proportion of their projects that were a given development type (i.e., affordable housing project or market rate) between 2018 and June 2019. Over half of the PH participant projects were affordable housing projects while just over a quarter of non-participant projects were affordable housing projects (Table 7). Survey respondents and market actor IDIs

noted that developers of affordable housing projects and market rate developers that own and operate the building after completion are more likely to value high-performance buildings.

Table 7: Proportion of Projects by Development Type

Between January 2018 and June 2019

	PH participant		Total non-participant		Non-participant subcategories				All[a]	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Affordable Housing	28	51%	45	27%	22	30%	23	25%	73	36%
Market rate - owner occupied	28	28%	45	45%	22	42%	23	48%	73	38%
Market rate - sold on completion	28	14%	45	19%	22	22%	23	17%	73	17%
Don't know	28	7%	45	9%	22	7%	23	10%	73	8%
Total [b]	***28***	***100%***	***45***	***100%***	***22***	***101%***	***23***	***100%***	***73***	***99%***

[a] In addition to the three responses excluded due to extremely high project counts, due to a survey programming issue three respondents were not presented with this question.

[b] Totals may not sum to 100% due to rounding.

Section 4 Baseline Market Effects Indicator Values and Indicator-Specific Recommendations

This section presents the baseline values for the PH program market effects indicators that this study sought to measure. Table 8 **summarizes the baseline indicator values our team recommends the PH program continue to track moving forward, as well as the expected trajectory of the measurements**. In most cases, the evaluation team expects the indicator values to grow as the program continues to influence the market. However, there are some that we would expect to shrink. For longer-term outcomes, the values might not change for years. Following the summary table are detailed results organized by market effect outcomes and their associated indicator(s). As identified by the PTLM, short-term outcomes were those for which changes in indicators should be measurable one to three years after program launch, while intermediate-term outcomes were those for which measurable changes in the market could be expected four to six years after program launch. Note that certain outcomes or associated indicators (often short-term outcomes) are focused **only on program participants**, because the PTLM does not anticipate the outcomes manifesting among non-participants in the measurement timeframe.

In most cases, the evaluation team operationalized each indicator with just one survey question or piece of secondary data. Where the evaluation team operationalized an indicator with multiple questions or pieces of data, we note this in the presentation of detailed results. For some indicators, we offer related information that is not part of the indicator but that offers additional context and may interest program staff.

Each indicator measurement assessed via the web survey is presented with the associated survey question. The team prefaces each measurement with two bullets:

- If we are recommending a value for the indicator, how the team operationalized the measurement and the value(s) we recommend.
- Whether or not the measurement warrants continued tracking. (There are multiple measurements for certain indicators, some more successful than others. We prioritize indicator measurements that yield clear takeaways and show room for future growth.)

We present the results by respondent group (participants, non-participants, and the non-participant subgroups). For each indicator, we identify the most appropriate measurement(s) in **bolded, green text** and their **values in green on lime background**. If a follow-up measurement occurred, these values are **bolded with a light blue background**.

We use the term “high-performance” throughout this section to describe (1) buildings designed to achieve low energy-use intensity (EUI) as measured in kBtu per square foot, or (2) the design

and construction practices used to execute these buildings. The definition of high-performance provided to survey respondents is found in Appendix B.[23]

[23] Due to the ambiguous nature of what constitutes a "high-performance" building, we included a survey question to quantify what respondent market actors consider a "high-performance" building. (Results are presented in Section 4.2.5.1.)

Table 8: Summary of Measurements and Recommended Indicator Baselines

Measurement	Baseline Value	Data Source	Expected Trajectory
Short-Term Outcomes (Measurable Changes Attributable to Program Expected in 1-3 Years)			
Outcome A: High Program Awareness and Participation, Indicator 1: Rates of Program Awareness			
Proportion **of "true non-participant" respondents** who indicated they were aware of PH as a building concept.	**29%**	Survey	Increase
Rate of program awareness among **all non-participant respondents**.	**8%**	Survey	Increase
Outcome A: High Program Awareness and Participation, Indicator 2: Rates of Program Penetration			
Rates of Program Penetration. (To be operationalized in a future study.)	**N/A (see below)**	Program tracking data and U.S. Census data	N/A (long-term increase)
Outcome B: Increased Participant Understanding and Awareness of PH Certification, Practices, and Benefits, Indicator 3: Participant Understanding of PH Benefits and Challenges			
Proportion of **participating respondents** indicating they received some level of training in PH design or construction principles.	**28%**	Survey	Increase
Outcome B: Increased Participant Understanding and Awareness of PH Certification, Practices, and Benefits, Indicator 4: Participant Awareness of PH Design Principles			
Proportion of **participating respondents** indicating they received some level of training in PH design or construction principles.	**28%**	Survey	Increase
Proportion of **participating respondents** who indicated they "always" implement certain passive design principles on their projects.	**16% thermal bridge; 38% continuous insulation; 9% solar gains; 22% ventilation; 16% minimized HVAC; 6% extremely air-tight**	Survey	Increase
Outcome B: Increased Participant Understanding and Awareness of PH Certification, Practices, and Benefits, Indicator 5: Participant Familiarity of PH Certification Processes			

Measurement	Baseline Value	Data Source	Expected Trajectory
Proportion of **participating respondents** who had worked on a project that was PH certified.	**16%**	Survey	Unknown (short-term) Increase (long-term)
Outcome C: Increased Adoption of Passive Design and Building Practices by Participant Market Actors, Indicator 6: Self-reported Building/Operation Practices of Participants			
Proportion of **participating respondents** that "always" tries to implement efficient practices.	**37% (PH-oriented), 40% (systems), 48% (other benefits)[a]**	Survey	Increase
Proportion of **participating respondents** that "always" succeeds in implementing efficient practices.	**12% (PH-oriented), 19% (systems), 35% (other benefits)[a]**	Survey	Increase
Proportion of **participating respondents** who said over 75% of their projects were all-electric.	**10%**	Survey	Increase
Outcome E: High Participant Satisfaction with Program, Indicator 8: Level of Participant Satisfaction with Program Support, Services, and Incentives			
The likelihood of **participating respondents** recommending the PH program using both the proportion of program promoters and the Net Promotor Score (NPS).	**61%, 45 (NPS)**	Survey	Increase
Mid-Term Outcomes (Measurable Changes Attributable to Program Expected in 4-6 Years)			
Outcome F: Increased Demand for PH Buildings in the Multifamily Market, Indicator 9: Proportion of New Buildings That Are PH Certified or Pre-certified			
Proportion of certified PH multifamily buildings in Massachusetts	**<1%**	Secondary data analysis	Increase
Proportion of pre-certified PH multifamily buildings in Massachusetts	**0%**	Secondary data analysis	Increase
Outcome F: Increased Demand for PH Buildings in the Multifamily Market, Indicator 10: Increased Requests for Passive Designs in RFPs			

Measurement	Baseline Value	Data Source	Expected Trajectory
Proportion of projects that had PH design or related language included in the RFP. (Base: **All respondents aware of PH only**)	**2%**	Survey	Increase
Outcome F: Increased Demand for PH Buildings in the Multifamily Market, Indicator 11: Increased Mentions of PH Accreditation in Advertisements and Real Estate Listings			
Proportion of developers that valued achieving high-performance standards "A great deal." (Base: **All developer or owner's project manager respondents**)	**25%**	Survey	Increase
Proportion of developers that perceived marketing advantages for achieving high-performance standards. (Base: **All developer or owner's project manager respondents**)	**42%**	Survey	Increase
Outcome G: Increased Number of PH-Certified and Skilled Market Actors, Indicator 12: Number of Market Actors with a PH Certification			
Total number of Massachusetts-based market actors with a PH certification.	**132**	Secondary data analysis	Increase
Outcome G: Increased Number of PH-Certified and Skilled Market Actors, Indicator 13: Self-Reported Levels of Skill in PH Practices (e.g., Air-Sealing, Thermal Bridge Details)			
Proportion of **all respondents** that "always" tries to implement efficient practices.	**27% (PH-oriented), 31% (systems), 35% (other benefits)**	Survey	Increase
Proportion of **all respondents** that "always" succeeds in implementing efficient practices.	**12% (PH-oriented), 16% (systems), 24% (other benefits)**	Survey	Increase
Outcome H: Increased Proportion of New Buildings That Are PH Certified or Pre-Certified, Indicator 14: Proportion of New Buildings in Massachusetts That Are PH Certified or Pre-certified			
Proportion of certified PH multifamily buildings in Massachusetts (same as Indicator 9)	**<1%**	Secondary data analysis	Increase
Proportion of pre-certified PH multifamily buildings in Massachusetts (same as Indicator 9)	**0%**	Secondary data analysis	Increase

Measurement	Baseline Value	Data Source	Expected Trajectory
Outcome I: Passive Design and Construction Practices Carried Over to Non-participant Projects, Indicator 15: Reports of Applying Knowledge/Skills for High-performance Building/Operation Learned through Program			
Proportion of **participating respondents** that reported carrying knowledge or experience gained on participating projects to their other work.	**81%**	Survey	Increase (short-term) Unknown (long-term)
Outcome K: Increased Proportion of New Buildings Which are Low EUI, Indicator 18: Proportion of buildings That Are Low EUI			
No measurement in absence of a 'low EUI' threshold value.	**N/A**		N/A
Outcome L: Increased Feasibility of Passive Design, Indicator 19: Market Actor Attitudes toward Passive Design Feasibility			
Proportion of **all respondents** who indicated it was "a little more" or "no more" difficult to execute a high-performance project than a code-compliant version of the same project	**31%**	Survey	Increase
Proportion of **all respondents** who indicated it has become easier to execute a high-performance building project since July of 2019.	**64%**	Survey	Increase
Long-Term Outcomes (Measurable Changes Attributable to Program Expected in 7-10 Years)			
Outcome T: Market Transformation, Indicator 32: Major Presence of PH Construction Observed in Neighboring States			
Proportion of PH certified multifamily buildings in Massachusetts compared to all PH certified buildings in the New England Region	**20% (buildings); 16% (units)**	Secondary data analysis	Unknown (short-term) Increase (long-term)
Proportion of PH pre-certified multifamily buildings in Massachusetts compared to PH pre-certified buildings New England Region	**39% (buildings); 61% (units)**	Secondary data analysis	Increase
Proportion of Certified PH Professionals in Massachusetts compared to New England Region	**54%**	Secondary data analysis	Increase

[a] *We organized specific design practices into three themes to simplify measuring this indicator: Passive House-oriented (enhanced air sealing, high levels of insulation, and designing to manage solar heat gain), systems and equipment (smaller high-efficiency HVAC systems, integrated building controls, balanced mechanical ventilation, and on-site renewables), and other benefits (indoor air quality considerations and other green building design considerations such as cool roofs, reflective exterior cladding, etc.).*

4.1 Short-Term Outcomes and Related Indicators

4.1.1 Outcome A: High Program Awareness and Participation

4.1.1.1 Indicator 1: Rates of Program Awareness

The evaluation team attempted to operationalize Indicator 1, Rates of Program Awareness, with two self-reported measurements: (1) awareness of PH as a building concept and (2) awareness of the PH program.

4.1.1.1.1 Awareness of Passive House as a Building Concept

- **We operationalized this indicator as the proportion of "true non-participant" respondents who indicated they were aware of PH as a building concept before the PH program was launched.** Less than one-third of "true non-participants" respondents (29%, or 7 of these 24 respondents) were aware of PH as a building concept prior to program launch. (By the time of the survey awareness among this group had increased to 42%.)
- **Recommendation: The PAs should track this measurement by respondent category moving forward, focusing on PH awareness among "true non-participants."**

Question QC1: *Before you were asked to participate in this survey, had you heard of the terms Passive House or Passive Building?*

We expect the amount of "true non-participants" to shrink over time and awareness to grow overall in the market, though a smaller number of "true non-participants" may result in this indicator shrinking as it is measured in future studies. "True non-participant" awareness of PH building concepts highlights the first step in understanding whether non-participant building practices could have been influenced by the program. This indicator coupled with program participation rate and the adoption of PH building practices will provide a clearer picture of which, if any, non-participant building practices have been influenced.

Of respondents aware of PH, 75% were aware before the inception of the program, and 11% of respondents could not recall when they first heard about PH. Of the ten (42%) "True non-participants" aware of PH as a building concept, only three had learned of the concept after program inception. Program staff may consider this information as they seek to broaden outreach and marketing efforts outside of typical marketing channels.

Table 9: Respondent Awareness of Passive House Concept

Base: All respondents (n=83)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Yes	32	100%	31	66%	21	91%	**10**	**42%**	63	80%
No	0	0	16	34%	2	9%	14	58%	16	20%

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Total	***32***	***100%***	***47***	***100%***	***23***	***100%***	***24***	***100%***	***79***	***100%***
When respondents first became aware of PH (n=63)										
2018 and before	22	69%	19	61%	12	57%	**7**	70% **(29%** of true non-participants)[b]	41	65%
January 2019 to June 2019	6	19%	0	0%	0	0%	**0**	**0%**	6	10%
July 2019 to December 2019	1	3%	2	6%	2	10%	0	0%	3	5%
2020	1	3%	4	13%	3	14%	1	10%	5	8%
2021	0	0%	1	3%	0	0%	1	10%	1	2%
I don't remember	2	6%	5	16%	4	19%	1	10%	7	11%
Total	***32***	***100%***	***31***	***100%***	***21***	***100%***	***10***	***100%***	***63***	***100%***

[a] Totals may not sum to 100% due to rounding.
[b] This indicator is operationalized as the proportion of "true non-participant" market actors that were aware of PH as a building concept before 2020. Only 7 of the 24 (or 24%) of "true non-participant" respondents were aware of the PH program during this timeframe.

4.1.1.1.2 Awareness of the Passive House Program

- **We operationalized this indicator as the rate of program awareness among non-participant respondents during the period right after program inception.** Less than one-tenth of non-participant respondents (8%, or four of 51 non-participant respondents) were aware of the existence of the PH program before 2020, while four in ten (41%) of non-participants had become aware of the program by the time of the survey. We did not operationalize awareness among PH participants for this indicator, as they are 100% aware of the program.
- **Recommendation: The PAs should track market actor awareness of the PH program for all respondents and for non-participant subgroup categories.**

Question QS2: *Before you were asked to participate in this survey, had you heard of the Multifamily Passive House Offering and the incentives available for pursuing projects that achieve Passive House levels of efficiency in multifamily new construction projects?*

Less than one-quarter (24%) of respondents were aware of the program in the program's first six months (20 of 83 respondents). Of those aware of the program, 38% became aware within the program's first six months and another 43% learned of the program in 2020. Among respondents who had not worked on PA-sponsored multifamily projects in 2018 through June 2019 (the baseline period), only 22% were aware before taking the survey.

Table 10: Respondent Awareness of the PH Program

Base: All respondents (n=83)

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Yes	32	100%	**21**	**41%**	17	62%	4	22%	53	64%
No	0	0	30	59%	10	38%	20	78%	30	36%
Total	***32***	***100%***	***51***	***100%***	***27***	***100%***	***24***	***100%***	***83***	***100%***
When respondents first became aware of PH (n=63)										
July 2019 to December 2019	16	50%	**4**	19% **(8% of NPs)** [b]	3	18%	1	25%	20	38%
2020	12	38%	11	52%	9	53%	2	50%	23	43%
2021	0	0	1	5%	1	6%	0	0	1	2%
I don't remember	4	12%	5	24%	4	24%	1	25%	9	17%
Total	***32***	***100%***	***21***	***100%***	***17***	***101%***	***4***	***100%***	***53***	***100%***

[a] Totals may not sum to 100% due to rounding.

[b] This indicator is operationalized as the proportion of non-participant market actors that were aware of the program before 2020. Only 4 of the 51 (or 8%) of non-participant (NP) respondents were aware of the PH program during this timeframe.

4.1.1.2 Indicator 2: Rates of Program Penetration

- **The baseline penetration rates should be based on the incentive level the project achieved rather than only on the enrolled participant counts.** This is because enrolled projects may drop out at various stages after receiving some incentives.[24] Essentially, basing penetration off enrolled participant counts results in a baseline measurement that only partially captures the program impacts. **The evaluation team did not operationalize Indicator 2, Rate of Program Participation, in this study because most enrolled projects are too early in their project lifecycle to know the outcome of the enrolled project and this indicator can be operationalized retrospectively.** Instead, we present an example of how program penetration in the multifamily market will be estimated in a future study by project outcome. We will update this example using the project outcome listed in the program tracking data.

- **Recommendation: In a future study, use the approach described below to calculate penetration of the PH program into the Massachusetts multifamily market. Use U.S. Census permitting and completed construction data to calculate penetration at both the building and unit level for each incentive level achieved by participant projects.**

The evaluation team provides the planned approach to estimate penetration of the PH program in the broader Massachusetts multifamily market at the building and unit level. **This information**

[24] The incentive levels of the PH program include feasibility study, energy modeling, pre-certification, and certification. Enrollment does not indicate which incentive level the project will achieve upon completion.

is currently for program information purposes and are not considered the baseline measurement for this indicator, but the next evaluation will use these total market size values when projects are further along the cycle. The estimates rely on a mix of program tracking data and U.S Census Building Permit Survey (BPS) counts of permitted residential units for buildings with five or more units.[25] These estimates are based on the **enrolled** participant project and unit counts. The evaluation team intends for the next iteration of this study to expand these estimates to include penetration levels based on the incentive level achieved. The program tracks this information for each participant, but as of the date of this study not enough time had passed since the first projects enrolled in the program for the results to be meaningful.

The penetration rate of projects enrolled in the PH program has increased on a year-by-year basis since 2018. Using BPS data as the denominator and program tracking data as the numerator, we estimate that projects participating in the PH program represented 35% of permitted multifamily units permitted in Massachusetts in 2021 and 8% of multifamily buildings over five units permitted in Massachusetts in 2021 (Table 11). The disparity between building and unit penetration rates indicates that projects enrolled in the program tend to be among those with higher numbers of units per building in the state.[26] Note that estimates recorded in the BPS may not accurately reflect the actual number of buildings permitted in the state.[27]

Table 11: Penetration of Enrolled PH Program Participant Projects in the Massachusetts Multifamily Market

Year	Permitted buildings (5+ unit buildings)			Permitted units (5+ unit buildings)		
	Massachusetts statewide total[a]	PH program enrolled count	Estimated penetration	Massachusetts statewide total[a]	PH program enrolled count	Estimated penetration
2018 [b]	289	1	0%	8,841	98	1%
2019	665	2	0%	10,086	149	1%
2020	482	22	5%	9,339	1,449	16%
2021	578	45	8%	10,321	3,566	35%

[a] U.S Census Building Permit Survey Counts for buildings with over five units in Massachusetts.

[b] The project that began in 2018 was further along in the project timeline than other enrolled projects and is tracked with 2018 permit data. (This project was involved in the Massachusetts Clean Energy Center's Passive Design Challenge.)

Multifamily mid- and high-rise construction timelines can be difficult to gauge, as completion can take up to three years from receiving a building permit and sometimes more. Future studies could improve this measurement by also examining penetration rates based on completed project counts from U.S. Census data in addition to penetration of permitted projects. [28] Below is an

[25] https://www.census.gov/construction/bps/stateannual.html

[26] Note this is consistent with the program's initial focus on the high-rise sector, and that nearly all of the projects that were enrolled in the PH program were high-rise projects at the time of this study's data request.

[27] The COVID-19 pandemic impacts on construction timelines, project activity, and decisions to abandon projects are not factored here which may result in an estimate that overstates the number of buildings that will ultimately be built.

[28] https://www.census.gov/construction/chars/xls/mfu_floors_cust.xls

example of how to calculate the penetration rate of completed MFHR program units based on statewide estimates of completed multifamily construction. The Census data provide counts of completed units by building floors at the census division level. We used this information to determine the number of completed units classified as high-rise construction (four or more stories),[29] prorating the counts based on the level of permit activity in Massachusetts.

The MFHR program penetration was 64% for units completed in 2019 and 46% for units completed in 2020 (Table 12).

Table 12: MFHR Program Penetration Estimates for Completed Units

Year	Statewide estimates for completed MFHR units	MFHR program completed units	Penetration of completed units
2019	7,508	4,769	64%
2020	9,427	4,374	46%

4.1.2 Outcome B: Increased Participant Understanding and Awareness of PH Certification, Practices, and Benefits

4.1.2.1 Indicator 3: Participant Understanding of PH Benefits and Challenges

- **We operationalized this indicator as the proportion of participants who indicated they received some level of training in PH design or construction principles prior to program launch.** Less than one-third of participant respondents (28%, or nine of 32 participant respondents) had received training in PH prior to program launch. By the time of the survey, two-thirds of participants (66%) had received some level of training in PH design or construction principles.
- **Recommendation: The PAs should continue to track these measurements for each respondent group moving forward.**

Question QC4: *Have you received any formal or informal training on Passive House design and/or construction principles?*

Nearly half of participants that had received training in PH were initially trained before the inception of the program (July 2019). This suggests that between one-third and one-half of early PH program participants were early adopters of PH practices. The types of PH training that market actors received is detailed in Appendix A.1.1.1.

Table 13: Respondent Received Training in Passive House Design Principles

Base: Respondents aware of PH (n=63)

[29] The evaluation did not determine the proportion of completed projects (or units) under four stories that have central systems and would qualify for the MFHR program.

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Yes	**21**	**66%**	12	39%	8	38%	4	42%	33	52%
No	11	34%	19	61%	13	62%	6	58%	30	48%
Total	***32***	***100%***	***31***	***100%***	***21***	***100%***	***10***	***100%***	***63***	***100%***
When respondents first received training (n=33)										
2018 and before	**6** [b]	**29%**	4	33%	1	13%	3	75%	10	30%
January 2019 to June 2019	**3** [b]	**14%**	2	17%	2	25%	0	0%	5	15%
July 2019 to December 2019	3	14%	0	0%	0	0%	0	0%	3	9%
2020	6	29%	5	42%	4	50%	1	25%	11	33%
2021	0	0%	0	0%	0	0%	0	0%	0	0%
I don't remember	3	14%	1	8%	1	13%	0	0%	4	12%
Total [a]	***21***	***100%***	***12***	***100%***	***8***	***101%***	***4***	***100%***	***33***	***99%***

[a] Totals may not sum to 100% due to rounding.

[b] This indicator measurement includes all participants that had PH training prior to program inception in July of 2019. Less than one-third of participant respondents had trained in PH (28%, or 9 of 32 participant respondents).

4.1.2.2 Indicator 4: Participant Awareness of PH Design Principles

The evaluation team attempted to operationalize indicator 4, participant awareness of PH design principles, with two self-reported measurements: (1) percent of participants trained in PH design or construction principles and (2) rate of successful implementation of PH design principles in projects.

4.1.2.2.1 Trained in Passive House Design Principles

- **This indicator is operationalized the same as Indicator 3: Participant Understanding of PH Benefits and Challenges (Section 4.1.2.1).**
- **Recommendation: The PAs should continue to track this indicator moving forward.**

4.1.2.2.2 Successful Implementation of Passive House Design Principles by Participants

- **We operationalized this indicator as the proportion of participating market actors who indicated they "always" implement certain passive design principles on their projects.** This measurement focused on baseline period projects (i.e., before the PH program started). Sixteen percent of participants reported that before the program started, they always applied thermal bridge free details, 38% always applied continuous insulation around the thermal envelope, 9% always optimized solar gains and losses (via window placement), 22% always incorporated balanced ventilation with moisture and heat recovery, 16% always minimized HVAC systems (i.e., reduced size of equipment to meet lower heating and cooling loads), and 6% always made buildings extremely air tight.

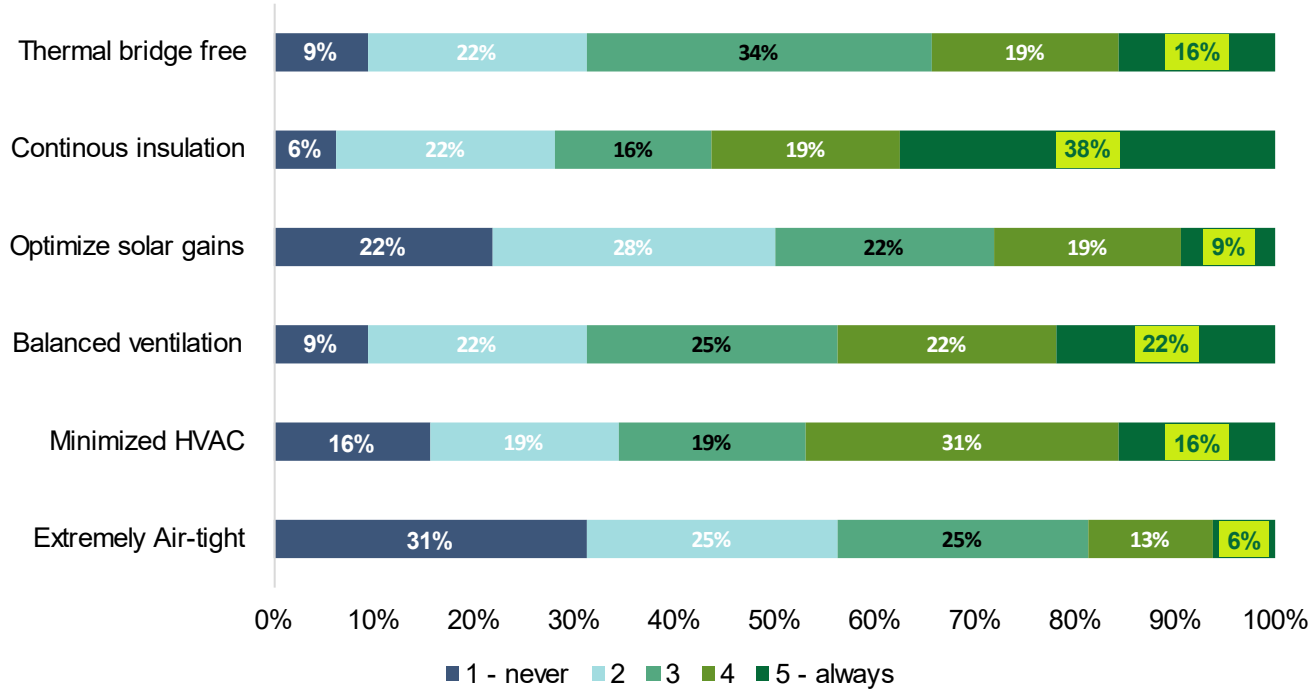
- **Recommendation: The PAs should track this measurement for each respondent group moving forward. In future measurements this question should also be asked of respondents that are unaware of PH.[30]**

Question QC10: *Please rate on a scale from 1 to 5, with 1 being never have implemented on a project and 5 being always implemented on projects, how often did you implement the following practices on your projects* ***between January 2018 and June 2019****?*

Detailed results for all respondent groups are presented in Appendix A.1.1.2.

Figure 1: Rate at Which Participants "Always" Applied Passive Design during Baseline Period

Base: Participants (n=32)



4.1.2.3 Indicator 5: Participant Familiarity of PH Certification Processes[31]

- **We operationalized participant awareness of PH certification processes as the proportion of participating respondents who had completed the PH certification process on a project.** Sixteen percent of participating respondents had completed the certification process on a project.

[30] The survey logic did not ask this question of respondents who were not aware of PH core design principles. However, market actors who are unaware of PH design principles might implement some or all of these practices. This question would yield insights into the frequency of these practices outside of program influence.

[31] The evaluation updated Indicator 5 from "Participant Awareness of PH Certification Process" to "Participant Familiarity with PH Certification Process." This update is to create greater alignment with the intended outcome, as the PH program intends to increase participant understanding of the PH certification process through project experience.

- **Recommendation: The PAs should continue to track this measurement for all respondent types.**

Question QC3: *How familiar are you with the certification process [POPUP DEFINTION AVAILABLE FOR PHI and PHIUS certifications]?*

Table 14 shows respondent familiarity with PH certification processes. Of the 13 respondents (21%) who had completed a PH certification or pre-certification process, all but two were participants in the PH program. The two non-PH participants had participated in a different PA-sponsored program. Note that participation in the PH program does not mean a project achieved pre-certification or final certification. Participation refers to whether the project is enrolled in the PH program. This explains how some participants may not be aware or have not been through the certification process.

Table 14: Respondent Familiarity with PH Certification Processes

Base: Respondents aware of PH (n=63)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
I am unaware of the PH certification process	1	3%	5	16%	2	10%	3	30%	6	10%
I know the certification exists, but am unfamiliar with any specific requirements	5	16%	11	35%	6	29%	5	50%	16	25%
I have explored the requirements for certification but have not been through the certification process	4	12%	12	39%	10	48%	2	20%	16	25%
I have worked on a project that has started the certification process but have not completed pre-certification	11	34%	1	3%	1	5%	0	0	12	19%
I have worked on a project that has completed pre-certification	6	19%	1	3%	1	5%	0	0	7	11%
I have worked on a project that has been certified as PH	**5**	**16%**	1	3%	1	5%	0	0	6	10%
Total [a]	***32***	***100%***	***31***	***99%***	***21***	***102%***	***10***	***100%***	***63***	***100%***

[a] Totals may not sum to 100% due to rounding.

4.1.3 Outcome C: Increased Adoption of Passive Design and Building Practices by Participant Market Actors

4.1.3.1 Indicator 6: Self-Reported Building/Operation Practices of Participants

The evaluation team attempted to operationalize indicator 6, self-reported building/operation practices of participants, with three self-reported measurements: (1) the frequency with which participants "always" ***try to implement*** high-performance design or construction practices on their projects, (2) the rate at which participants said they "always" ***successfully implement*** high-performance design or construction practices, and (3) the frequency with which all-electric equipment are installed in participating projects. Detailed results for these measurements can be found in Appendix A.1.2.

There is some overlap between the practices described in Section 4.1.2.2.2 and the practices described below. In Section 4.1.2.2.2, respondents aware of PH design and construction core principles were asked the frequency they incorporated these principles into their projects during the 18 months prior to program launch. In this section, all respondents indicate the frequency of attempting and succeeding at various high-performance design and construction practices, some of which overlap with the PH design and construction core principles, in more recent projects.

4.1.3.1.1 Frequency with Which Participants Attempt to Implement High-Performance Design and Construction Practices

- **We operationalized this indicator as the proportion of participating respondents who answer that they "always" try to implement a series of high-performance design or construction practices.** Thirty-seven percent said they always tried to implement PH practices, 40% always tried to implement system- or equipment-oriented practices, and 48% always tried to implement practices geared toward realizing non-energy impacts (NEIs) and other sustainability features. (Note that these responses do not imply that the respondents achieved PH levels of performance.)
- **Recommendation: The PAs should track this measurement for each respondent group moving forward.**

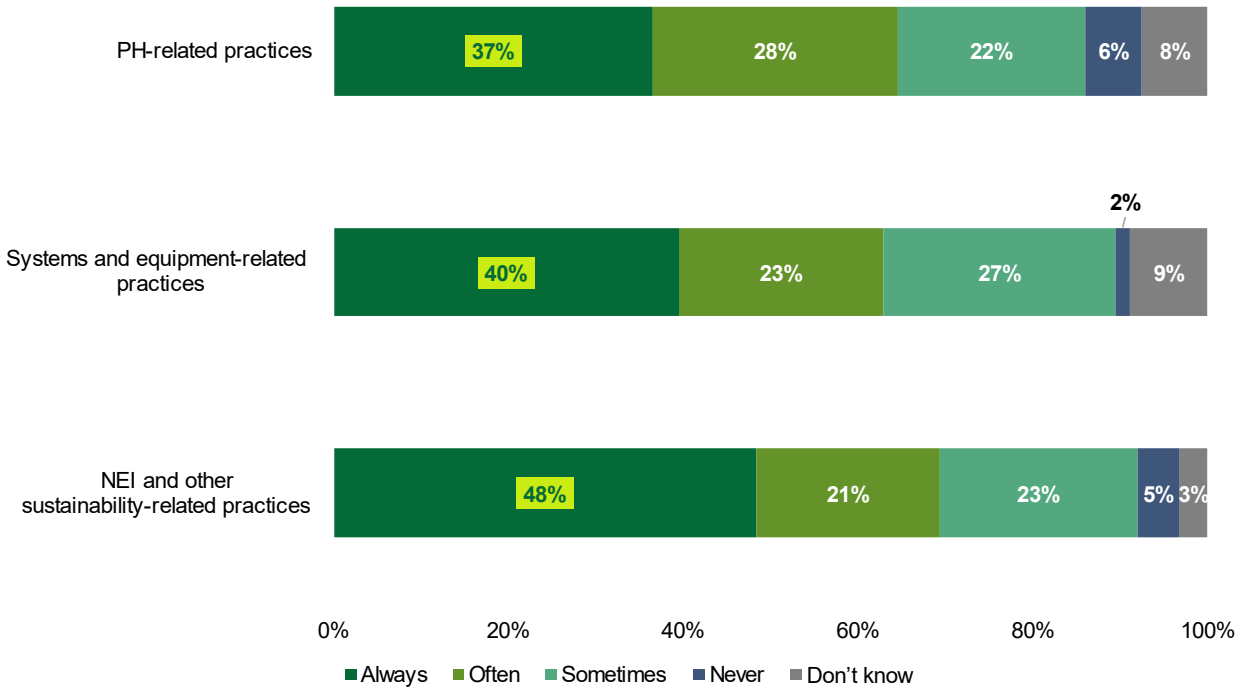
Question QR7: ***Thinking of your most recent projects****, on a scale of 1 to 4 where 1 is "Never" and 4 is "Always," how often do you or your project teams* ***try to implement*** *the following high-performance design or construction practices in your projects, regardless of whether they are actually implemented? ("Trying" in this case could mean including these practices in initial planning discussions, feasibility studies or early design iterations, getting cost estimates, etc.)*

We organized specific design practices into three themes to simplify reporting: 1) PH practices (enhanced air sealing, high levels of insulation, and managing solar heat gain), 2) systems and equipment (smaller high-efficiency HVAC systems, integrated building controls, balanced mechanical ventilation, and on-site renewables), and 3) other benefits (indoor air quality considerations and other green building design considerations, such as cool roofs, reflective exterior cladding, etc.).[32]

[32] The team recognizes that these granular practices are not mutually exclusive among the three themes used to consolidate them. For example, PH projects could use on-site renewables and are frequently electrified and equipped with balanced mechanical ventilation systems. Our association of practices and themes is meant to ease the reporting of both multiple granular indicator measurements and associates' practices with themes that seemed most relevant.

Figure 2: How Often Participants Try to Implement High-Performance Design or Construction Practices

Base: Participants (n=31)



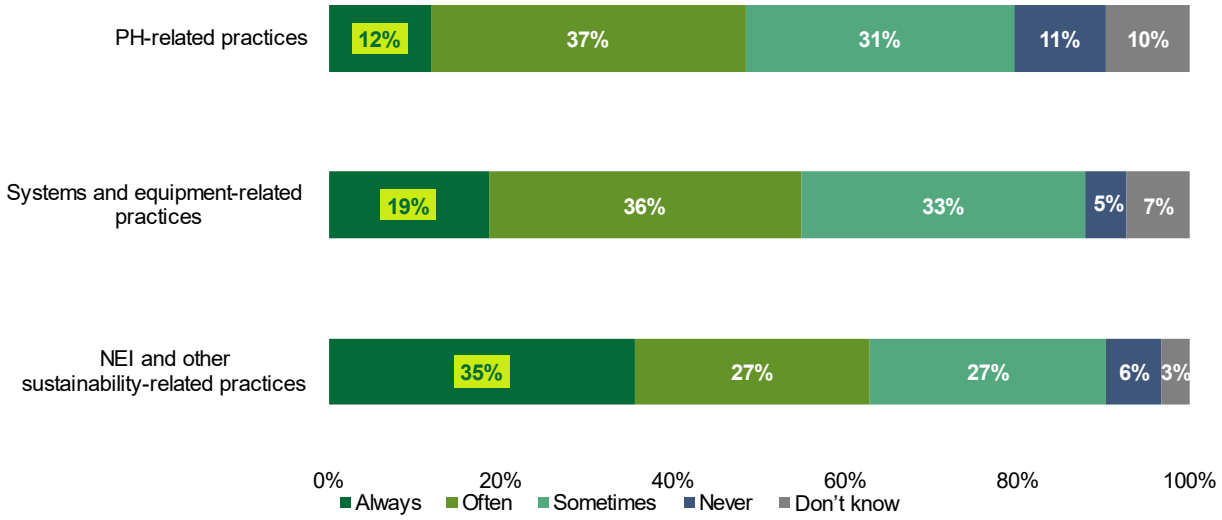
4.1.3.1.2 Successful Implementation of High-Performance Design and Construction Practices by Participants

- **We operationalized this indicator as the proportion of participating respondents who indicated they "Always" implement a set of high-performance design and construction practices on their projects.** Twelve percent said they always implement PH practices, 19% always implement system and equipment-oriented practices, and 35% always implement practices geared toward realizing non-energy impacts (NEIs) and other sustainability features.
- **Recommendation: The PAs should track this measurement for each respondent group moving forward**

Question QR8: ***Thinking of your most recent projects****, on a scale of 1 to 4 where 1 is "Never" and 4 is "Always," how often do you or your project teams* ***actually implement*** *the following high-performance design and construction practices in your projects? (By "actually implement," we mean they are included in final designs or construction, depending on the status of the project.)*

Figure 3: How Often Participating Respondents Implement High-Performance Design and Construction Practices

Base: Participants (n=31)



4.1.3.1.3 Frequency of All-Electric Equipment in Participant Projects

- **We operationalized this indicator as the proportion of participating respondents who said that over 75% of their projects were all-electric.**[33] Ten percent of participant respondents indicated that 75% or more of their projects were all-electric before the PH program launched. We acknowledge that the emphasis on electrification in broader state policies may diminish the value of tracking this indicator. Nonetheless, future tracking of electrification at the project level and by end-use may shed light on whether the PH program has pushed greater market adoption of high-efficiency electric systems, particularly domestic hot water systems, in multifamily buildings.
- **Recommendation: The PAs should track this measurement for each respondent group moving forward.** Note the question we used to measure this indicator is tied to a larger set of questions that include details on the proportion of electric- versus fossil fuel-fired equipment by end-use. Together these questions can provide insights into the evolution of non-program practices over time. (See Appendix A.1.2 for additional details.) In addition to tracking survey responses, the next study will incorporate program tracking data for completed projects, including data on specific equipment types, levels of efficiency, and fuels used by participants.

With the development of the Massachusetts 2050 Decarbonization Roadmap and the recent passing of the S.9 Climate Bill, the evaluation team expects that building electrification will be emphasized as an energy-efficiency strategy.[34] The complexity of the broader policy support for

[33] All-electric projects do not include any fossil fuel-fired equipment for heating, water heating, or cooking.
[34] MA 2050 Decarbonization Roadmap: https://www.mass.gov/info-details/ma-decarbonization-roadmap, S.9 Bill: https://malegislature.gov/bills/192/S9

electrification may lead to looking at the difference in all-electric projects completed by participants and non-participants in future indicator measurements. Building electrification includes replacing fossil fuel with electricity in the HVAC, water heating, and (where applicable) cooking end-uses. Given this and the program focus on PH and similar high-performance building practices, which often incorporate electrification and the use of renewables, the survey asked specific questions about electrification and the implementation of on-site renewable energy generation before the launch of the PH program. Due to the survey length and competing question priorities, renewable energy questions were only included as optional questions. The detailed results for electrification by end-use and on-site renewable energy systems are presented in Appendix A.1.2.

Table 15 summarizes the electrification results at the project level. Half the sample (50%), including 52% of participants, reported having no all-electric projects before the start of the PH program. Just 7% of the sample, and 10% of participants, reported that 75% or more of the projects they worked on before the PH program were all-electric.

Question QT6: ***Between January 2018 and June 2019*** *what percent of your projects were fully electrified (space heating, water heating, and cooking)?*

Table 15: Percent of Projects That Were All-Electric before PH Program Launch

Base: All respondents (n=72)

All-electric projects	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
None	15	52%	21	49%	12	57%	9	41%	36	50%
Less than 25%	10	34%	10	23%	6	29%	4	18%	20	28%
25-50%	0	0%	6	14%	2	10%	4	18%	6	8%
51-75%	0	0%	1	2%	0	0%	1	5%	1	1%
Over 75%	3	**10%**	2	5%	0	0%	2	9%	5	7%
I don't remember	1	3%	3	7%	1	5%	2	9%	4	6%
Total [a]	29	99%	43	100%	21	101%	22	100%	72	100%

[a] Totals may not sum to 100% due to rounding.

4.1.3.1.3.1 *Additional Context*

Respondents also reported the rate of all-electric projects since the program launch (Table 16). This percentage of respondents that reported not having worked on an all-electric project decreased from 50% to 30%. The results suggest that more market actors are being exposed to all-electric projects and more all-electric projects have come to market since July of 2019.

Question QT8: ***Now thinking of your most recent projects,*** *what percent of your projects were fully electrified (space heating, water heating, and cooking)?*

Table 16: Percent of Recent Projects That Are All-Electric

Base: All respondents (n=69)

All-electric buildings (n=69)	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
None	7	27%	14	33%	6	29%	8	36%	21	30%
Less than 25%	7	27%	12	28%	7	33%	5	23%	19	28%
25-50%	6	23%	6	14%	3	14%	3	14%	12	17%
51-75%	2	8%	3	7%	1	5%	2	9%	5	7%
Over 75%	3	**12%**	4	9%	2	10%	2	9%	7	10%
Don't know	1	4%	4	9%	2	10%	2	9%	5	7%
Total [a]	26	101%	43	100%	21	101%	22	100%	69	99%

[a] Totals may not sum to 100% due to rounding.

4.1.4 Outcome E: High Participant Satisfaction with Program

4.1.4.1 Indicator 8: Level of Participant Satisfaction with Program Support, Services, and Incentives

- **We operationalized this indicator as the likelihood of participants recommending the PH program using the percent of participants that are "promoters" and the Net Promotor Score (NPS).**[35] Overall, 61% of participants are "promoters"—that is, there is a high likelihood that these participants will actively promote the program to other potential participants by word of mouth. The Net Promoter Score was 45 out of a possible 100 points.
- **Recommendation: The PAs should track these measurements for each respondent group moving forward.**

Question QS6: *Using a scale from 0 to 10, with 0 being "Extremely unlikely" and 10 being "Extremely likely," how likely are you to recommend the Passive House Offering?*

The Net promoter score was 45 out of a possible 100 points, which is considered a favorable score (Figure 4).[36] Overall, 61% of participants are "promoters"—that is, there is a high likelihood that these participants will actively promote the program to other potential participants by word of mouth. However, 23% of respondents are classified as "passives" and 16% are classified as "detractors," which indicates there is room for the program to improve the participant experience.

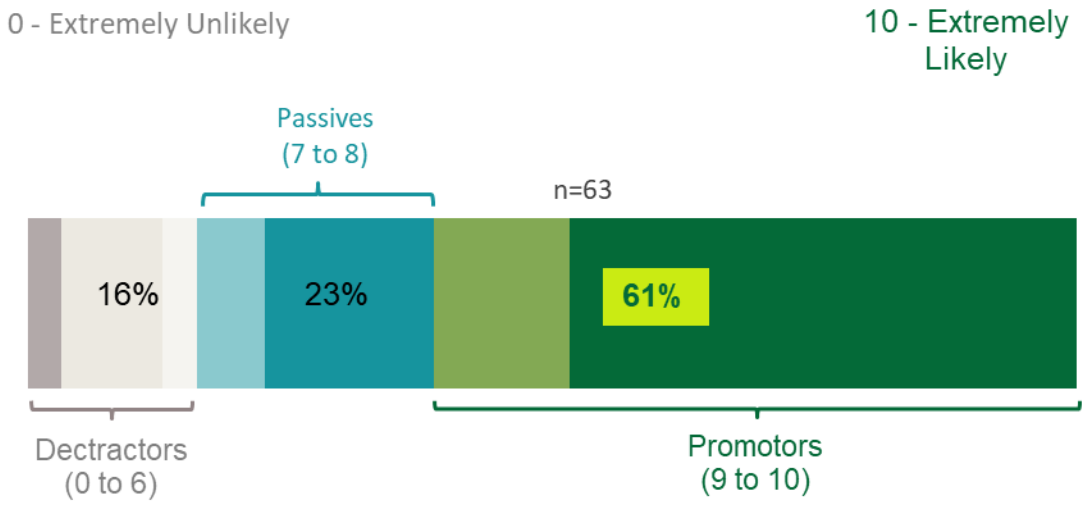
Additional context on participant project status and key decision makers are included in Appendix A.1.3.

[35] The response scale ranged from 0 to 10, with 0 being "extremely unlikely" and 10 being "extremely likely." This rating is used to calculate the Net Promotor Score (NPS), a well-established measure of customer loyalty. With the NPS, respondents are grouped as promoters (score 9-10), passives (7-8), and detractors (0-6). The NPS is calculated by subtracting the percentage of detractors from the percentage of promotors and presented as a whole number.

[36] https://www.qualtrics.com/experience-management/customer/good-net-promoter-score/

Figure 4: Likelihood of Recommending the PH Program

Base: Participants (n=31)



4.2 Medium-Term Outcomes and Related Indicators

4.2.1 Outcome F: Increased Demand for PH Buildings in the Multifamily Market

4.2.1.1 Indicator 9: Proportion of New Buildings That Are PH Certified or Pre-certified

- **We operationalized this indicator using the number of certified multifamily buildings completed in Massachusetts before the start of the PH program**. Just one PH certified building with 28 units, or less than 1% of permitted residential units for buildings with five or more units in Massachusetts was in existence between 2017 and 2018. No multifamily projects in Massachusetts had been pre-certified before the program started.[37]
- **Recommendation: The PAs should continue to track this indicator moving forward. Tracked indicators include the number of certified and pre-certified projects at the building- and unit-level.[38]**

Only one certified PH multifamily building in Massachusetts existed before the PH program began in July 2019. There were no pre-certified multifamily buildings in Massachusetts before the PH program launched. To determine the denominator needed to calculate the baseline penetration value for this indicator, the team considered multiple time periods, including the 18-month time

[37] The date of pre-certification was not included in the certification databases; however, to determine the number of pre-certified multifamily buildings in Massachusetts, the evaluation team leveraged certification data pulled for the MA19R05 Passive House Assessment which was collected from the certification databases before the PH program began.

[38] Pre-certification refers to the design of the building that meets PH standards. PH certification refers to the constructed building meeting the PH standards. A building can achieve pre-certification and not achieve full certification.

period before program launch, which was used as the baseline time period for survey responses. Ultimately, the evaluation team considered the availability of a pathway for multifamily buildings to become PH certified as the baseline time period for calculating penetration into the market. In late 2015, PHIUS released multifamily-specific guidelines.[39] The team used the release date of the PHIUS certification pathway for multifamily buildings as the basis of the denominator.[40] A one-year lag time was applied to allow time for project teams to consider the multifamily guidelines into project designs. The team applied the count of permitted units in buildings with five or more units in Massachusetts between 2017 and 2018 as the denominator.[41]

Table 17: Penetration of Certified and Pre-Certified PH Projects in the Massachusetts Multifamily Market before Program Launch (2017 and 2018)

Year	Permitted units (5+ unit buildings)	Permitted buildings (5+ unit buildings)
2017 permit counts	8,841	289
2018 permit counts	9,630	303
Total permits between 2017 and 2018	18,471	592
Certified Project Penetration		
PH certified before program launch	28	1
Baseline Penetration of PH Certified MF buildings	**0.15%**	**0.17%**
Pre-Certified Project Penetration		
Pre-certified count	0	0
Baseline Penetration of pre-certified buildings	**0%**	**0%**

Prior to the official launch of the Mass Save PH program, the Massachusetts Clean Energy Center (CEC) offered grant money to pursue PH standards through the CEC's Passive House Design Challenge program. The CEC awarded these grants to the recipients, eight affordable housing multifamily projects totaling 540 units, on November 6, 2019, shortly after the Mass Save PH program started.[42]

As of December 2021, seven of these eight projects are also participants in the PH program. Of these seven, one has achieved full PH certification, and the rest have achieved pre-certification.[43,]

[39] https://www.phius.org/phius-certification-for-buildings-products/project-certification/programs-version-dates
[40] Prior to the release of the multifamily certification pathway, PHIUS certified multifamily buildings on a case-by-case basis. The team was unable to determine whether PHI released a multifamily certification pathway prior to 2015; however, expanding the time period of permitted buildings would ultimately reduce the penetration rate even closer to zero.
[41] https://www.census.gov/construction/bps/stateannual.html
[42] https://www.masscec.com/about-masscec/news/baker-polito-administration-announces-173-million-support-energy-efficient
[43] https://www.phius.org/phius-certification-for-buildings-products/certified-projects-database?sort=%60Projects%60.%60StateId%60+ASC accessed 12.7.2021

[44, 45] An additional eight participant projects have also achieved pre-certification.[46] Together, these participating projects account for over 93% of the multifamily buildings and 98% of residential units that were pre-certified in Massachusetts as of December 2021. If we exclude the Massachusetts CEC's Passive House Design Challenge projects from the numerator of this calculation[47], the proportion of statewide pre-certified multifamily buildings and units that participate in the PH program drops to 53% and 45%, respectively.

Table 18 shows project counts for certified and pre-certified PH multifamily projects in Massachusetts as of December 2021.

Table 18: Massachusetts PH Pre-Certified and Certified Multifamily Project Totals as of December 2021

	PH Participant Projects		Non-participant projects		MA CEC PH Design Projects	
	Buildings	Units	Buildings	Units	Buildings	Units
Pre-certified	14**	730**	1	18	6	395
Certified	1**	98**	1*	28*	1	98

* This project was a MFHR program participant and was the only certified multifamily project in Massachusetts before the launch of the PH program in July 2019.
** These counts include the projects that were a part of the Massachusetts CEC Passive House Design Challenge.

4.2.1.2 Indicator 10: Increased Requests for Passive Designs in RFPs

- **We operationalized this indicator as the proportion of all respondents who were aware of PH and said that PH considerations were mentioned in over half the project request for proposals (RFPs) they reviewed during the baseline period.** Just one respondent (2%) indicated that PH considerations were included in RFP language over half of the time during that period.
- **Recommendation: The PAs should continue to track this measurement for all respondent groups moving forward.**

Question QC7: *Between January 2018 and June 2019*, *how frequently were requests for passive buildings, passive design, Passive House levels of efficiency, or related language included in RFPs?*

Two-thirds of respondents who were aware of the PH concept indicated that they never (34%) saw mentions of PH considerations in project RFPs between January 2018 and June 2019 or saw

[44] https://passivehouse-database.org/index.php?lang=en# accessed 12.7.2021
[45] The PHIUS- and PHI-certified project database were used to determine the count of pre-certified and certified multifamily projects in Massachusetts. These projects were cross-referenced with the PH program participant tracking data to determine if any pre-certified or certified multifamily projects in Massachusetts were outside the purview of the PH program.
[46] The evaluation team cross-referenced the projects from certified project databases with the program tracking data to determine which projects were enrolled in the PH program and which were not.
[47] This calculation assumes that the Massachusetts CEC projects (that also are enrolled in the PH Program) would have still achieved pre-certification regardless of the PH program.

them less than 25% of the time (34%). Just one respondent (2%) indicated that PH considerations were included in RFP language over half of the time during the baseline period (Table 19).

Table 19: Frequency of Mentions of PH in Project RFPs during Baseline Period (January 2018-June 2019)

Base: Respondents aware of PH concept (n=62)

Frequency	PH Participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Never	8	26%	13	42%	7	33%	6	60%	21	34%
Less than 25%	12	39%	9	29%	7	33%	2	20%	21	34%
25-50%	6	19%	3	10%	2	10%	1	10%	9	15%
51-75%	0	0%	0	0%	0	0%	0	0%	**0**	**0%**
Over 75%	0	0%	1	3%	1	5%	0	0%	**1**	**2%**
Don't know	5	16%	5	16%	4	19%	1	10%	10	16%
Total [a]	31	100%	31	100%	21	100%	10	100%	62	101%

[a] Totals may not sum to 100% due to rounding.

4.2.1.2.1 Additional Context

Because the baseline period ended over two years before respondents completed the survey, we also asked all respondents to assess how frequently they have seen PH considerations mentioned in project RFPs *since* the baseline period. Fifteen percent of respondents reported having seen PH considerations included in over half of the project RFPs they reviewed or have been involved in since June 2019.

Table 20: Frequency PH Was Mentioned in Project RFPs after Baseline Period

Base: All respondents (n=69)

QT10 n=(69)	PH Participant		Total non-participant		Non-participant subcategories: Other PA-sponsored program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Never	2	8%	8	19%	3	14%	5	23%	10	14%
On less than 25% of RFPs	8	31%	17	40%	7	33%	10	45%	25	36%
On 25-50% of RFPs	8	31%	6	14%	4	19%	2	9%	14	20%
On 51-75% of RFPs	4	15%	4	9%	3	14%	1	5%	**8**	**12%**
Over 75%	2	8%	0	0%	0	0%	0	0%	**2**	**3%**
Don't know	2	8%	8	19%	4	19%	4	18%	10	14%
Total	26	100%	43	100%	21	100%	22	100%	69	100%

4.2.1.3 Indicator 11: Increased Mentions of PH Accreditation in Advertisements and Real Estate Listings

- **We operationalized this indicator with two measurements using as the base only respondents that were classified as developers or owner's project managers. These measures are (1) developers that valued achieving high-performance standards "a great deal" prior to the start of the PH program and (2) developers that perceived marketing advantages for achieving high-performance standards.** Twenty-five percent of developers indicated they found "a great deal" of value in achieving high performance standards. Forty-two percent of developer respondents indicated that they perceived a marketing advantage for high-performance projects.
- **Recommendation: The PAs should continue to track this measurement for developer respondents of all groups moving forward.** Note that follow-up measurements will include both a question that asks developers about their own perception and perception of other developers. In addition to surveying market actors, the follow-up iteration of this study will review real-estate listing aggregator websites to determine whether PH accreditation is mentioned in advertisements and real estate listings.[48]

Question QR2: *Thinking back to before July 2019, on a scale from 1 to 4, where 1 is "Not at all" and 4 is "A great deal," how much would you say owners and developers valued having their projects achieve high-performance standards before July 2019?*

The evaluation team limited this indicator measurement to the developers and owner's project managers respondent categories. However, the questions asked in the survey may have led to developers responding from their own perspective or from their perception of other developers. In the next iteration of the survey, developers and owner's project managers will be asked about their own perceptions and about other developer perceptions to bridge the results between studies.

The results for all respondent types and additional context on how all survey respondents perceive developers that value high-performance design and construction are included in Appendix A.2.2.

Table 21: Developer Level of Value for Achieving High-Performance Standards during Baseline Period (January 2018-June 2019)

Base: Developers and owner's project managers (n=28)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
A great deal	4	27%	3	23%	2	18%	1	50%	7	25%
Somewhat	7	47%	5	38%	5	45%	0	0%	12	43%
A little	4	27%	5	38%	4	36%	1	50%	9	32%
Not at all	0	0%	0	0%	0	0%	0	0%	0	0%
Total	**15**	**100%**	**13**	**100%**	**11**	**100%**	**2**	**100%**	**28**	**100%**

[48] This secondary data review was not conducted as a part of this study due to the limited number of completed PH certified multifamily buildings in Massachusetts.

Question QR4: *Before July 2019, did you find multifamily project owners and developers perceived marketing advantages to high-performance buildings that made these buildings more competitive in real estate and rental markets?*

Note that participant developers were less likely to perceive a marketing advantage than non-participant counterparts during the 18 months prior to the start of the program. This may be due to developers responding about their perception of multifamily developers as a whole rather than their own individual perception. As noted above, the follow-up study will ask about both developers individual perception and market perception.

Table 22: Developers Perception of Market Advantages for Achieving High-Performance Standards during Baseline Period (January 2018-June 2019)

Base: Developers and owner's project managers (n=24)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Yes	3	30%	7	50%	5	42%	2	100%	10	42%
No	7	70%	7	50%	7	58%		0%	14	58%
Total	**10**	**100%**	**14**	**100%**	**12**	**100%**	**2**	**100%**	**24**	**100%**

4.2.2 Outcome G: Increased Number of PH-Certified and Skilled Market Actors

4.2.2.1 Indicator 12: Number of Market Actors with a PH Certification

- **We operationalized this indicator as the total number of Massachusetts-based market actors with a PH certification before the program launched.** As of April 2019, there were 132 market actors with some type of PH certification (e.g., consultant, rater, builder).[49] By August 2021, 355 market actors had some type of PH certification, an increase of 169%. The overwhelming majority were certified through PHIUS (96% and 95% in each of the two measurements, respectively).
- **The PAs should continue to track this indicator moving forward using both publicly available databases (the source of these measurements) and program training records.**

Table 23 provides counts of Massachusetts-based PH-certified market actors as of April 2019 for the baseline indicator measurement. A follow-up measurement is also included as of August 2021, a little over two years after the launch of the program. The evaluation team identified these market actors using publicly available databases, including the PHIUS-certified professionals and

[49] Due to the certification databases not including the date a professional became certified, the evaluation team leveraged previously collected data on the number of certified PH professionals used during the MA19R05 Passive House Assessment.

PHI PH professional databases.[50, 51] The count of market actors measured in April 2019 was part of the previous PA-sponsored MA19R05 Passive House Assessment and represents the baseline measurement for this indicator. The team used the same publicly available databases in August 2021 to generate an updated count of certified market actors. The count of certifications listed on the PHIUS and PHI websites has nearly tripled between the baseline period and August 2021, rising from 128 to 355 certifications.[52] In other words, as of August 2021, 63% of the certified PH professionals in Massachusetts were certified after the program launched.

Table 23: Passive House Certifications Held by Massachusetts Market Actors [a]

Source: Publicly available databases

Certification Type	Baseline Measurement (April 2019)			Follow-up Measurement (August 2021)		
	PHIUS[b]	PHI	Total	PHIUS[b]	PHI	Total
Certified Consultant	76	1	**77**	180	4	**184**
Certified Builder	33	0	**33**	118	5[c]	**123**
Certified Rater	3	N/A	**3**	11	N/A	**11**
Certified Verifier	15	N/A	**15**	27	N/A	**27**
Certified Designer	N/A	5	**0**	N/A	10	**10**
Totals	**127**	**6**	**132**	**336**	**19**	**355**

[a] *Includes professionals confirmed to have physical locations in Massachusetts; does not include professionals in nearby states who may work across state lines.*

[b] *Some market actors and their companies hold multiple certifications (e.g., PHIUS CPHC and PHIUS+ Verifier).*

[c] *Referred to as "tradespeople" in PHI database.*

4.2.2.2 Indicator 13: Self-Reported Levels of Skill in PH Practices (e.g., Air-Sealing, Thermal Bridge Details)

The evaluation team attempted to operationalize indicator 13, self-reported levels of skill in PH practices, with two self-reported measurements: (1) the frequency with which respondents "always" attempt to implement high-performance design or construction practices on their projects, and (2) the rate at which respondents said they "always" successfully implement high-performance design or construction practices.[53] (Detailed results for these measurements can be found in Appendix A.1.2.)

[50] https://www.phius.org/find-a-professional
[51] https://cms.passivehouse.com/en/training/find-professional/
[52] Note that the database of certified professionals does not distinguish the market sector certified individuals operate in. These counts do not consider whether an individual works only on single-family or commercial projects.
[53] We organized the high-performance design and construction practices by theme, as described in Section 4.1.3.1.1.

4.2.2.2.1 Frequency with Which Market Actors Attempt to Implement High-Performance Design and Construction Practices

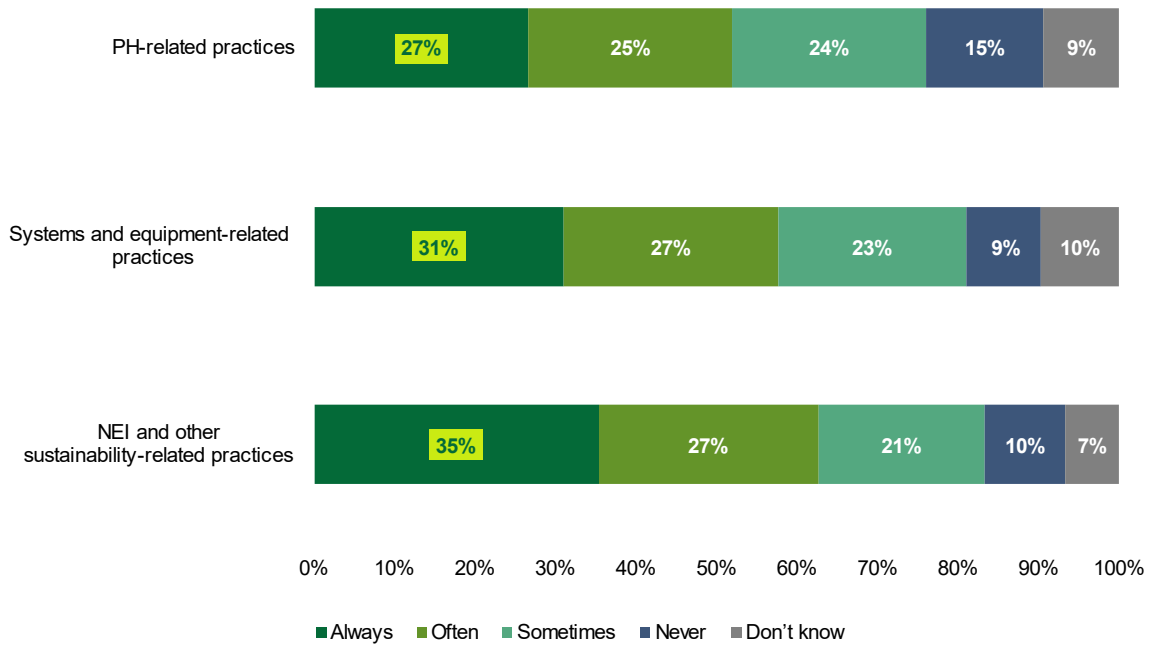
- **We operationalized this indicator as the proportion of all respondents who answer that they "Always" try to implement a series of high-performance design or construction practices.** Twenty-seven percent said they always tried to implement PH practices, 31% always tried to implement system- or equipment-oriented practices, and 35% always tried to implement practices geared toward realizing NEIs and other sustainability features. (Note that these responses do not imply that the respondents actually achieved PH levels of performance.)
- **Recommendation: The PAs should track this measurement for all respondents moving forward.**

Question QR7: ***Thinking of your most recent projects****, on a scale of 1 to 4 where 1 is "Never" and 4 is "Always," how often do you or your project teams* ***try to implement*** *the following high-performance design or construction practices in your projects, regardless of whether they are actually implemented? ("Trying" in this case could mean including these practices in initial planning discussions, feasibility studies or early design iterations, getting cost estimates, etc.)*

In Section 4.1.3.1 we presented the responses to these questions for participating respondents only as part of Outcome C, Indicator 6. Indicator 13 is meant to show progress in the broader market, and thus includes responses from all respondents.

Figure 5: How Often All Market Actors Try to Implement High-Performance Design or Construction Practices

Base: All respondents (n=75)



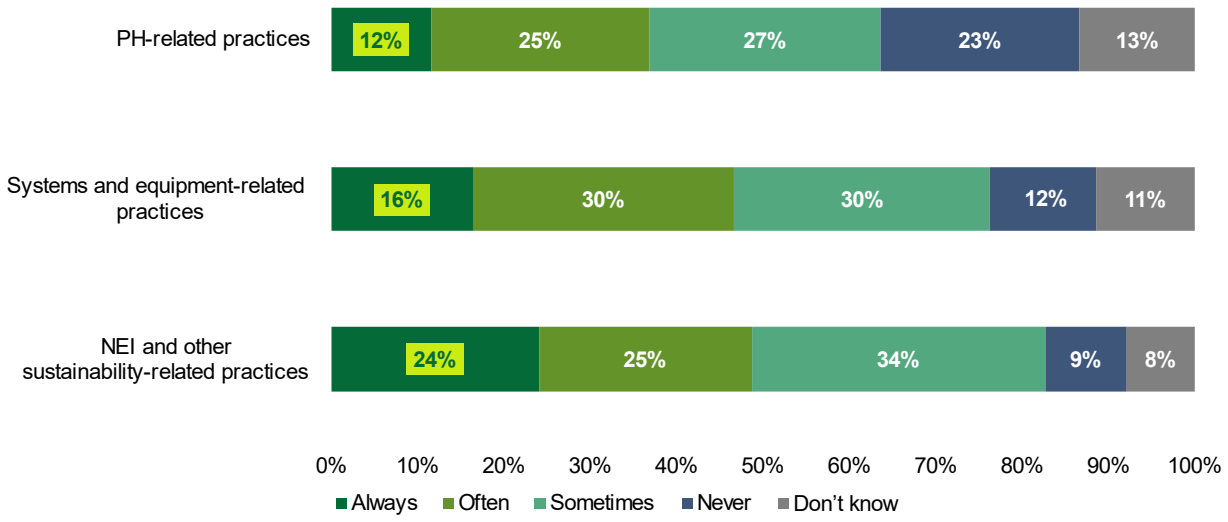
4.2.2.2.2 Successful Implementation of High-Performance Design and Construction Practices

- **We operationalized this indicator as the proportion of all respondents who indicated they "Always" implement a set of high-performance design and construction practices on their projects.** Twelve percent said they always implement PH practices, 16% always implement system- and equipment-oriented practices, and 24% implement practices geared toward realizing NEIs and other sustainability features.
- **Recommendation: The PAs should track this measurement for all respondents moving forward**

Question QR8: ***Thinking of your most recent projects****, on a scale of 1 to 4 where 1 is "Never" and 4 is "Always," how often do you or your project teams* ***actually implement*** *the following high-performance design and construction practices in your projects? (By "actually implement," we mean they are included in final designs or construction, depending on the status of the project.)*

Figure 6: How Often Participating Respondents Implement High-Performance Design and Construction Practices

Base: All respondents (n=75)



4.2.3 Outcome H: Increased Proportion of New Buildings That Are PH Certified or Pre-certified

4.2.3.1 Indicator 14: Proportion of New Buildings in Massachusetts That Are PH Certified or Pre-certified

- **This indicator is operationalized the same as Indicator 9: Proportion of New Buildings in Massachusetts that are PH certified or pre-certified (Section 4.2.1.1).**
- **Recommendation: The PAs should continue to track this indicator moving forward.**

4.2.4 Outcome I: Passive Design and Construction Practices Carried Over to Non-participant Projects

4.2.4.1 Indicator 15: Reports of Applying Knowledge/Skills for High-performance Building/Operation Learned through Program

- **We operationalized this indicator as the proportion of participating market actors who reported carrying over knowledge or experience gained on participating projects to their other work.** Eighty-one percent of participating respondents reported carrying over knowledge or experience gained on participating PH projects to their non-participating projects (Table 24).
- **Recommendation: The PAs should continue to track this indicator moving forward.** However, we note that results for this indicator should be interpreted with caution as self-report bias is highly likely. As we describe in Section 5.2.1, other reports and secondary data can provide additional evidence of the program influence over Outcome I: Passive Design and Construction Practices Carried Over to Non-participant Projects.

Question QT1: *Do you recall instances where you've gained new knowledge or experience on a project that participated in the Passive House Offering that you then carried over to projects that **did not** participate in the Passive House Offering? This could include, for example, working with new HVAC equipment types, using building energy modeling, or using more advanced envelope construction methods.*

While we expect this indicator to increase over time, fewer non-participant projects in the future could reduce carryover into the non-participant market. In Appendix A.2.3, we report the specific practices that respondents said they carried over to other non-participating projects.

Table 24: Participant Carryover of Knowledge or Experience from PH to Non-Participating Projects

Base: PH program participants (n=31)*

Carried Over Knowledge or Experience from PH Program	n	%
Yes	25	81%
No	2	6%
Don't know	4	13%
Total	**31**	**100%**

**One participant dropped from the survey before responding to this question.*

4.2.5 Outcome K: Increased Proportion of New Buildings That Are Low Energy Usage Intensity (EUI)

4.2.5.1 Indicator 18: Proportion of Buildings That Are Low EUI

- **The team could not operationalize a measurement for indicator 18 using available data.**

- **Recommendation: The PAs should revisit this indicator if additional data become available with which to define low EUI thresholds for multifamily building types. A baseline could be set in a follow-up study if additional data become available.**

  Alternatively, the PAs could consider changing the indicator to something other than a measurement of proportion, such as monitoring trends in measures of central tendency for EUI values over time.

To generate a baseline value for the proportion of low-EUI buildings among Massachusetts multifamily buildings, there needs to be agreement as to what EUI value constitutes "low EUI" for multifamily buildings. Currently there is not consensus around the definition of "low EUI" for the Massachusetts market. [54]

We see a path forward to operationalizing this indicator with a consensus around what defines "low EUI" for a MFHR building using survey results from this evaluation (Table 25), other secondary data, or a combination of the two. The respondents, in all categories, suggested that a high-performance multifamily building uses 45% of the energy that a code-compliant building uses (or has a 55% reduction in energy consumption).

Question QM1: *Based on your experience, a newly constructed high-performance multifamily building uses what percent of the energy that a newly constructed code-compliant multifamily building of the same type uses?*

Table 25: Respondent Energy Reduction Requirements to Be Considered High-Performance (Percent of Energy Used Compared to Code-Compliant Building)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
High-performance buildings	29	46%	45	45%	22	45%	23	45%	74	45%

If a "low EUI" threshold is developed to determine low-EUI buildings, the team can leverage available data from the previous MA19R05 Massachusetts Passive House Assessment and two Non-Residential New Construction (NRNC) EUI Baseline studies performed for Massachusetts to estimate the proportion of buildings that are "low EUI." [55] Those evaluations included data on new multifamily buildings constructed before the launch of the PH program. In addition, the Pacific Northwest National Laboratory (PNNL) performs an energy analysis of each new code iteration for a series of various building prototypes, including a mid- and high-rise apartment building, as part of their Building Codes work for the DOE. The data included with these prototype buildings

[54] The on-going NRNC Market Effects Baseline study (MA20X12-B-NRNCMEB) also determined that there was a lack of a definitive values to determine what "low EUI" is by building type.
[55] The two MA EUI studies can be found here: https://ma-eeac.org/wp-content/uploads/MA20X02-B-EUIBASE_Report_2021.05.05_Final.pdf and https://ma-eeac.org/wp-content/uploads/MA-NRNC-EUI-Final-Memo-MA19C12-B-NCEUIBSLN-1-24-2020-.pdf

includes building EUI, derived from energy modeling, for the mid- and high-rise apartment building made to the standards of recent ASHRAE and IECC code iterations.[56]

4.2.6 Outcome L: Increased Feasibility of Passive Design

4.2.6.1 Indicator 19: Market Actor Attitudes toward Passive Design Feasibility

- **The team operationalized this indicator with two measurements: (1) the proportion of all respondents who responded it was either "a little more" or "no more" difficult to execute a high-performance project than a code-compliant version of the same project and (2) the proportion of respondents who indicated it has become easier to execute a high-performance building since July 2019.** Thirty-one percent of respondents indicated it was either "a little more" or "no more" difficult to execute a high-performance version of a project than a code-compliant version of the same project. About two-thirds of respondents (64%) indicated it has become easier to design or construct a high-performance building since July of 2019.
- **Recommendation: The PAs should continue to track this indicator moving forward.**

Question QM2: *Please indicate which of the following statements best describes executing a high-performance project* ***compared to executing a code-compliant project of the same type****.*

Table 26: Difficulty of Executing High-Performance Project Compared to Similar Code-Compliant Project

Base: All respondents (n=74)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
No more difficult	2	7%	3	7%	2	9%	1	4%	**5**	**7%**
A little more difficult	8	28%	10	22%	5	23%	5	22%	**18**	**24%**
Somewhat more difficult	15	52%	24	53%	9	41%	15	65%	39	53%
A lot more difficult	4	14%	7	16%	6	27%	1	4%	11	15%
Don't know	0	0%	1	2%	0	0%	1	4%	1	1%
Total [a]	29	101%	45	100%	22	100%	23	99%	74	100%

[a] Totals may not sum to 100% due to rounding.

Question QF2: *Do you believe it has become easier* ***since July 2019*** *to design and construct a high-performance multifamily building, such as a Passive House building?*

[56] The report with this data can be found here: https://www.osti.gov/biblio/1194305

Table 27: Has It Become Easier to Construct a High-Performance Building Since July of 2019?

Base: All respondents (n=77)

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	%	n	%	%
Yes	27	84%	22	49%	15	68%	7	30%	**49**	**64%**
No	1	3%	4	9%	2	9%	2	9%	5	6%
No change	2	6%	12	27%	3	14%	9	39%	14	18%
Don't know	2	6%	7	16%	2	9%	5	22%	9	12%
Total [a]	32	99%	45	101%	22	100%	23	100%	77	100%

[a] Totals may not sum to 100% due to rounding.

4.3 Long-Term Outcomes and Related Indicators

4.3.1 Outcome T: Market Transformation

4.3.1.1 Indicator 32: Major Presence of PH Construction Observed in Neighboring States

- **We operationalized this indicator with three measurements: (1) the count of certified PH buildings before 2020, (2) the count of pre-certified PH buildings, and (3) the count of certified PH professionals.**[57,58] One of five multifamily projects that were certified in the New England region before 2020 are in Massachusetts (or 16 percent of residential units). Thirty-nine percent of pre-certified projects are in Massachusetts (or 61% of residential units). Fifty-four percent of certified PH professionals in the New England region are in Massachusetts. State specific measurements are included in Table 28 and Table 29. This data will be used to create a time-series to show the level of PH activity in surrounding states compared to Massachusetts.
- **Recommendation: Track counts for projects and certified PH professionals in each follow-up evaluation that covers market effects and consider expanding benchmarking efforts.** The next evaluation could expand on this indicator by reviewing program incentives, incentive levels, and whether other programs and policies may be driving PH adoption in neighboring states. For example, the evaluation could identify states where there is no PH program support and compare them to Massachusetts on key aspects of the multifamily housing market, such as the number of certified market actors, pre-certified and certified multifamily buildings, and overall penetration into the market. This would help to contextualize differences between states with and without program

[57] The date for when projects are pre-certified is not included in the PH project databases.
[58] Similar to the same approach to determine the count of certified professional in other states as described in Section 4.2.2.1.

support. Another possibility is to ask market actors whether knowledge they have gained from the PH program has carried over to projects in other states.

The evaluation team used PH databases of certified projects and certified professionals to provide baseline data for this indicator.[59,60] In theory, market actors and their organizations that participate in the PH program in Massachusetts may carry over their practices to other projects in Massachusetts. In cases where these organizations work outside of Massachusetts, these practices may also be carried over to projects in other states.

Table 28: Multifamily Passive House Building and Unit Counts in Surrounding States

State	Multifamily Building Count (5+ units)			Multifamily Unit Count		
	Certified before 2020	Certified 2020 and 2021	Pre-certified only[b]	Certified before 2020	Certified 2020 and 2021	Pre-certified only[b]
CT [a]	-	7	18	-	68	400
MA [a]	1	1[c]	14	28	98[c]	730
ME	2	-	1	93	-	13
NH	1	2	2	24	53	42
RI	-	-	1	-	-	6
VT	1	-	-	30	-	-
Total	**5**	**9**	**36**	**175**	**121**	**1,191**

[a] Incentive programs that target PH construction exist or have historically existed in these states.
[b] The project data for pre-certified projects did not include the date they were pre-certified.
[c] One certified multifamily PH project in MA was not included due to being a college dormitory.

Table 29 provides counts of PH-certified market actors in the Northeast at the time the PH program launched in Massachusetts. Companies may operate regionally, and increased demand for PH projects in Massachusetts could drive increased certifications in neighboring states as well. Any use of these numbers in future market effects quantification efforts requires data on local contexts as well, for example the existence of PH-oriented programs in those states.

Table 29: PH-Certified Market Actors in the Northeast at Program Launch

State	Builder	CPHC	Rater	Verifier	Certification Total
Connecticut	13	17	4	3	**37**
Maine	5	7	-	-	**12**
Massachusetts	33	77*	3	15	**127**
New Hampshire	10	12	-	2	**24**
Vermont	18	16	1	-	**35**
State Total	**79**	**52**	**8**	**20**	**235**

**Includes one PHI certified PH consultant*

[59] https://passivehouse-database.org/
[60] https://www.phius.org/phius-certification-for-buildings-products/certified-projects-database

Section 5 Approaches for Market Effects Indicators Not Yet Measured

For each market effects indicator for which this study did not establish a baseline measurement, we present an assessment of what, if any, secondary data is available for the indicator and how to measure it. We present each market effects assessment in the following format:

Options. We select the "best" option to measure the indicator regardless of whether the data is currently available. We present "alternative" options in case the "best" option is not feasible.

Project types and market actors involved: Identifies the project types (i.e., participant projects, non-participant projects, or both) and the stakeholders (e.g., developers, occupants) necessary for measurement.

Timeframe: When it would be appropriate to measure the indicator for the first time.

Data sources and requirements: Lists the data required to establish the baseline measurement, and potential sources of the data.

Narrative:

When additional explanation is warranted, we provide more context on how to undertake the baseline measurement, and in some cases, additional approaches, and ideas in case the sources listed under "Data sources and requirements" are unavailable.

5.1 Short-Term Outcomes and Related Indicators

5.1.1 Outcome D: Verified and Enhanced Program Energy Savings

5.1.1.1 Indicator 7: Participant Energy Usage Compared to Model Estimates, Traditional RNC Participants, Baseline Results, and Billing Data

Options. Best: MFHR baseline conducted with non-participating (NP) projects that complete construction in the same year as the bulk of the initial PH participants and before the next indicator measurement. **Alternatives:** Building permit reviews, energy models, offering NP project developers incentives to share their projects' energy model or plans with the PAs, or other secondary data sources such as evaluations conducted in Massachusetts and the New England region or national data sources.

Project types and market actors involved:

- PH program participants
- MFHR program participants
- Non-program MFHR projects

Timeframe: Two years post-completion, to allow for full occupancy, normalization of building use characteristics, and sufficient time-series of energy monitoring and billing data. Measurement is dependent on when the bulk of initial participant projects is completed.

Data requirements:

- PH program participant energy models **and** post-occupancy energy monitoring data
- Non-program MFHR billing data **and** square footage (or secondary data sources if unavailable)[61]
- MFHR Program participant energy models **and** billing data

5.2 Medium-Term Outcomes and Related Indicators

5.2.1 Outcome I: Passive Design and Construction Practices Carried Over to Non-Participant Projects

5.2.1.1 Indicator 16: Baseline Market Assessments and Reports That Characterize Changes in the Multifamily Market

Options. Best: Identify and track key takeaways on topics such as core PH design and construction principles, electrification, and other high-performance design and construction practices from the available body of evaluation findings in Massachusetts covering the MFHR and MFLR market, and from any new baseline studies or market characterization reports that provide insights into baseline market practices. [62] This could include some research focused on the NRNC market. **Alternative:** Ask market actors questions on this topic in the next study measuring indicators.

Project types and market actors involved:

- PH program participants
- MFHR program participants
- Non-program MFHR projects
- Practitioners and customers in the MFHR market

Timeframe: The next study measuring indicators is planned to start in fall of 2023. The follow-up study will include follow-up survey questions included in this study on various high-performance design and construction practices.

Data requirements:

- MFHR Baseline update (primary data), survey data with market actors, market characterization findings for equipment (efficiencies/saturations/penetrations) using

[61] These data will be challenging to estimate without a new baseline study that includes MFHR non-participant projects or a comprehensive dataset of multifamily projects in Massachusetts that includes square footage and can be linked to utility consumption data.
[62] Note that evaluations that occur in the New England region may be used to fill in informational and data gaps not covered in evaluations in Massachusetts.

secondary data, MFHR building energy usage data (assessments of building energy models or utility billing data), or additional data on market practices (studies on building electrification, heat pump usage, etc.).

Narrative:

Data from additional evaluations can be reviewed and reported alongside this survey data to create a more comprehensive dataset on changes in MFHR building practices. For example, baseline data equipment types, efficiencies, and saturations (e.g., the proportion of heating systems in new buildings made up of heat pumps, or the average EER and COP of heat pump systems installed in new MFHR buildings). Additional market research data not used to operationalize an indicator can be found in Appendix A.3. In addition, data reported above used to operationalize other indicators that would be relevant here include: Figure 1, Figure 2, Figure 3, Figure 5, Table 33, Table 37, Table 15, Table 18, and Table 19.

5.2.2 Outcome J: High Owner and Occupant Satisfaction

5.2.2.1 Indicator 17: Satisfaction of Owners and Occupants with Participating Buildings

Options. Best: Ask developers, owners, and occupants of participating buildings questions on this topic in the next study measuring indicators. **Alternative:** If it is not possible to develop a good sample frame of developers, owners, and/or occupants of participating buildings, ask participating market actors about reactions they have observed among developers, owners, and occupants of participating buildings.

Project types and market actors involved:

- Developers, owners, and occupants of participating buildings
- Participating market actors

Timeframe: The next study measuring indicators should occur during the next iteration of the study (fall 2023), ultimately dependent on the number of completed projects.

Data requirements:

- Program participant owner or developer contact information. (The program currently collects data for primary and secondary project contacts, which mostly consists of developers and sustainability consultants.)
- Participant project addresses to identify occupants. Coordination with owners or management companies may be required.
- Program participant market actor contact information. (This is currently challenging to acquire as the program tracking data streamlined which market actors are tracked in program data.)

5.2.3 Outcome L: Increased Feasibility of Passive Design

5.2.3.1 Indicator 20: Incremental Cost Decreases Relative to Past PH Program Participants and ISP Construction

Options. While the data to measure this indicator do not currently exist, PA and implementation staff confirmed in interviews that the program will begin to collect cost data at the energy conservation measure (ECM) level upon completion of a project in the PH program. The PAs, implementation, and evaluation teams could work together to develop a consistent cost data collection form for program participants that balances the needs of the program, implementation, evaluation, and marketing. This should require a fairly modest level of effort to execute.

Project types and market actors involved:

- Participant projects
- Non-participant projects

Timeframe: Measuring this indicator is based on the success of collecting cost data at the ECM-level from participant projects, but it is expected to be measurable during the next round of research in fall 2023. (Depending on the level of rigor and the effort required to acquire incremental cost estimates, incremental costs may be assessed as a separate evaluation activity.)

Data requirements:

- ECM cost data collected from participant projects (and potentially estimated incremental cost projections depending on the cost data that is collected by the program).[63]
- Non-participant project ECM specifications and cost estimates.
- Secondary data scan for studies on costs of PH and non-PH multifamily buildings and incremental cost studies.

Narrative:

The incremental cost to build to PH levels of efficiency is one of the primary barriers to broader market adoption. Project costs may increase due to advancing code requirements and baseline practices, even if a decrease in the incremental cost to achieve PH or similar levels of efficiency is observed over time.

The program does not have a standardized cost data collection form to distribute to completed participant projects. This should be addressed before the bulk of initial projects are completed to ensure cost data are captured consistently. Collecting data on costs at the ECM level with initial program participants is key to understanding PH project costs. However, this is only one piece of the puzzle, and estimating the cost for what would have been done without the PH program support need to be estimated to determine the overall incremental costs of program participation.

Additional sources, such as the Massachusetts Clean Energy Center (CEC), have collected incremental cost data from projects that participated in the PH design challenge (most of which are participants in the PH program as well) and estimate incremental costs range between 1.4% and 2.8%.[64] Program staff may consider collaborating with the CEC on methods used to

[63] The Massachusetts CEC Passive House Design Project recipients have provided incremental cost projections. The PAs could leverage the cost data collection processes developed for the CEC projects to estimate project-specific incremental costs. Expanding the data collection efforts on project teams may require additional incentives to offset the additional incremental cost projections.

[64] https://www.masscec.com/emerging-initiatives/passive-house

determine incremental cost estimates and to provide bonus incentives for project teams that conduct these incremental cost analyses. In the absence of this sort of data collection, the evaluation team would need to conduct incremental cost assessments for a sample of participant projects, leveraging the UDRH and/or current code levels to estimate a baseline cost scenario. However, the evaluation team would like to note that incremental cost studies are typically complex and challenging to execute. This is due to access to system and equipment costs, design decisions, and other assumptions, which may be more accurate if estimated by the project team.[65]

5.2.4 Outcome M: Emissions Reductions

5.2.4.1 Indicator 21: Reduced Lifetime Emissions from Participant Buildings Compared to Traditional Program and Non-Program Buildings (i.e., Operational Savings, Fuel Selection, Material Selection)

Options. Program staff interviewees indicated there is no plan or anticipated effort to track carbon emissions beyond current program plans that provide information on avoided carbon emissions based on savings. There are no current program plans to account for carbon emission reductions related to embodied carbon in materials or societal benefits from reducing carbon from the atmosphere. Due to potential changes in the future, the evaluation team includes this assessment, though it may not ultimately be operationalized as a market effects indicator.[66]

Timeframe: There is currently no expectation to measure this indicator. However, the evaluation team includes an assessment on what is needed to measure this indicator if changes to the Massachusetts energy-efficiency policy framework to allow for claiming additional carbon emission reductions occur in the lifetime of the PH program.

Data requirements:

- PH program tracking data (energy consumption, system types, and fuel selection data).
- MFHR program tracking data (energy consumption, system types, and fuel selection data).
- Assessments of site energy usage (by fuel source) compared to other PA-sponsored multifamily projects and non-program projects.[67]
- Survey or baseline study results of non-participant equipment, fuel selection, and material choices.

Narrative:

[65] Project teams may have early design iterations that they are able to leverage to estimate costs that would have theoretically occurred if they did not pursue PH, which could provide a more accurate assessment of the incremental costs for a given project.

[66] https://malegislature.gov/Bills/192/S9/BillHistory

[67] Measurement of carbon impacts are time dependent, and thus either detailed load shapes or interval and generation data would be required to conduct a high-rigor measurement—especially if renewables, electric vehicles, and storage batteries are present. Alternatively, a deemed load shape or profile could be applied to projects which highlight the impacts of fuel switching and overall annual energy consumption.

Carbon emission reductions from operational savings can be assessed through comparison of site and source energy usage among PH participants, MFHR, and non-participants.[68] The evaluation team envisions measurement for this indicator as an expansion of the indicator assessment detailed in Section 5.1.1 (Indicator 7) through the application of source energy factors based on site energy usage results.

If alterations to the Massachusetts energy-efficiency policy framework do change within the life of the PH program, the following options can be used: **Best.** Obtaining data for non-PA sponsored projects without an updated MFHR baseline study[69] that details what the non-program market is implementing in their projects will be challenging. **Alternative.** In the absence of new primary data or sufficient secondary data, the evaluation team plans to leverage the UDRH, reported survey findings from this evaluation (Table 16, Table 17, and Appendix A.1.2), and any baseline equipment or fuel data gathered in any potential follow-up surveys to estimate source emissions from the baseline scenarios.

Material selection is currently beyond the purview of the program. However, if the policy requirements or expectations change the energy-efficiency framework policy to align further with decarbonization goals, then incorporating tools to track embodied carbon into program participation requirements/bonus incentives should be planned immediately.

5.2.5 Outcome N: Positive NEI Experienced in Participant Buildings

Generally, non-energy impacts (NEIs) are measured as their own impacts apart from market effects as they are very complex to isolate and measure. We do not suggest measuring NEIs under the market effects framework. Rather, specific NEIs should be targeted for further research to quantify the associated benefits.

5.2.5.1 Indicator 22: The Value of Positive NEIs Experienced as a Result of the PH Offering[70]

Options. The recent RNC NEI Quick Hit Assessment (MA20X14-B-RNCNEI) study identified NEIs expected from residential new construction. Some, if not all, may be applicable to the PH program (i.e., increased thermal resilience, improved indoor air quality, and operations and maintenance benefits).[71] Should any studies of RNC NEIs that result from PH design and construction be published before the next study to measure indicators, these could potentially be applied to the PH program, adjusting for any differences between the Massachusetts PH program and population versus those of other studies. **Alternative:** Survey building owners and/or occupants to validate and monetize selected NEIs identified in the RNC NEI Quick Hit Assessment study. This could be measured either as part of a follow-up to the RNC NEI Quick Hit Assessment study or as part of a broader owner or occupant survey for the PH program.

Project types and market actors involved:

- PH program participant owners and occupants

[68] Source energy represents the total amount of raw fuel that is required to operate the building and incorporates all transmission, delivery, and production losses.
[69] Through on-site visits or detailed plan reviews to get mechanical, building shell, and other energy-related data.
[70] The evaluation team updated this indicator from the "number" of positive NEIs experienced to the "value" of positive NEIs experienced to better reflect the benefits to the owners and occupants of PH buildings.
[71] https://ma-eeac.org/wp-content/uploads/MA20X14_RNC-NEI_Final-Report_-2021.10.06.pdf

- Non-participant project owners and occupants (optional)

Timeframe: Search for PH NEI literature before the next study measuring PH market effects indicators. If needed, collect data to monetize PH NEIs at least one year after the bulk of initial PH participant buildings start being occupied.

Data requirements: Secondary data from literature or primary data from either survey(s), field measurements, or a combination of both.

5.2.6 Outcome O: Development of Additional PH Offerings

5.2.6.1 Indicator 23: The Number of PH Offerings Expands into Other Market Sectors in Massachusetts

Options. Track new and existing program pathways that leverage PH or PH levels of efficiency (such as the NRNC program).

Project types and market actors involved:

- PAs and team
- Implementation team
- Evaluation team

Timeframe: Discuss during planning stage or initial research stages of next evaluation on market effect for the PH program.

Data requirements:

- Documentation of new program offerings or plans to explore new market segments
- Market characterization studies or scans that detail the viability of PH or PH levels of efficiency in different market segments

Narrative:

The program staff interviews covered current and potential plans to expand program offerings for PH or PH levels of efficiency into other market segments and is reported in the Indicator memo (Appendix D).

5.3 Long-Term Outcomes and Related Indicators

5.3.1 Outcome P: Advances in Building Codes and Regulations

5.3.1.1 Indicator 24: Changes in Building Codes (e.g., Inclusion of PH and ZNE Stretch Codes)

Options. To track this indicator, the PAs could document any effort related to supporting the adoption of an updated stretch code that requires Zero Net Energy (ZNE) or PH levels of efficiency.[72] This could include contributions to code updates, code advocacy, and presentations that support increased stretch code adoption. In addition, the PAs could document any data or

[72] Note that these efforts may be tracked in other PA-sponsored evaluation efforts, such as through code promulgation and attribution studies.

evidence the program provides to support DOER efforts to adopt an increased stretch code. The level of effort to track and document this is low; however, effort could increase if the PAs deepen their involvement in adopting a ZNE or similar building energy code.

Project types and market actors involved:

- PAs and program staff

Timeframe: Ongoing over the next two residential energy code update cycles.

Data requirements:

- Documentation of any efforts to support Department of Energy Resources (DOER) stretch energy code and state building code advancements that require ZNE or PH levels of efficiency.

Narrative:

Currently, the program will support the DOER efforts to investigate and propose a PH and ZNE stretch code. Technical and economic data gathered by the program from participants will provide this support. Note that due to the long project timelines associated with designing and constructing multifamily buildings, most initial participants of the PH program are not completed and therefore have not achieved PH certification (or similar levels of efficiency).

5.3.1.2 Indicator 25: Perceptions of Program Influence

Options. Survey participating and non-participating market actors asking about their current practices. Ask participating market actors how their practices have changed since participating in the program, and how their experiences with the program influenced those changes.

Project types and market actors involved:

- PH program participants
- MFHR program participants
- Non-program MFHR projects

Timeframe: The evaluation team expects to measure this in the fall 2023 study.

Data requirements: Surveys with market actors impacts of program on their practices.

5.3.2 Outcome Q: Persistent Energy Savings in Market Overall

5.3.2.1 Indicator 26: Reductions of EUI in New Multifamily Buildings

Options. Metered data and square footage for participant buildings, billing data and square footage for participant and non-participant buildings, other PA-sponsored program data, Residential Energy Consumption Survey (RECS) and Commercial Building Energy Consumption Survey (CBECS), and building permit data are all potential sources for measuring reductions in the EUIs of new multifamily buildings. This indicator would leverage EUI baseline and follow-up measurements that are a part of other medium-term indicators (Section 4.2.5.1). Since the PH program requires program participants to meter energy consumption, both modeled and actual consumption data will be available for participant projects. The options for determining the EUI of the population of non-participant buildings depend on the extent of the available data and the

level of effort employed for the measurement. If an updated baseline evaluation for mid- or high-rise multifamily buildings becomes available, this information could be used to estimate non-participant EUI. Execute a billing data analysis is more difficult but a potential option if a sample population of non-participant buildings is identified as part of other activities (for example, through follow-up market effects indicator measurements, other evaluations, or program efforts). While there could be options for estimating non-participant EUI values through secondary data such as the RECS, CBECS, or building department visits, leveraging the estimated energy consumption values from the UDRH may be more effective in the absence of baseline or billing data.

Project types and market actors involved:

- PH program participants
- MFHR program participants
- Non-program MFHR projects

Timeframe: Two years post-completion, to allow for full occupancy, normalization of building use characteristics, and sufficient time-series of energy monitoring and billing data. Measurement is dependent on when the bulk of initial participant projects is completed.

Data requirements:

- PH program participant energy models **and** post-occupancy energy monitoring data
- Non-program MFHR billing data **and** square footage (or secondary data sources if unavailable)
- MFHR program participant energy models **and** billing data

5.3.2.2 Indicator 27: Perceptions of Program Influence

Options. Survey participating and non-participating market actors asking about their current perceptions of program influence. Ask participating market actors how the program has influenced their projects and the broader multifamily market in Massachusetts.

Project types and market actors involved:

- PH program participants
- MFHR program participants
- Non-program MFHR projects

Timeframe: This indicator can be measured in fall 2023 or in a third iteration of this study.

Data requirements: Surveys with market actors assessing perceptions of program influence

5.3.2.3 Indicator 28: Observed Lower Energy Consumption and Peak Demand from Participant Projects

Options. See Section 5.1.1.1 and Section 5.3.2.1 for descriptions of the potential approaches to measure this indicator.

Project types and market actors involved:

- PH program participants

- MFHR program participants
- Non-program MFHR projects

Timeframe: Two years post-completion, to allow for full occupancy, normalization of building use characteristics, and sufficient time-series of energy monitoring and billing data. Measurement is dependent on when the bulk of initial participant projects are completed.

Data requirements:

- PH program participant energy models **and** post-occupancy energy monitoring data.
- Non-program MFHR billing data **and** square footage (or secondary data sources if unavailable).
- MFHR program participant energy models **and** billing data.

Narrative:

The lower energy consumption of passive buildings coupled with on-site renewables may decrease the burden on the power grid and make the power grid more resilient as greater emphasis on strategic electrification takes place over the long term. As program penetration increases to the broader multifamily market, the impact and implications of an increased proportion of newly constructed multifamily buildings designed to passive standards will contribute to an overall increase of completely (or mostly) electric buildings. While it is likely that passive projects will utilize electric space heating and cooling systems; the current options for electric water heating are very limited. The addition of electric space heating may trigger winter peak demands, let alone potential impacts to the grid from future electric water heating solutions as strategic electrification efforts broaden. While the winter peak demand impact on grid resilience may be attributed to broader strategic electrification efforts, including broader adoption of electric vehicles, the program should consider the impact on the grid specific to passive buildings – increased utilization of electric systems in lower load buildings compared to increased utilization of electric systems in non-passive buildings.

5.3.3 Outcome R: Increased NEIs in Overall Multifamily New Construction Market

5.3.3.1 Indicator 29: Increased NEIs Experienced in Broader Multifamily Market

Options. The measurement for this indicator depends on the level to which NEIs associated with high-performance construction are found to exist, how Indicator 22 is measured (Section 5.2.5.1), and the availability of secondary data to leverage. This indicator will need to consider the penetration of certified PH buildings (Section 4.2.1.1) and the level of PH design and construction principles used in the broader multifamily market (Section 4.2.4.1) to determine broader NEI impacts on the market.

Project types and market actors involved:

- PH program participants and occupants
- Non-participant projects and occupants

Timeframe: At least one year, preferably two, after measuring NEIs from PH for the first time.

Data requirements:

- Penetration rates of PH in the multifamily market
- Previous results from NEI assessments associated with high-performance new construction
- NEI-focused survey results with market actors, owners, and occupants

5.3.4 Outcome S: Savings from Non-Regulated Loads and Non-Traditional Measures

5.3.4.1 Indicator 30: Increased Number of Claimable Measures Included in the UDRH for PH Offering

Options. Interviews with program staff clarified that the PH program may lead to the program supporting newer technologies and ECMs for which it does not currently claim savings. PAs can record and track the number of claimable measures included in the UDRH for the PH program or supply this information to the evaluation team to track.

Project types and market actors involved:

- PAs and team
- Implementation team
- Evaluation team

Timeframe: Periodic assessments with the PAs, program staff, implementation, and evaluation teams throughout the life of the program, likely during initial planning stages for market effects evaluations.

Data requirements:

- Descriptions of new and nascent technology used in PH participant projects
- Analyses on ECMs not currently included in the UDRH to determine potential savings opportunities

5.3.5 Outcome T: Market Transformation

5.3.5.1 Indicator 31: A Majority of Short-, Medium-, and Long-term Outcomes are Measured and There is a Major Presence of PH in Broader Multifamily Market

Project types and market actors involved:

- PH program participants
- MFHR program participants
- Non-program MFHR projects

Timeframe: Estimated seven to ten years, after two follow-up market effects evaluations to ensure baseline and follow-up measurements are captured.

Data requirements:

- Baseline measurements for most short-, medium-, and long-term indicators

- Follow-up measurements for most short-, medium-, and long-term indicators
- Non-participant building efficiency levels

5.3.5.2 Indicator 32: Major Presence of PH Construction Observed in Neighboring States

The evaluation team was able to operationalize the baseline measurement for this indicator in this study (Section 4.3.1.1).

Section 6 Additional Recommendations and Considerations

In Section 4 we presented recommendations specific to individual indicators and in Section 5 we discussed data requirements for measuring indicators that were not measured in this evaluation. Here we present additional, more general recommendations and considerations about the program and about program tracking data.

6.1 RECOMMENDATIONS

Develop cost data collection forms to determine participant costs at the measure level. This information would help the program, implementation, and evaluation teams understand how incremental costs change throughout the life of the program. The PAs could leverage existing data collection processes, for example by examining how the Massachusetts CEC captured incremental cost data from their Passive Design participant projects. The PAs could also create data collection forms through a consensus approach with program, implementation, and evaluation staff.

Before the next study measuring changes in market effects indicators, characterize the multifamily market actor population to assess the size of the market, ideally coordinating this research with similar research on the non-residential new construction (NRNC) market. This study focused on establishing indicator baselines with the PH program. A fundamental next step to accurately quantifying the market effects generated by the program is characterizing the market to understand the proportion of the market the program reaches. This information can also help identify and address possible self-selection bias in this and future web survey efforts. To help ensure accurate estimates of the proportion of the market the program reaches and improve the likelihood of successfully and defensibly quantifying market effects from the PH program, the PAs should undertake a market characterization study that focuses on estimating the population of market actors of various types (e.g., architects, MEP engineers) working on multifamily new construction in Massachusetts. The PAs should complete the market characterization study before planning a follow-up study to re-measure indicators covered in this study and indicators that remain to be measured.

For market effects from Paths 1 and 2 of the NRNC program, EEAC consultants have raised a similar concern about lack of data on market actor populations and program reach in the NRNC market. Due to overlap among the market actors working on multifamily and NRNC projects, the multifamily and NRNC market characterization research should be coordinated or even conducted jointly.

In addition, program implementors may leverage this research to identify who in the market is not being reached and develop strategies to increase program coverage in the non-participant market.

The PAs could substantially increase the volume of project contact information contained in the tracking base without burdening participants by adding to the program data contact information that is already part of the project plans, specifications, and other documents that participants must submit to the program. Currently, the program tracking data supplies contact information for just two contacts per project. These usually include a developer or sustainability consultant that interfaces with their implementation team contact. This makes evaluation difficult and results less reliable by preventing evaluators from conducting outreach to market actors and confirming participation status. It is the evaluation team's understanding that the reason just two contacts per project are listed in the program tracking database is to reduce the reporting burden on participants. However, a wealth of additional contact information is contained in the submittals that participants are required to supply for each project. As program and implementation staff must go through these submittals carefully, extracting the additional contact information to add to the database should not be an excessive burden.

Plan to update values for all indicators measured in this evaluation in late 2023. In 2023the program will enter the four-to-six-year period over which the PTLM predicts short-term outcomes will manifest in the market. It is important to reassess indicators when measurable changes are expected in the market to avoid recall issues and other factors that could impact accuracy and attribution. This timeline falls at the end of the expected short-term outcomes and the beginning of mid-term outcomes and will be a good point to assess whether unforeseen issues or market shifts may impact the ability to quantify market effects or warrant changes. The PAs have already identified late 2023 through 2024 as the likely time to execute such a study, which is in line with this recommendation. A Stage 1 plan for the study is included in the Massachusetts Three-Year Energy Efficiency Plan for 2022 – 2024. That timing would also be appropriate for assessing the outcomes and indicators not measured in this study, largely because by then a large portion of projects initially enrolled in the PH program will be completed. As part of the study, the evaluation team should also develop an approach to quantify market effects from the program given the data on hand, the results of the market characterization study recommended above, and the results from the completed participant projects.

If PA or implementation staff are not doing so already, track PA-sponsored PH trainings, including the number and type of trainings conducted, market actor participation counts, and the number and type of certifications gained through PA-sponsorship. The evaluation team suggests compiling this information to determine the program impacts on any increases in certified PH professionals in Massachusetts and provide evidence of program influence over increases in market-actor awareness, understanding, and the skill levels associated with PH and other high-performance design and construction practices. If possible, track which of the certified or trained market actors have also worked on a participant project would highlight the link between program sponsored training with real-world experience.

Indicator-specific Recommendations. In Table 30, we summarize all the recommendations, considerations, and conclusions for each specific indicator. In most cases where the team was able to measure an indicator baseline, the recommendation is to update the same measurement during the follow-up study. Some recommendations address how to tackle unsuccessful measurements with additional data or identify measurements that could be hard to interpret over

time. As this table serves as a high-level planning document, it also includes key takeaways and action items for indicators not measured in this study (covered in Section 5).

Table 30: Summary of Indicator-Level Results

Recommendations, Considerations, and Results for Each Indicator
Short-Term Outcomes (Measurable Changes Attributable to Program Expected in 1-3 Years)
Outcome A: High Program Awareness and Participation, Indicator 1: Rates of Program Awareness
Recommendation: Update the two measurements presented. Track these for each respondent group.
Outcome A: High Program Awareness and Participation, Indicator 2: Rates of Program Penetration
Recommendation: Use the approach described in this study to calculate program penetration based on each incentive level achieved by projects that are complete rather than solely based on initial enrollment.
Outcome B: Increased Participant Understanding and Awareness of PH Certification, Practices, and Benefits, Indicator 3: Participant Understanding of PH Benefits and Challenges
Recommendation: Update the measurement presented. Track this for each respondent group.
Outcome B: Increased Participant Understanding and Awareness of PH Certification, Practices, and Benefits, Indicator 4: Participant Awareness of PH Design Principles
Recommendation: Update the two measurements presented. Track these for each respondent group. Ensure PH design principle questions are asked of all survey respondents, rather than only respondents aware of PH as a building concept.
Outcome B: Increased Participant Understanding and Awareness of PH Certification, Practices, and Benefits, Indicator 5: Participant Familiarity of PH Certification Processes
Recommendation: Update the one measurement presented. Track this for each respondent group.
Outcome C: Increased Adoption of Passive Design and Building Practices by Participant Market Actors, Indicator 6: Self-reported Building/Operation Practices of Participants
Recommendation: Update the three measurements presented. Track these for each respondent group.
Consideration: Revisit whether the frequency of all-electric equipment in participant projects is a valuable indicator to continue to track prior to fielding the web survey. This indicator may be more effectively tracked via PH program tracking data. This data can be compared to MFHR and MFLR program tracking data and any new baseline or non-program data that is available. In absence of non-program project data, obtained from a baseline study, tracking these equipment trends in the non-program respondent population should be conducted.
Outcome D: Verified and Enhanced Program Energy Savings 7: Participant Energy Usage Compared to Model Estimates, Traditional RNC participants, Baseline Results, and Billing Data
The PAs should review the options presented in Section 5.1.1.1 to assess the value of this indicator to the program theory and which measurement options are most feasible for the program.
Outcome E: High Participant Satisfaction with Program, Indicator 8: Level of Participant Satisfaction with Program Support, Services, and Incentives
Recommendation: Update the one measurement presented. Track this for each respondent group.

Recommendations, Considerations, and Results for Each Indicator
Mid-Term Outcomes (Measurable Changes Attributable to Program Expected in 4-6 Years)
Outcome F: Increased Demand for PH Buildings in the Multifamily Market, Indicator 9: Proportion of New Buildings That Are PH Certified or Pre-certified
Recommendation: Update the two measurements presented.
Outcome F: Increased Demand for PH Buildings in the Multifamily Market, Indicator 10: Increased Requests for Passive Designs in RPFs
Recommendation: Update the one measurement presented. Track these for each respondent group.
Outcome F: Increased Demand for PH Buildings in the Multifamily Market, Indicator 11: Increased Mentions of PH Accreditation in Advertisements and Real Estate Listings
Recommendation: Update the two measurements presented. Track these for each respondent group. Include an additional question for developers to provide responses based on their own perception and their perception of other developers.
Outcome G: Increased Number of PH-Certified and Skilled Market Actors, Indicator 12: Number of Market Actors with a PH Certification
Recommendation: Update the one measurement presented.
Outcome G: Increased Number of PH-Certified and Skilled Market Actors, Indicator 13: Self-Reported Levels of Skill in PH Practices (e.g., Air-Sealing, Thermal Bridge Details)
Recommendation: Update the two measurements presented. Track these for each respondent group.
Outcome H: Increased Proportion of New Buildings That Are PH Certified or Pre-Certified, Indicator 14: Proportion of New Buildings in Massachusetts That Are PH Certified or Pre-certified
Recommendation: Update the two measurements presented.
Outcome I: Passive Design and Construction Practices Carried Over to Non-participant Projects, Indicator 15: Reports of Applying Knowledge/Skills for High-performance Building/Operation Learned through Program
Recommendation: Update the one measurement presented. Track this for participant respondents.
Outcome I: Passive Design and Construction Practices Carried Over to Non-participant Projects, Indicator 16: Baseline Market Assessments and Reports That Characterize Changes in the Multifamily Market
Consideration: In the recommended study to characterize the population of market actors in the multifamily market, prior to the next measurement of market effects, include a literature review of the multifamily baseline practices in Massachusetts to determine to what extent secondary data sources can be leveraged in future measurements of market effects.
Outcome J: High Owner and Occupant Satisfaction, Indicator 17: Satisfaction of Owners and Occupants with Participating Buildings
The PAs should review the options presented in Section 5.2.2.1 to assess the value of this indicator to the program theory and which measurement options are most feasible for the program.
Outcome K: Increased Proportion of New Buildings Which are Low EUI, Indicator 18: Proportion of buildings That Are Low EUI

Recommendations, Considerations, and Results for Each Indicator
Recommendation: Revisit calculation of low EUI proportions if new data becomes available or a consensus around what defines 'low EUI' thresholds for multifamily buildings is determined. Can be done retrospectively and in the future based on the availability of data.
Consideration: In absence of a "low EUI" threshold, this indicator could be changed to monitor trends in measures of central tendency for EUI values over time.
Outcome L: Increased Feasibility of Passive Design, Indicator 19: Market Actor Attitudes toward Passive Design Feasibility
Recommendation: Update the two measurements presented. Track these for each respondent group.
Outcome L: Increased Feasibility of Passive Design, Indicator 20: Incremental Cost Decreases Relative to Past PH Program Participants and ISP construction
Recommendation: Develop a consistent cost data collection for program participants.
Consideration: Potential bonus incentives to project teams that provide the baseline measure, efficiency, and cost that would have been implemented in absence of the program (e.g., what measures changed during the feasibility and energy modeling stages).
Outcome M: Emissions Reductions, Indicator 21: Reduced Emissions from Participant Buildings Compared to Traditional Program and Non-Program Buildings (i.e., Operational savings, Fuel Selection, Material Selection)
There are currently no expectations to measure this indicator. However, an assessment on measuring it was included in this report, as it was an outcome and indicator identified in the PH PTLM, and to account for potential changes in policy that increase the relevancy of this outcome.
Outcome N: Positive NEI Experienced in Participant Buildings, Indicator 22: The Value of Positive NEIs Experienced as a Result of the PH Offering
The PAs should review the options presented in Section 5.2.5.1 to assess the value of this indicator to the program theory and which measurement options are most feasible for the program.
Outcome O: Development of Additional PH offerings, Indicator 23: The Number of PH Offerings Expands into Other Market Sectors in Massachusetts
Revisit this indicator during the planning stage or initial research stages in the next study.
Long-Term Outcomes
(Measurable Changes Attributable to Program Expected in 7-10 Years)
Outcome P: Advances in Building Codes and Regulations, Indicator 24: Changes in Building Codes (e.g., Inclusion of PH and ZNE Stretch Codes)
The PAs are already tracking efforts to support DOER research on updates to Massachusetts energy codes (e.g., cost, and technical data from PH program participants. The PAs should track and document any increased effort in supporting code updates.
Outcome P: Advances in Building Codes and Regulations, Indicator 25: Perceptions of Program Influence
Measurements of this indicator would expand upon survey questions that ask about current practices, how they have changed, and the extent to which the program influenced these changes.
Outcome Q: Persistent Energy Savings in Market Overall, Indicator 26: Reductions of EUI in Multifamily Buildings
The PAs should review the options presented in Section 5.3.2.1 to assess the value of this indicator to the program theory and which measurement options are most feasible for the program.

Recommendations, Considerations, and Results for Each Indicator
Outcome Q: Persistent Energy Savings in Market Overall, Indicator 27: Perceptions of Program Influence
The PAs should review the options presented in Section 5.3.2.2 to assess the value of this indicator to the program theory and which measurement options are most feasible for the program.
Outcome Q: Persistent Energy Savings in Market Overall, Indicator 28: Observed Lower Energy Consumption and Peak Demand from Participant Projects
The PAs should review the options presented in Section 5.3.2.3 to assess the value of this indicator to the program theory and which measurement options are most feasible for the program.
Outcome R: Increased NEIs in Overall Multifamily New Construction Market, Indicator 29 Increased NEIs Experienced in Broader Multifamily Market
The measurement for this indicator likely depends on available data and the successful measurement of Outcome N, Indicator 22.
Outcome S: Savings from Non-Regulated Loads and Non-Traditional Measures, Indicator 30: Increased Number of Claimable Measures Included in the UDRH for PH Offering
Review program tracking data for new and nascent technology used by PH participant projects.
Outcome T: Market Transformation, Indicator 31: A Majority of Short-, Medium-, and Long-term Outcomes are Measured and There is a Major Presence of PH in Broader Multifamily Market
This indicator is viewed more as confirmation that the PH PTLM has been met and may not be necessary to track as a specific indicator.
Outcome T: Market Transformation, Indicator 32: Major Presence of PH Construction Observed in Neighboring States
Recommendation: Update the three measurements presented. Track these for each respondent group.

6.2 CONSIDERATIONS

Consider providing project teams additional incentives to deliver incremental cost estimates in addition to actual project cost data. Incremental cost evaluations are challenging to execute because acquiring cost data at the measure level can be prohibitive, and because determining the baseline measure relies on assumptions (primarily from the UDRH). Project teams are in a unique position to provide incremental cost estimates for their projects, as they likely have a baseline version of the project assessed during the feasibility study and have access to specific costs. This data could feed into any evaluations that estimate incremental costs for the PH program and would also be useful in developing approaches to reduce barriers to broader market adoption of PH or similar levels of efficiency.

PA staff should reassess all aspects of the PH PTLM for any necessary adjustments now that the program has been in operation for a few years. The MA19R05 Passive House Program Theory and Logic Model was established in 2020, and nearly three years have passed since the program entered the market. The team understands that PTLMs are meant to be living documents and that circumstances change once a program design moves from theory to practice. Failing to make necessary adjustments to program theory and indicator measurement plans

before the execution of the next study that measures indicators could lock the program into an approach and a group of metrics that might not best reflect its impact.

While continuing to target multifamily project owners and developers with general education and outreach, the PAs should consider also providing non-developer market actors with tools and strategies that could help them to encourage project decision-makers to achieve greater levels of efficiency. Respondents aware of PH indicated that the project owner or developer was the primary driver behind the decision to pursue incentives through the PH program. They noted that other project stakeholders, such as the project team or sustainability consultants, can also drive this decision. If the program is not doing so already, the PAs should consider providing market actors with tools and strategies to help them sell project developers and owners on PH or other high-performance projects.

Consider conducting brief exit interviews or surveys with participants that drop out of the program to better understand which costs were too high and to inform program efforts to overcome those cost barriers. Respondents indicated that the number one reason for their project dropping out of the PH program was due to the incremental cost associated with achieving PH or similar levels of efficiency (Table 41).

The memo presented in Appendix D **provides additional considerations for program and implementation staff.** At a high level, these considerations are to:

1. Document and expand PA efforts to influence project RFPs to include language about incorporating PH or similar levels of efficiency in the project,[73] and track mentions of this language and impacted projects.
2. Consider offering training to appraisers to help them develop expertise in valuing high-performance buildings and other sustainability features. Having trained appraisers available in the market should help the construction financing of projects pursuing PH levels of efficiency. The program already targets real estate agents as a part of the workforce development component. The program could research whether any training or certification in valuation of high-performance buildings is currently offered to appraisers by any entity. If there is, the PAs could support and provide input to this training. If there is not, the PAs could develop and offer the training.
3. Reduce barriers for low-rise multifamily projects to enroll in the PH program. For example, HERS raters that operate in the low-rise multifamily market can more effectively encourage future participation in the program if they had training on how to communicate the value and incentive structure of the PH program to market actors.
4. Determine which, if any, of the remaining market segments in Massachusetts can support programmatic offerings to achieve PH levels of efficiency. These market segments may

[73] This could include PH or similar levels of efficiency requirement, requirements to include PH core design principles, PH certification or pre-certification requirements, explicit inclusion of other high-performance design and construction practices, selection bonuses for project teams that include PH (or related high-performance strategies) in their responses, and teams that apply integrated project delivery strategies.

include retrofits or renovations in the single-family, multifamily, and commercial markets as well as new construction for single-family homes and prefabricated homes.

5. Review the initial PH participant projects to identify whether equipment not currently covered in the UDRH is commonly used and whether it warrants inclusion. Consider the impacts of design strategies such as managing solar gains and eliminating thermal bridging.

Appendix A Market Actor Survey Detailed Findings

This appendix presents more detailed reporting or additional data for some of the indicators described in Section 4. This includes tables that show results by respondent category and noteworthy survey findings that did not yield direct indicator measurements. For ease of navigation, the information is organized by the outcome and indicator with which they are, or were meant to be, associated.

A.1 Short-Term Outcomes and Related Indicators

A.1.1 Outcome B: Increased Understanding and Awareness of PH Certification, Practices, and Benefits

A.1.1.1 Indicator 3: Participant Understanding of PH Benefits and Challenges

Question QC6: *Please describe the training and any resulting certifications you received. (Example: I took a course to become a Certified Passive House Consultant through PHIUS, or I watched a webinar that discussed Passive House principles.)*

Most respondents reported being trained in PH design and construction principles through non-certification courses and webinars, followed by taking the Certified Passive House Consultant (CPHC) course, which leads to certification upon passing an exam (Table 31).

Table 31: Respondent Passive House Level of Training

Base: Respondents that reported some PH training (n=33)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
PH courses and webinars	10	48%	8	67%	5	63%	3	75%	18	55%
CPHC	5	24%	2	17%	1	13%	1	25%	7	21%
Professional Experience	4	19%	0	0%	0	0%	0	0%	4	12%
Verifier	2	10%	0	0%	0	0%	0	0%	2	6%
Individual Research	0	0%	2	17%	2	25%	0	0%	2	6%
Total	***21***	***100%***	***12***	***100%***	***8***	***100%***	***4***	***100%***	***33***	***100%***

A.1.1.2 Indicator 4: Participant Awareness of PH Design Principles

Successful Implementation of Passive House Design Principles by Participants

Question QC10: *Please rate on a scale from 1 to 5, with 1 being never have implemented on a project and 5 being always implemented on projects, how often did you implement the following practices on your projects* ***between January 2018 and June 2019****?*

Table 32: Rate of Implementing Passive House Design and Construction Principles in Projects during the Baseline Period (January 2018-June 2019)

Base: All respondents (n=78)

Extremely air-tight construction										
	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
1 - Never	10	31%	22	48%	13	59%	9	38%	32	41%
2	8	25%	8	17%	3	14%	5	21%	16	21%
3	8	25%	6	13%	1	5%	5	21%	14	18%
4	4	13%	5	11%	1	5%	4	17%	9	12%
5 - Always	2	6%	5	11%	4	18%	1	4%	7	9%
Total*	***32***	***100%***	***46***	***100%***	***22***	***100%***	***24***	***100%***	***78***	***100%***
Using minimized HVAC systems										
	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
1 - Never	5	16%	12	26%	8	36%	4	17%	17	22%
2	6	19%	6	13%	2	9%	4	17%	12	15%
3	6	19%	11	24%	3	14%	8	33%	17	22%
4	10	31%	8	17%	4	18%	4	17%	18	23%
5 - Always	5	16%	9	20%	5	23%	4	17%	14	18%
Total*	***32***	***100%***	***46***	***100%***	***22***	***100%***	***24***	***100%***	***78***	***100%***
Using balanced heat and moisture recovery ventilation										
	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
1 - Never	3	9%	15	33%	9	41%	6	25%	18	23%
2	7	22%	9	20%	5	23%	4	17%	16	21%
3	8	25%	9	20%	3	14%	6	25%	17	22%
4	7	22%	6	13%	2	9%	4	17%	13	17%
5 - Always	7	22%	7	15%	3	14%	4	17%	14	18%
Total*	***32***	***100%***	***46***	***100%***	***22***	***100%***	***24***	***100%***	***78***	***100%***
Window placement that optimizes solar gains in the winter and minimizes in the summer										
	PH participant				Non-participant subcategories				All	

			Total non-participant		Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
1 - Never	7	22%	17	37%	10	45%	7	29%	24	31%
2	9	28%	8	17%	5	23%	3	13%	17	22%
3	7	22%	11	24%	3	14%	8	33%	18	23%
4	6	19%	7	15%	3	14%	4	17%	13	17%
5 - Always	3	9%	3	7%	1	5%	2	8%	6	8%
Total*	***32***	***100%***	***46***	***100%***	***22***	***100%***	***24***	***100%***	***78***	***100%***

Applying continuous insulation around the entire envelope

	PH participant		Non-participant subcategories						All	
			Total non-participant		Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
1 - Never	2	6%	9	20%	4	18%	5	21%	11	14%
2	7	22%	6	13%	4	18%	2	8%	13	17%
3	5	16%	9	20%	4	18%	5	21%	14	18%
4	6	19%	8	17%	2	9%	6	25%	14	18%
5 - Always	12	38%	14	30%	8	36%	6	25%	26	33%
Total*	***32***	***100%***	***46***	***100%***	***22***	***100%***	***24***	***100%***	***78***	***100%***

Eliminating or significantly reducing thermal bridging

	PH participant		Non-participant subcategories						All	
			Total non-participant		Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
1 - Never	3	9%	11	24%	4	18%	7	29%	14	18%
2	7	22%	6	13%	5	23%	1	4%	13	17%
3	11	34%	10	22%	3	14%	7	29%	21	27%
4	6	19%	10	22%	4	18%	6	25%	16	21%
5 - Always	5	16%	9	20%	6	27%	3	13%	14	18%
Total*	***32***	***100%***	***46***	***100%***	***22***	***100%***	***24***	***100%***	***78***	***100%***

A.1.2 Outcome C: Increased Adoption of Passive Design and Building Practices by Participant Market Actors

A.1.2.1 Indicator 6: Self-Reported Building/Operation Practices of Participants

Indicator 6 (Section 4.1.3.1) and Indicator 13 (Section 4.2.2.2) are operationalized with values from Question QR7 and QR8. The operationalized values for both indicators are highlighted in Table 33 and Table 34. Indicator 6 is based on participant responses and is highlighted in **green**. Indicator 13 is based on all responses and is highlighted in **blue**.

Frequency with Which Participants Attempt to Implement High-Performance Design and Construction Practices

Question QR7: ***Thinking of your most recent projects****, on a scale of 1 to 4 where 1 is "Never" and 4 is "Always," how often do you or your project teams* ***try to implement*** *the following high-performance design or construction practices in your projects, regardless of whether they are actually implemented? ("Trying" in this case could mean including these practices in initial planning discussions, feasibility studies or early design iterations, getting cost estimates, etc.)*

Table 33: Detailed Response Data: How Often Participants Attempt to Implement Efficient Practices

Base: All respondents (n=75)

Extremely air-tight construction (PH)										
	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Always	13	**42%**	6	14%	3	14%	3	13%	19	**25%**
Often	8	26%	13	30%	6	29%	7	30%	21	28%
Sometimes	6	19%	9	20%	7	33%	2	9%	15	20%
Never	2	6%	11	25%	4	19%	7	30%	13	17%
Don't know	2	6%	5	11%	1	5%	4	17%	7	9%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

Above-code insulation (PH)										
	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Always	12	**39%**	12	27%	6	29%	6	26%	24	**32%**
Often	10	32%	9	20%	4	19%	5	22%	19	25%
Sometimes	6	19%	11	25%	7	33%	4	17%	17	23%
Never	0	0%	7	16%	3	14%	4	17%	7	9%
Don't know	3	10%	5	11%	1	5%	4	17%	8	11%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

Managing solar heat gain (PH)										
	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Always	9	**29%**	8	18%	5	24%	3	13%	17	**23%**
Often	8	26%	9	20%	3	14%	6	26%	17	23%
Sometimes	8	26%	14	32%	5	24%	9	39%	22	29%
Never	4	13%	9	20%	7	33%	2	9%	13	17%
Don't know	2	6%	4	9%	1	5%	3	13%	6	8%

Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

PH summary

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	34	37%	26	20%	14	22%	12	17%	60	27%
Often	26	28%	31	23%	13	21%	18	26%	57	25%
Sometimes	20	22%	34	26%	19	30%	15	22%	54	24%
Never	6	6%	27	20%	14	22%	13	19%	33	15%
Don't know	7	8%	14	11%	3	5%	11	16%	21	9%
Total*	***93***	***100%***	***132***	***100%***	***63***	***100%***	***69***	***100%***	***225***	***100%***

Smaller capacity, high-efficiency HVAC equipment (Systems and equipment)

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	13	42%	10	23%	6	29%	4	17%	23	31%
Often	9	29%	14	32%	6	29%	8	35%	23	31%
Sometimes	6	19%	8	18%	4	19%	4	17%	14	19%
Never	0	0%	6	14%	4	19%	2	9%	6	8%
Don't know	3	10%	6	14%	1	5%	5	22%	9	12%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

Balanced ventilation w/ heat recovery (Systems and equipment)

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	19	61%	16	36%	7	33%	9	39%	35	47%
Often	5	16%	12	27%	7	33%	5	22%	17	23%
Sometimes	4	13%	10	23%	5	24%	5	22%	14	19%
Never	0	0%	2	5%	1	5%	1	4%	2	3%
Don't know	3	10%	4	9%	1	5%	3	13%	7	9%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

On-site renewables (Systems and equipment)

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	10	32%	3	7%	2	10%	1	4%	13	17%
Often	6	19%	13	30%	5	24%	8	35%	19	25%
Sometimes	13	42%	13	30%	6	29%	7	30%	26	35%
Never	1	3%	11	25%	7	33%	4	17%	12	16%

Don't know	1	3%	4	9%	1	5%	3	13%	5	7%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

Building management systems (Systems and equipment)

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	7	**23%**	15	34%	6	29%	9	39%	22	**29%**
Often	9	29%	12	27%	6	29%	6	26%	21	28%
Sometimes	10	32%	6	14%	3	14%	3	13%	16	21%
Never	1	3%	7	16%	5	24%	2	9%	8	11%
Don't know	4	13%	4	9%	1	5%	3	13%	8	11%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

System and equipment summary

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	49	**40%**	44	25%	21	25%	23	25%	93	**31%**
Often	29	23%	51	29%	24	29%	27	29%	80	27%
Sometimes	33	27%	37	21%	18	21%	19	21%	70	23%
Never	2	2%	26	15%	17	20%	9	10%	28	9%
Don't know	11	9%	18	10%	4	5%	14	15%	29	10%
Total*	***124***	***100%***	***176***	***100%***	***84***	***100%***	***92***	***100%***	***300***	***100%***

Indoor air quality (Other benefits)

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	20	**65%**	12	27%	5	24%	7	30%	32	**43%**
Often	4	13%	16	36%	8	38%	8	35%	20	27%
Sometimes	6	19%	7	16%	5	24%	2	9%	13	17%
Never	0	0%	4	9%	2	10%	2	9%	4	5%
Don't know	1	3%	5	11%	1	5%	4	17%	6	8%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

Other "Green" building design features (Other benefits)

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	10	**32%**	11	25%	5	24%	6	26%	21	**28%**
Often	9	29%	12	27%	7	33%	5	22%	21	28%
Sometimes	8	26%	10	23%	3	14%	7	30%	18	24%

Never	3	10%	8	18%	5	24%	3	13%	11	15%
Don't know	1	3%	3	7%	1	5%	2	9%	4	5%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

Other benefits (NEIs, sustainability) summary										
	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	30	48%	23	26%	10	24%	13	28%	53	35%
Often	13	21%	28	32%	15	36%	13	28%	41	27%
Sometimes	14	23%	17	19%	8	19%	9	20%	31	21%
Never	3	5%	12	14%	7	17%	5	11%	15	10%
Don't know	2	3%	8	9%	2	5%	6	13%	10	7%
Total*	***62***	***100%***	***88***	***100%***	***42***	***100%***	***46***	***100%***	***150***	***100%***

* Totals may not sum to 100% due to rounding.

Successful Implementation of High-Performance Design and Construction Practices by Participants

Question QR8: ***Thinking of your most recent projects****, on a scale of 1 to 4 where 1 is "Never" and 4 is "Always," how often do you or your project teams* ***actually implement*** *the following high-performance design and construction practices in your projects? (By "actually implement," we mean they are included in final designs or construction, depending on the status of the project.)*

Table 34: Detailed Response Data: How Often Participating Respondents Implement Efficient Practices

Base: All respondents (n=75)

Extremely air-tight construction (PH)										
	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	2	6%	5	11%	3	14%	2	9%	7	9%
Often	11	35%	4	9%	0	0%	4	17%	15	20%
Sometimes	10	32%	10	23%	6	29%	4	17%	20	27%
Never	4	13%	18	41%	10	48%	8	35%	22	29%
Don't know	4	13%	7	16%	2	10%	5	22%	11	15%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

Above-code insulation (PH)										
	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	6	19%	7	16%	4	19%	3	13%	13	17%
Often	13	42%	11	25%	5	24%	6	26%	24	32%

Sometimes	9	29%	11	25%	6	29%	5	22%	20	27%
Never	1	3%	8	18%	4	19%	4	17%	9	12%
Don't know	2	6%	7	16%	2	10%	5	22%	9	12%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

Managing solar heat gain (PH)

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	3	10%	3	7%	2	10%	1	4%	6	8%
Often	10	32%	8	18%	4	19%	4	17%	18	24%
Sometimes	10	32%	10	23%	4	19%	6	26%	20	27%
Never	5	16%	16	36%	9	43%	7	30%	21	28%
Don't know	3	10%	7	16%	2	10%	5	22%	10	13%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

PH summary

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	11	12%	15	11%	9	14%	6	9%	26	12%
Often	34	37%	23	17%	9	14%	14	20%	57	25%
Sometimes	29	31%	31	23%	16	25%	15	22%	60	27%
Never	10	11%	42	32%	23	37%	19	28%	52	23%
Don't know	9	10%	21	16%	6	10%	15	22%	30	13%
Total*	***93***	***100%***	***132***	***100%***	***63***	***100%***	***69***	***100%***	***225***	***100%***

Smaller capacity, high-efficiency HVAC equipment (Systems and equipment)

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	7	23%	5	11%	3	14%	2	9%	12	16%
Often	13	42%	13	30%	5	24%	8	35%	26	35%
Sometimes	9	29%	12	27%	6	29%	6	26%	21	28%
Never	0	0%	7	16%	5	24%	2	9%	7	9%
Don't know	2	6%	7	16%	2	10%	5	22%	9	12%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

Balanced ventilation w/ heat recovery (Systems and equipment)

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	10	32%	7	16%	3	14%	4	17%	17	23%

Often	14	45%	16	36%	8	38%	8	35%	30	40%
Sometimes	5	16%	10	23%	4	19%	6	26%	15	20%
Never	0	0%	5	11%	4	19%	1	4%	5	7%
Don't know	2	6%	6	14%	2	10%	4	17%	8	11%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

On-site renewables (Systems and equipment)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Always	2	**6%**	3	7%	3	14%	0	0%	5	**7%**
Often	9	29%	7	16%	3	14%	4	17%	16	21%
Sometimes	14	45%	16	36%	7	33%	9	39%	30	40%
Never	5	16%	12	27%	6	29%	6	26%	17	23%
Don't know	1	3%	6	14%	2	10%	4	17%	7	9%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

Building management systems (Systems and equipment)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Always	4	**13%**	11	25%	5	24%	6	26%	15	**20%**
Often	9	29%	10	23%	4	19%	6	26%	19	25%
Sometimes	13	42%	10	23%	6	29%	4	17%	23	31%
Never	1	3%	7	16%	4	19%	3	13%	8	11%
Don't know	4	13%	6	14%	2	10%	4	17%	10	13%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

System and equipment summary

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Always	23	**19%**	26	15%	14	17%	12	13%	49	**16%**
Often	45	36%	46	26%	20	24%	26	28%	91	30%
Sometimes	41	33%	48	27%	23	27%	25	27%	89	30%
Never	6	5%	31	18%	19	23%	12	13%	37	12%
Don't know	9	7%	25	14%	8	10%	17	18%	34	11%
Total*	***124***	***100%***	***176***	***100%***	***84***	***100%***	***92***	***100%***	***300***	***100%***

Indoor air quality (Other benefits)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%

Always	16	**52%**	9	20%	4	19%	5	22%	25	**33%**
Often	8	26%	12	27%	5	24%	7	30%	20	27%
Sometimes	5	16%	14	32%	8	38%	6	26%	19	25%
Never	1	3%	4	9%	2	10%	2	9%	5	7%
Don't know	1	3%	5	11%	2	10%	3	13%	6	8%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

Other "Green" building design features (Other benefits)

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	6	**19%**	5	11%	3	14%	2	9%	11	**15%**
Often	9	29%	8	18%	2	10%	6	26%	17	23%
Sometimes	12	39%	20	45%	11	52%	9	39%	32	43%
Never	3	10%	6	14%	3	14%	3	13%	9	12%
Don't know	1	3%	5	11%	2	10%	3	13%	6	8%
Total*	***31***	***100%***	***44***	***100%***	***21***	***100%***	***23***	***100%***	***75***	***100%***

Other benefits (NEIs, sustainability) summary

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Always	22	**35%**	14	16%	7	17%	7	15%	36	**24%**
Often	17	27%	20	23%	7	17%	13	28%	37	25%
Sometimes	17	27%	34	39%	19	45%	15	33%	51	34%
Never	4	6%	10	11%	5	12%	5	11%	14	9%
Don't know	2	3%	10	11%	4	10%	6	13%	12	8%
Total*	***62***	***100%***	***88***	***100%***	***42***	***100%***	***46***	***100%***	***150***	***100%***

* Totals may not sum to 100% due to rounding.

Frequency of All-Electric Equipment and On-Site Renewable Energy Systems in Respondent Projects

Question QT7: ***Between January 2018 and June 2019****, what is the most typical end-use that did not end up being electrified on your projects?*

Table 35: Most Common Non-Electric End-Use during Baseline Period

Base: All respondents (n=72)

	PH participant		Total non-participant		Non-participant subcategories: Other PA-sponsored MF program		Non-participant subcategories: True non-participant		All	
	n	%	n	%	n	%	n	%	n	%
Space heating	15	52%	15	35%	9	43%	6	27%	30	42%

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Water heating	2	7%	12	28%	5	24%	7	32%	14	19%
Cooking	5	17%	7	16%	3	14%	4	18%	12	17%
N/A: all gas systems	3	10%	6	14%	4	19%	2	9%	9	13%
N/A: all-electric systems	1	3%	0	0%	0	0%	0	0%	1	1%
Don't know	3	10%	3	7%	0	0%	3	14%	6	8%
Total	**29**	**100%**	**43**	**100%**	**21**	**100%**	**22**	**100%**	**72**	**100%**

Question QT9: ***Now thinking of your most recent projects,*** *what is the most typical end-use that is not electrified on your projects?*

Table 36: Most Common Non-Electric End Use in Recent Projects

Base: All respondents (n=69)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Water heating	15	58%	17	40%	10	48%	7	32%	32	46%
Space heating	3	12%	10	23%	4	19%	6	27%	13	19%
Cooking	2	8%	7	16%	2	10%	5	23%	9	13%
Not applicable, projects are all-electric	2	8%	2	5%	2	10%	0	0%	4	6%
Not applicable, projects use gas for these systems	2	8%	2	5%	1	5%	1	5%	4	6%
Don't know	2	8%	5	12%	2	10%	3	14%	7	10%
Total [a]	**26**	**102%**	**43**	**101%**	**21**	**102%**	**22**	**101%**	**69**	**100%**

[a] Totals may not sum to 100% due to rounding.

Question QT4: *Thinking about the projects you worked on* ***between January 2018 and June 2019****, what percentage of heating and water heating equipment types and fuels were used with the following end-uses?*

Table 37: Detailed Response Data: Fuel and Equipment Selection for Heating and Water Heating End-Uses during the Baseline Period

Base: All respondents (n=73)

Fuel Type	PH Participant	Total non-participant	Non-participant subcategories		All
			Other PA-sponsored MF program	True non-participant	
n	*30*	*43 ->*	*21*	*22*	*73*
Space Heating: Centralized Systems					
Natural gas	41%	45%	46%	44%	43%
Electric Heat Pump	35%	17%	12%	21%	24%
Electric Resistance	4%	5%	2%	7%	4%
Other/N/A	20%	34%	40%	28%	28%
Space Heating: Individual Unit Systems					
Natural gas	39%	52%	61%	44%	47%
Electric Heat Pump	39%	21%	23%	19%	28%
Electric Resistance	2%	7%	6%	8%	5%
N/A	20%	19%	9%	29%	20%
Water Heating: Centralized Systems					
Natural gas	56%	51%	44%	56%	53%
Electric Heat Pump	7%	5%	2%	7%	6%
Electric Resistance	3%	5%	4%	5%	4%
N/A	34%	40%	49%	31%	37%
Water Heating: Individual Unit Systems					
Natural gas	47%	53%	65%	42%	51%
Electric Heat Pump	12%	15%	14%	16%	14%
Electric Resistance	8%	10%	8%	11%	9%
N/A	32%	22%	14%	30%	26%

Question QT5: *Thinking about the projects you worked on **between January 2018 and June 2019**, what percentage of cooking equipment types and fuels were used on the following end-uses?*

Table 38: Detailed Response Data: Cooking Fuels Used during the Baseline Period

Base: All respondents (n=72)

Fuel Type	PH Participant	Total non-participant	Non-participant subcategories		All
			Other PA-sponsored MF program	True Non-participant	

n	*29*	*43 ->*	*21*	*22*	*72*
Cooking ranges					
Natural Gas	27%	46%	40%	52%	38%
Electric Resistance	67%	48%	57%	39%	56%
Induction Stovetops	6%	6%	3%	9%	6%
Cooking ovens					
Natural Gas	28%	36%	28%	44%	33%
Electric Resistance	69%	58%	69%	47%	62%
Induction Stovetops	3%	6%	3%	8%	5%

Question QI1: *About how many of the multifamily new construction projects you worked on **between January 2018 and June 2019** included on-site renewable energy generation?*

On-site renewable energy questions were only included in the optional section of the survey due to survey length and the need to balance competing question priorities. Due to a limited number of respondents answering the optional questions and increased chance for self-selection bias, these data are presented for informational purposes only.

Table 39: Percent of Projects with On-Site Renewable Energy before PH Program Launch

Base: Optional survey questions respondents (n=32)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
None	1	8%	8	42%	3	33%	5	50%	9	28%
Less than 25%	6	46%	4	21%	2	22%	2	20%	10	31%
25-50%	3	23%	4	21%	1	11%	3	30%	7	22%
51-75%	1	8%	1	5%	1	11%	0	0%	2	6%
Over 75%	2	15%	2	11%	2	22%	0	0%	4	12%
Total [a]	**13**	**100%**	***19***	***100%***	***9***	***99%***	***10***	***100%***	***32***	***99%***

[a] Totals may not sum to 100% due to rounding.

A.1.3 Outcome E: High Participant Satisfaction with Program

A.1.3.1 Indicator 8: Level of Participant Satisfaction with Program Support, Services, and Incentives

While keeping participation levels high is a goal of the PH program, it is also imperative that these participant projects remain participants through the life of the project (which ultimately leads to the project achieving PH certification or a non-certified high-performance building). One quarter of respondents did not have any projects drop out, while 28% percent of respondents were initial

participants that ultimately dropped out (i.e., did not pursue or achieve pre-certification). Another 34% had a mix of projects that stayed in the program and dropped out.

Question QS4: *Please indicate whether any of your Passive House project(s) received initial support from the offering but then dropped out?*

Table 40: Respondent Summary of Participant Project Status

Base: Participants (n=32)

Status of Participant Projects	n	%
Yes, the project(s) completed a feasibility assessment or initial energy modeling but ultimately did not continue in the Passive House Offering.	9	28%
Some projects are still enrolled, and some projects dropped out of the Passive House Offering.	11	34%
No, all my project(s) completed the offering or are still actively engaged, with the expectation of meeting all the technical requirements of the Passive House Offering.	8	25%
I don't know	4	12%

Question QS5: *Why did your project(s) stop participating in the Passive House Offering?*

For participants that indicated all or some of their projects dropped out, the survey asked the reason why as an open-ended question. Table 41 presents the categorized responses. The primary reason for dropping out of the PH program was the incremental cost to achieve PH. Although the PH program provides richer incentives than the traditional MFHR program, some project teams may not be able to acquire the financing necessary to make the efficiency upgrades required to achieve PH certification or levels of efficiency. Program and implementation staff could consider conducting brief exit interviews or surveys with participants that drop out of the program to better understand which costs were too high and inform program efforts to overcome cost barriers.

Table 41: Respondent Rationale for Not Maintaining in the PH Program

Base: Participants that had at least some projects drop out (n=18)

Reported Issue	n	%
Incremental costs	15	83%
Funding issues	1	6%
Inexperienced feasibility consultant	1	6%
Too late in design process	1	6%

Question QC9: *Of the different parties involved in your multifamily new construction projects, who typically drives the decision to pursue Mass Save incentives through the Passive House Offering?*

The survey asked respondents that were aware of PH who ultimately was the primary driver behind the decision to pursue incentives through the program. Respondents indicated that the project owner or developer was the primary driver behind the decision, but that other project stakeholders, such as the project team or sustainability consultants, can also drive the decision.

The program should continue targeting general education and outreach efforts at multifamily project owners and developers and provide non-developer market actors tools and strategies on how to push the decision-makers of their projects to achieve greater levels of efficiency. While providing market actors with tools and strategies to push projects to a better efficiency outcome may not be useful for developers already interested in PH or other high-performance projects, it presents one opportunity to capture projects outside of the program purview.

Some respondents noted that cities and municipalities may also be driving the decision to pursue program participation. Respondents indicated cities predominately in the Boston Metro area, such as the City of Boston, Cambridge, Somerville, and Watertown, which all have permit and zoning ordinances that push projects to greater levels of efficiency. Mentions in the "other" category include energy modeler and affordable housing funding agencies.

Table 42: Key Drivers of Decision to Participate in the PH Program

Base: Respondents aware of PH (n=63)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Owner or developer	23	72%	21	68%	14	67%	7	70%	44	70%
Project Team (i.e., architects, engineers, builders)	3	9%	4	13%	2	10%	2	20%	7	11%
Local code or Municipality requirements	3	9%	1	3%	0	0%	1	10%	4	6%
Owner's project manager	1	3%	2	6%	2	10%	0	0%	3	5%
Sustainability consultant	0	0%	1	3%	1	5%	0	0%	1	2%
Other	2	6%	1	3%	1	5%	0	0%	3	5%
Don't know	0	0%	1	3%	1	5%	0	0%	1	2%
Total [a]	***32***	***99%***	***31***	***99%***	***21***	***102%***	***10***	***100%***	***63***	***101%***

[a] Totals may not sum to 100% due to rounding.

A.2 Medium-Term Outcomes and Related Indicators

A.2.1 Outcome F: Increased Demand for PH Buildings in the Multifamily Market

A.2.1.1 Indicator 11: Increased Mentions of PH Accreditation in Advertisements and Real Estate Listings

This indicator was operationalized with results from developer and owner project manager respondent types only. The following are the same questions but with results from all respondents.

Question QR2: ***Thinking back to before July 2019****, on a scale from 1 to 4, where 1 is "Not at all" and 4 is "A great deal," how much would you say owners and developers valued having their projects achieve high-performance standards before July 2019?*

Table 43: Perception of Importance for Developers to Achieve High-Performance Standards during Baseline Period (January 2018-June 2019)

Base: All respondents (n=73)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
A great deal	6	19%	4	10%	2	10%	2	9%	10	14%
Somewhat	15	48%	20	48%	11	55%	9	41%	35	48%
A little	10	32%	18	43%	7	35%	11	50%	28	38%
Not at all	0	0%	0	0%	0	0%	0	0%	0	0%
Total	***31***	***99%***	***42***	***101%***	***20***	***100%***	***22***	***100%***	***73***	***100%***

Question QR4: *Before July 2019, did you find multifamily project owners and developers perceived marketing advantages to high-performance buildings that made these buildings more competitive in real estate and rental markets?*

Table 44: Marketing Advantages for Developers to Achieve High-Performance Standards during Baseline Period (January 2018-June 2019)

Base: All respondents (n=63)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Yes	5	21%	18	46%	10	48%	8	44%	23	37%
No	19	79%	21	54%	11	52%	10	56%	40	63%
Total	***24***	***100%***	***39***	***100%***	***21***	***100%***	***18***	***100%***	***63***	***100%***

The survey also asked respondents whether developers that valued high-performance construction shared similar traits (Table 45). In general, respondents saw affordable housing developers and developers that own and operate their projects as likely to value high-performance construction (39%). Respondents also saw some developers as intrinsically valuing sustainability (23%) and higher budget projects (12%), which could cause them to value high-performance construction.

Question QR5: *Did the building owners and developers who perceived marketing advantages share any similar traits, for example geographic, size of project, or affordable/market-rate project type?*

Table 45: Shared Traits of Developers That Value High-Performance Construction

Base: All respondents (n=62)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Yes	26	93%	30	88%	16	89%	14	88%	56	90%
No	2	7%	4	12%	2	11%	2	12%	6	10%
Total	***28***	***100%***	***34***	***100%***	***18***	***100%***	***16***	***100%***	***62***	***100%***

Types Valuing HP Construction (n=56)	n	%
Long-term owners or affordable housing developers	33	59%
Developer valuing sustainability	13	23%
Higher budget projects	7	12%
Experienced developers	2	4%
Non-energy benefits	1	2%

A.2.2 Outcome G: Increased Number of PH-Certified and Skilled Market Actors

A.2.2.1 Indicator 13 Self-Reported Levels of Skill in PH Practices (e.g., Air-Sealing, Thermal Bridge Details)

The detailed results associated with this indicator are presented in Appendix A.1.2 to reduce report length.

A.2.3 Outcome I: Passive Design and Construction Practices Carried Over to Non-Participant Projects

A.2.3.1 Indicator 15: Reports of Applying Knowledge/Skills for High-Performance Building/Operation Learned through Program

Question QT2: *Please indicate which of the following practices you've adopted on other projects because of working on a project participating in the Passive House Offering?*

Table 31 provides details on the specific practices that PH participants reported carrying over into their other work. (Multiple responses were allowed on this question.) Over half of participants who reported skill carryover used advanced air sealing techniques and some type of energy recovery ventilation in their projects that did not participate in the PH program.

Table 46: Practices Carried Over from Participating Projects

Base: Participants who reported carrying practices from participating projects to other work (n=25)

Practices	n	% of participants
Incorporate high-efficiency heating systems (above code-compliant efficiency)	11	44%
Incorporate high-efficiency water heating system (above code-compliant efficiency)	12	48%
Continuous insulation around the thermal envelope	10	40%
Advanced air sealing techniques, including maintaining a continuous air barrier	15	60%
Building energy modeling to inform project design	9	36%
Feasibility studies to inform project efficiency goals	10	40%
Increased insulation levels in the building shell beyond code or baseline market practices (for example, greater than R-15 for a mass wall, or R-19 for wooden frame)	9	36%
Thermal bridge free details	10	40%
Use of thermal break products	11	44%
Air infiltration testing	7	28%
Energy or heat recovery ventilation	13	52%
High-efficiency windows (U-value less than 0.32)	11	44%
Optimized window-to-wall ratios to maximize solar gains	9	36%
Minimized HVAC equipment capacity due to shell improvements	7	28%
Efficient building envelope design to optimize heating energy performance	1	4%
Shading studies, consideration of heat gain from occupants, more focus on humidity control	1	4%

Question QT3: *Please indicate which of the following practices, if any, you typically incorporate into your projects?*

Table 47 provides details on the specific practices used by non-participants and by PH participants that reported ***not*** carrying over into their other work. Only two PH participants indicated not carrying over skills and practices learned on PH projects, which limit the usefulness of these results.

Table 47: Use of Efficient Practices by Respondents Not Reporting Carryover

Practices	PH Participant (n=2)		Non-PH Participant (n=43)	
	count	%	count	%
Incorporate high-efficiency heating system (above code-compliant efficiency)	2	100%	8	16%
Incorporate high-efficiency water heating system (above code-compliant efficiency)	2	100%	12	24%
Continuous insulation around the thermal envelope	2	100%	9	18%

Advanced air sealing techniques, including maintaining a continuous air barrier	2	100%	7	14%
Building energy modeling to inform project design	1	50%	4	8%
Feasibility studies to inform project efficiency goals	1	50%	3	6%
Increased insulation levels in the building shell beyond code or baseline market practices (for example, greater than R-15 for a mass wall, or R-19 for wooden frame)	1	50%	7	14%
Thermal bridge free details	1	50%	3	6%
Use of thermal break products	2	100%	4	8%
Air infiltration testing	2	100%	6	12%
Energy or heat recovery ventilation	2	100%	8	16%
High-efficiency windows (U-value less than 0.38)	2	100%	10	20%
Optimized window-to-wall ratios to maximize solar gains	2	100%	4	8%
Minimized HVAC equipment capacity due to shell improvements	2	100%	5	10%
None of these practices	0	0%	6	12%

A.3 Market Research Findings from Survey

The following subsection includes findings from the web survey not used to operationalize an indicator. These findings are organized by topic.

A.3.1 Time Period of Initial Participation

Question QC3: *When did you first participate in the Passive House Offering?*

Over 80% of participant respondents were initially involved with the program in the first year-and-a-half of program inception (Table 48). Follow-up measurements for this metric may provide information to program staff on the amount of new market actors participating in the program annually.

Table 48: Time Period Participant First Participated in the PH Program

Base: Participants (n=32)

Time period	Participants	
	n	%
Between July 2019 and December 2019	14	44%
2020	13	41%
2021	4	12%
I don't remember	1	3%
Total	**32**	**100%**

A.3.2 Barriers to Executing High-Performance Construction

Question QR1: *We are interested in understanding the barriers to demand for high-performance multifamily buildings in Massachusetts as they existed **before July 2019**. Below is a list of barriers. For each one, please think back to your experience with multifamily projects **before July 2019.** Using a scale from 0 (Not a barrier) to 3 (A major barrier), based on your experience, tell us how substantial a barrier each of the following was to the demand for high-performance multifamily buildings in Massachusetts **before July 2019**.*

The team organized specific barriers into three themes to simplify operationalizing this indicator: costs and finances, lack of trained market actors, and market value (Figure 7). The detailed results for each individual barrier are presented for participants in Figure 8 and non-participants in Figure 9.

Figure 7: Primary Barriers to High-Performance Construction

Base: Participants (n=32)

Figure 8: Participant Ranking of Barriers to PH Construction

Base: Participants (n=32)

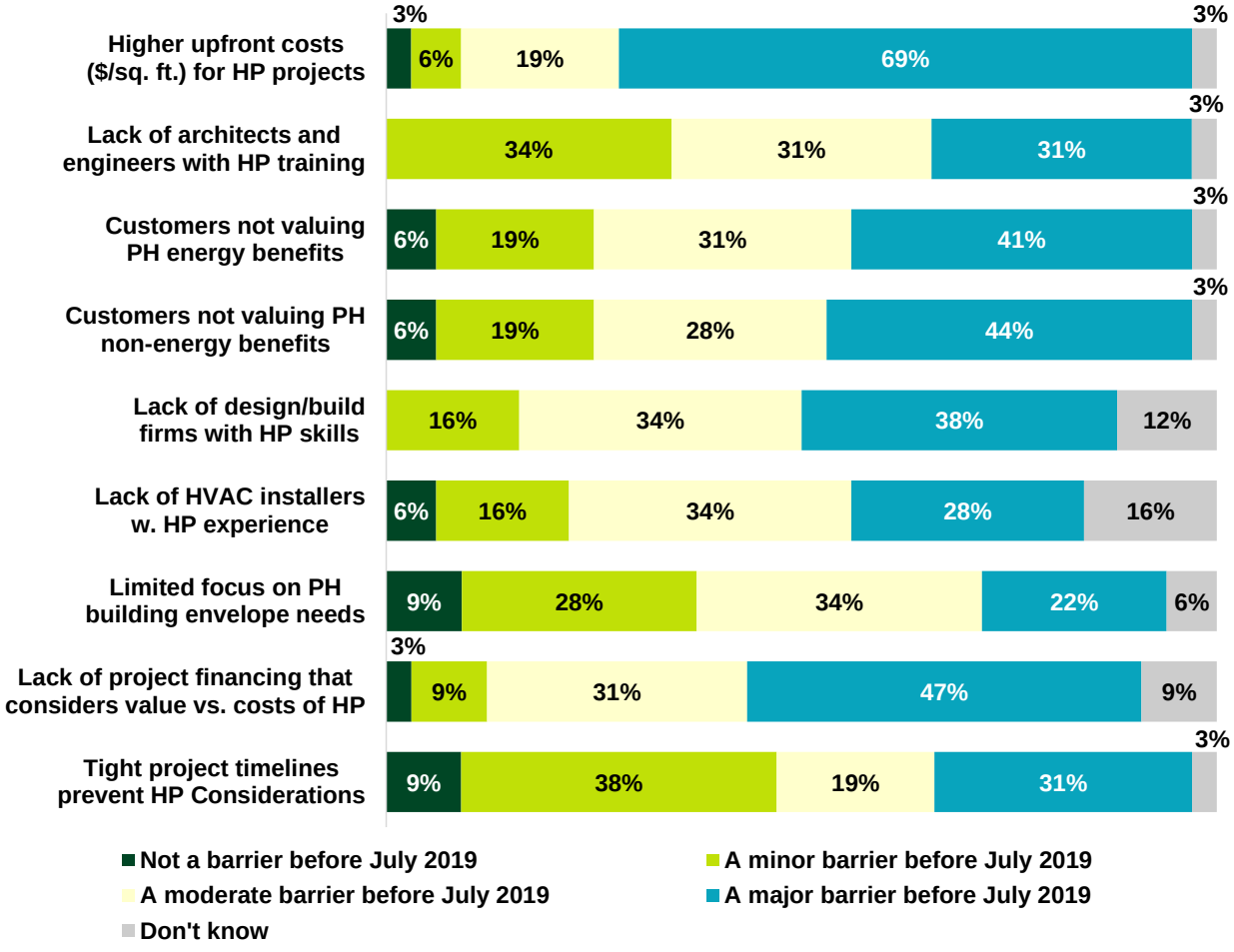
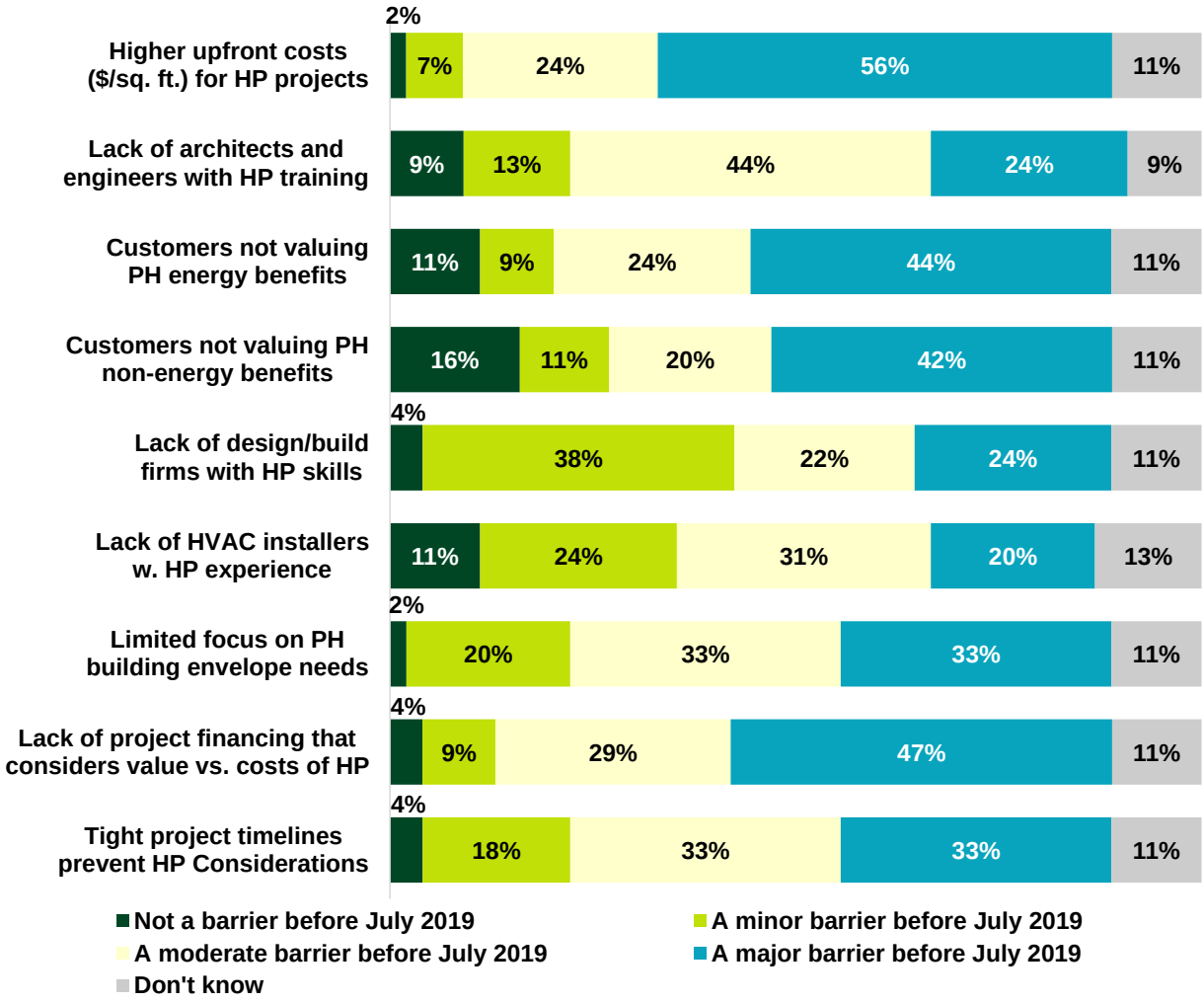


Figure 9: Non-Participant Ranking of Barriers to PH Construction

Base: Non-participants (n=45)



A.3.3 Non-Energy Impacts

Question QT11: *What are potential non-energy impacts associated with high-performance multifamily buildings? Please indicate whether each potential non-energy impact has a positive or negative impact using the sliders. Use a scale of -3 to +3, where -3 indicates a significant adverse impact of high-performance buildings and +3 indicates a significant positive impact of high-performance buildings. 0 indicates that there is no impact.*

The survey respondents were asked on a scale from negative three to positive three, with zero indicating no impact, how impactful were potential NEIs that are associated with high-performance construction (Table 49). The respondents, both participant and non-participant, perceive positive impacts from high-performance construction for all potential NEIs. Respondents estimated thermal comfort was the most impactful NEI, followed by resilience to extreme weather events. However, without further research to quantify the impact and monetize the value of these potential NEIs, only market actor perception can drive measurements for this indicator.

Table 49: Average Impact of Potential NEIs of High-Performance Construction

Scale: -3 to 3, 0 indicates no impact

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	avg.	n	avg.	n	avg.	n	avg.	n	avg.
Thermal comfort	28	1.86	32	1.81	18	2	14	1.57	60	1.83
Resilience to extreme weather events	27	2	34	1.44	19	1.79	15	1	61	1.69
Noise reduction	27	1.7	30	1.43	15	1.6	15	1.27	57	1.56
Indoor air quality	28	1.75	32	1.31	18	1.5	14	1.07	60	1.52
Building durability	27	1.59	32	1.38	17	1.53	15	1.2	59	1.47
Potential increased lifespan of mechanical equipment	27	1.04	29	1.24	15	1.27	14	1.21	56	1.14

In addition to the NEI impacts estimated above, respondents reported rates of systems by fuel (Table 37 and Table 38 in the subsection above). The RNC NEI quick hit study monetized NEIs for non-combustion stoves. While actual project file data can be used to determine the prevalence of gas and electric systems in program participant buildings, non-participant buildings will need to have gas and electric system saturation estimated from primary data, [74] if available, or secondary data sources such as the U.S. Census Bureau, Energy Information Agency data, and broader market surveys such as the Residential Energy Consumption Survey (RECS) and Commercial Building Energy Consumption Survey (CBECS).

A.3.4 Air Infiltration Testing Practices

Question QC11: *What percentage of the projects you worked on **between January 2018 and June 2019** had air-infiltration tests conducted to verify the airtightness of the building?*

[74] Such as an updated MFHR baseline study or surveys with non-participant market actors.

Table 50: Average Proportion of Projects That Conducted Air-Infiltration Projects during the Baseline Period (January 2018-June 2019)

Base: All respondents (n=76)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Average percent of projects that conduct air-infiltration tests	32	56%	44	42%	22	49%	22	35%	76	48%

A.3.5 Respondent Awareness of Energy Use Intensity (EUI)

Question QE1: *Before you encountered this survey, had you heard of the term "energy use intensity" (EUI)?*

Table 51: Respondent Awareness of EUI Prior to the Survey

Base: Optional respondents (n=32)

	PH participant		Total non-participant		Non-participant subcategories				All	
					Other PA-sponsored MF program		True non-participant			
	n	%	n	%	n	%	n	%	n	%
Yes	9	69%	5	26%	3	33%	2	20%	14	44%
No	4	31%	14	74%	6	67%	8	80%	18	56%
Total	***13***	***100%***	***19***	***100%***	***9***	***100%***	***4***	***100%***	***32***	***100%***

Appendix B Market Actor Survey Instrument

In this appendix, we present the final web survey guide submitted to the PAs on July 7, 2021.

B.1 Background for Reviewers

This web survey instrument is meant to measure selected indicators of market effects outcomes from the PH program, as outlined in the PH Indicator memo dated April 26, 2021. Since this study has similar goals as the C&I New Buildings & Major Renovations Market Effects Baseline Study (MA20X12-B-NRNCMEB) but for a different offering, NMR developed this survey by adapting the MA20X12-B-NRNCMEB survey to meet the needs of this study.

This survey targets architects; mechanical, electrical, and plumbing (MEP) engineers; design and build contractors; sustainability consultants; developers; commissioning agents; and owner's project managers (OPMs). Other types of market actors that will be included in the survey sample frame but may lack the holistic perspectives on projects include mechanical system (HVAC and water heating) installation contractors and mechanical equipment manufacturer representatives. We expect responses to vary by market actor type and will report them by market actor type as data allows. Because we did not have dependable data on the number of each type of market actor active in Massachusetts, we did not set recruitment targets by market actor type.

The survey is meant to collect data from program participants, non-participants, and market actors who work on both participating and non-participating projects, binning respondents into these three groups after collecting the data. NMR developed the participant sample through a review of program tracking data and participant project files. We obtained non-participant samples by purchasing market actor contact information from ConstructConnect®, a third-party market data aggregator. The survey is organized by market effects themes to create a smooth user experience and ease the development of skip patterns for respondents not informed about certain themes. We designed these questions to be applicable to multiple types of market actors, with some market actor-specific questions where appropriate.

The PH Offering was launched in July 2019. The goal of this survey is to establish baseline indicators for each expected market effect *before* the start of the offering. The timeframe that the survey asks respondents about is January 2018 through June 2019. Although it may be difficult for a survey respondent to recall past project specifics, we believe using the date the program launched is preferable to asking about projects between 2017 and 2018, as recall will be even more challenging for the respondent with earlier timeframes.

The table below is a matrix that maps survey questions to indicators they measure. The table only covers indicators measured in this web survey. Table 2 provides the summary of outcomes, indicators, and proposed data sources as outlined in the PH Indicator memo.

Table 49: Detailed Mapping of Questions to Indicators

#	Outcome	Indicator of outcome	Indicator measurement questions
Short-term (1 to 3 years)			
1	High program awareness and participation	Rates of program awareness	QS2, QS3, QS7, QC1
2	Increased understanding and awareness of PH Certification, Practices, and Benefits	Participant understanding of PH benefits and challenges	QC6, QR1, QR2, QR3, QR4, QR5
		Participant awareness of PH design principles	QC6, QC10, QT1, QT2
		Participant awareness of PH certification processes	QC1, QC2, QC3, QC4, QC5, QC6
3	Increased adoption of passive design and building practices by participant market actors	Self-reported building/operation practices of participants	QR6, QR7, QR8, QT2,QT4, QT5, QT6, QT7
5	High participant satisfaction with program	Level of participant satisfaction with program support, services, and incentives	QS4, QS5, QS6, QC9
Mid-term (4 to 6 years)			
6	Increased demand for PH buildings in the multifamily market overall	Increased requests for passive designs in RFPs	QC7, QE5, QR2, QR3, QR4
7	Increased number of PH-certified and skilled market actors	Self-reported levels of skill in PH practices (e.g., air-sealing, thermal bridge detail)	QC8, QC10, QM1, QR1, QR7, QR8, QT3
9	Passive design and construction practices carried over to non-participant projects	Reports of applying knowledge/skills for high-performance bldg./operation learned through program	QT1, QT2
		Baseline market assessments and reports that characterize changes in the MF market	QC10, QC11, QR1, QR7, QR8, QT3, QT4, QT5, QT6, QT7, QI1
11	Increased proportion of new buildings that are low Energy Usage Intensity (EUI)	Proportion of buildings that are low EUI (or extremely efficient)	QC8, QE1, QE2, QE3, QE4, QE5, QE6, QE7, QE8
12	Increased feasibility of passive design	Market actor attitudes toward passive design feasibility	QC9, QM1, QF1, QF2, QR1, QC1
		Incremental cost decreases relative to past PH program participants and ISP construction	Not included due to length of survey and complexity of incremental costs

14	Positive NEI experienced in participant buildings	The number of positive NEIs experienced as a result of the PH Offering	QT8

B.2 RECRUITING EMAIL

[Subject Line] Mass Save: Multifamily New Construction Study Opportunity

[**BODY**]

Dear XY,

We are reaching out to you about an opportunity to participate in a study on newly constructed multifamily buildings in Massachusetts supported by the Sponsors of Mass Save®. **We are offering a $50 incentive to participate in the study**, to be paid directly to you or your company.

What we are asking you to help with: Complete a web survey about your experience and perspectives on the multifamily new construction market in Massachusetts. The survey will take approximately 15-20 minutes to complete.

Why we are reaching out to you: You have been identified as someone with expertise in the multifamily new construction market. By sharing your knowledge of the marketplace, you will help the Sponsors of Mass Save better understand the market conditions in which their new construction program operates so that they can improve the program and better assess its impacts on statewide climate progress. The program is a key component of helping the building sector meet the state's ambitious climate goal of net-zero carbon emissions by 2050.

About the Study: NMR Group has been contracted by the Sponsors of Mass Save to conduct this study in support of the Mass Save PH Offering, geared towards newly constructed multifamily buildings in Massachusetts. Berkshire Gas, Cape Light Compact, Eversource, Eversource Gas of Massachusetts, Liberty Utilities, National Grid and Unitil work together as Mass Save to help residents and businesses across Massachusetts save money and energy, providing energy-efficiency programs and services while simultaneously leading the state to a clean and energy-efficient future.

All the information you provide will be treated as confidential, and your responses will be reported with no identifying information, grouped with the responses of your peers. If you have additional questions regarding the study, please contact:

B.3 SURVEY INSTRUMENT

B.3.1 Pop-Up Definitions

[PROGRAMMING NOTE: DISPLAY AFTER QS2 SURVEY QUALIFIER AND INTRODUCTION]

[NOTE FOR REVIEWERS: **These definitions will be made available as pop-up windows throughout the survey when any of the terms below appear**.]

Please click on the terms below to review their definitions. The questions will reference them frequently. You will also be able to see the definitions by hovering over or selecting the "Definitions" icon when the terms appear in a question. [PROGRAMMING NOTE:

EACH TIME ONE OF THESE TERMS APPEARS, SHOW PROGRAM DEFINITION AS POP-UP WHEN RESPONDENTS HOVER OVER THE TERM]

Zero Net Energy (ZNE) or Zero Energy Building (ZEB): Zero energy buildings combine energy efficiency and renewable energy generation to consume only as much energy as can be produced onsite through renewable resources over a specified time period. [2]

Passive House (or Passive Building): Passive buildings are a subset of high-performance buildings. Passive House comprises a set of design principles used to attain a quantifiable and rigorous level of energy efficiency within a specific quantifiable comfort level. "Optimize your gains and losses based on climate" summarizes the approach. A passive building is designed and built in accordance with these five building-science principles:

1. Employ continuous insulation throughout the entire envelope without any thermal bridging;
2. The building envelope is extremely airtight, preventing infiltration of outside air and loss of conditioned air;
3. Employ high-performance windows (double or triple-paned windows depending on climate and building type) and doors - solar gain is managed to exploit the sun's energy for heating purposes in the heating season and to minimize overheating during the cooling season;
4. Use some form of balanced heat- and moisture-recovery ventilation;
5. Use a minimal space conditioning system.[3]

Passive House Institute (PHI): PHI is an independent research institute and international building certification body that awards certifications to buildings that achieve their performance-based passive building specifications.[4]

Passive House Institute U.S. (PHIUS): PHIUS is a building certification body that awards certifications to buildings that achieve climate-specific, performance-based passive building standards.[5]

High-Performance Buildings: For the purpose of this survey, Mass Save defines high-performance buildings as having greatly reduced energy consumption per sq. ft. compared to other buildings. High-performance buildings may also include the following elements:

- Multiple highly efficient building systems
  - Building envelope that minimizes space conditioning load
  - High-efficiency HVAC equipment
  - Building management system
- A commissioning process to ensure all systems are set to operate at maximum efficiency
- Training of building operators to properly operate the energy saving equipment.

- **High-performance buildings may incorporate Passive House design characteristics or even achieve Passive House or ZNE certification.** LEED certification itself does not meet the criteria for high-performance. Likewise, high-performance buildings often utilize efficient heat pump technologies, but the presence of highly efficient mechanical equipment alone does not mean the building is high-performance.

Participating Project: Participating projects are defined in this survey as projects you've worked on that have received incentives from Mass Save through the Passive House Offering, which began in July of 2019. This offering includes multifamily buildings with five or more units. Projects that participate in other Mass Save-sponsored multifamily new construction programs, such as the low-rise and high-rise programs, are not considered participating projects for the purpose of this survey. Projects that do not engage with any Mass Save programs are also not considered participating projects.

Passive House Offering Requirements:

- Must be a multifamily building in Massachusetts with 5 or more units.
- Must be enrolled prior to 100% schematic design.
- Participants must pursue Passive House certification.
- Participants must agree to monitor and provide data on whole-building gas and electric consumption, and renewables if present.
- Participants must hire a Passive House consultant certified by PHIUS or PHI to conduct a feasibility study and serve as a consultant throughout the design and certification process.
- Pre-certification is required for post-construction incentives.

Multifamily Low-Rise Program: The multifamily low-rise program includes multifamily buildings that are three stories or fewer and are individually metered.

Multifamily High-Rise Program: The multifamily high-rise program includes newly constructed (or gut rehab >50%) multifamily buildings of four stories or more. In addition, buildings with a central HVAC that are under four stories qualify.

B.3.2 Screening and Introductory Questions

QS1. Did you work on multifamily new construction projects in Massachusetts **before July of 2019**? This includes newly constructed low-rise and high-rise residential apartment or condominium projects with more than five units.

a. Yes [CONTINUE] Great! You are eligible to take this survey and receive the $50 gift card after you complete it.

b. No [TERMINATE SURVEY] Unfortunately, you are not eligible for this survey. Thank you for your interest.

Here's some important information you need to know about the program before you get started. The **Mass Save® *Passive House offering*** *offers various technical and financial incentives including:*

- Training and technical assistance for multifamily new construction projects
- Financial incentives for feasibility assessments
- Financial incentives for early energy modeling
- Financial incentives for pre-certification from a Passive House certification body
- Financial incentives for achieving final certification from a Passive House certification body and/or for the project's achieved energy savings. [POP UP WINDOW WITH DESCRIPTION OF CERTIFICATION BODIES]

This survey focuses solely on newly constructed multifamily buildings in Massachusetts. Respondents need not have involvement with projects that participated in the Passive House offering to respond to the survey. This survey asks questions regarding the time frame between 2018 and June 2019, before the Passive House offering began. [POP UP WINDOW WITH DESCRIPTION OF PASSIVE HOUSE PROGRAM REQUIREMENTS]

QS2. Before you were asked to participate in this survey, had you heard of the Multifamily Passive House offering and the incentives available for pursuing projects that achieve Passive House levels of efficiency in multifamily new construction projects?

a. Yes. [IF YES] When did you first hear about the Passive House offering? ☐ between July 2019 and December 2019 ☐ 2020 ☐ 2021 ☐ I don't remember.

b. No.

QS3. [IF QS2=YES] Have you worked on a project that has participated in the Passive House Offering? This includes a project that conducted an initial feasibility test through the Passive House offering, but ultimately did not pursue Passive House.

a. Yes. [IF QS3=YES] When did you first participate in the Passive House offering? ☐ between July 2019 and December 2019 ☐ 2020 ☐ 2021 ☐ I don't remember.

b. No.

c. I don't know

QS4. [IF QS3=YES] Please indicate whether any of your Passive House project(s) received initial support from the offering but then dropped out?

a. No, all my project(s) completed the offering or are still actively engaged, with the expectation of meeting all the technical requirements of the Passive House offering.

b. Yes, the project(s) completed a feasibility assessment or initial energy modeling but ultimately did not continue in the Passive House offering.

c. Some projects are still enrolled, and some projects dropped out of the Passive House offering.

d. I don't know.

QS5. [IFQS4=B OR C] Why did your project(s) stop participating in the Passive House offering?

a. [OPEN-ENDED RESPONSE]

QS6. [IF QS3=YES] Using a scale from 0 to 10, with 0 being "Extremely unlikely" and 10 being "Extremely likely," how likely are you to recommend the Passive House offering? [DROP DOWN #0-10, DON'T KNOW = 98, REFUSED=99]

a. [IF QS <5] Why would you be unlikely to recommend the multifamily Passive House offering? [OPEN-ENDED RESPONSE]

QS7. What was your *primary* role on multifamily new construction projects **between January 2018 and June 2019**? (If you hold more than one role, please pick the role you filled most frequently.) [PROGRAMMING NOTE: Allow only one selection]

a. Developer

b. Owners project manager

c. Architect

d. MEP Engineer

e. Sustainability Consultant

f. Design/build contractor

g. HVAC contractor

h. HVAC manufacturer representative

i. Commissioning agent

j. Building operations staff

k. Other (please specify) [PROVIDE TEXT FIELD]

QS8. Approximately how many total multifamily new construction projects did you work on **between January 2018 and June 2019**? They did not have to start or finish during that time. Count any that were active in design or construction.

[PROVIDE NUMERICAL FIELD]

QS9. Please tell us about the size, in residential units, of the [FIELD REFERENCE TO QS8 RESPONSE HERE] multifamily projects you worked on **between January 2018 and June 2019**. Using your best guess of total units, indicate how many of these new construction projects fall into the following size categories. [REMIND RESPONDENT THAT SUM OF FIELDS MUST EQUAL QS8 RESPONSE, DISPLAY WARNING IF ≠ QS8 AND ASK THEM TO CORRECT]

a. Less than 25 units

b. 25 to 50 units

c. 51 to 75 units

d. 76 to 99 units

e. 100 to 199 units

f. 200 to 299 units

g. Over 300 units

QS10. About how many of the projects you worked on **between January 2018 and June 2019** were involved in each of the Mass Save multifamily new construction programs listed below? [Programming note: allow respondents to view Participating Projects definition]

[PROVIDE NUMERIC FIELD. REMIND RESPONDENT THAT SUM OF FIELDS MUST EQUAL QS8 RESPONSE, DISPLAY WARNING IF ≠ QS8 AND ASK THEM TO CORRECT]

a. Projects that participated in the Mass Save Residential High Rise Multifamily New Construction Program [PROGRAMMING NOTE: POP UP DEFINTION]

b. Projects that participated in the Mass Save Residential Low Rise Multifamily New Construction Program [PROGRAMMING NOTE: POP UP DEFINTION]

c. Projects that did not participate in a Mass Save New Construction Program

d. I don't know

QS11. About what percentage of the projects you worked on **between January 2018 and June 2019** were market rate or affordable housing projects? [PROGRAMMING PERCENT; 100% VALIDATION]

a. Affordable housing projects

b. Market rate projects (owner-operated)

c. Market rate projects (sold upon completion)

d. Don't know

B.3.3 Indicator Questions

Increased understanding and awareness of Passive House Certification, Practices, Challenges, and Benefits

QC1. Before you were asked to participate in this survey, had you heard of the terms Passive House or Passive Building? [PROVIDE DEFINITION POP-UP]

a. Yes

b. No [SKIP to QC10]

QC2. [IF QC1=YES] When did you first hear about the terms Passive House or Passive Building?

a. 2018 or before

b. Between January 2019 and June 2019

c. Between July 2019 and December 2019

d. 2020

e. 2021

f. I don't recall

QC3. [IF QC1=YES] How familiar are you with the certification process [POPUP DEFINTION AVAILABLE FOR PHI and PHIUS certifications]?

a. I am unaware of the Passive House certification process

b. I know the certification exists, but am unfamiliar with any specific requirements.

c. I have explored the requirements for certification but have not been through the certification process.

d. I have worked on a project that has started the certification process but have not completed pre-certification.

e. I have worked on a project that has completed pre-certification.

f. I have worked on a project that has been certified as Passive House.

g. I don't know.

QC4. [IF QC1=YES] Have you received any formal or informal training on Passive House design and/or construction principles?

a. Yes

b. No

QC5. [IF QC4=YES] When did you first receive training that covered Passive House design and/or construction principles?

a. 2018 or before

b. Between January 2019 and June 2019

c. Between July 2019 and December 2019

d. 2020

e. 2021

f. I don't recall

QC6. [IF QC4=YES] Please describe the training and any resulting certifications you received (example: I took a course to become a Certified Passive House Consultant through PHIUS or I watched a webinar that discussed Passive House principles).

a. [OPEN-ENDED RESPONSE].

QC7. [IF QC1 = "YES"] **Between January 2018 and June 2019**, how frequently were requests for passive buildings, passive design, passive house levels of efficiency, or related language included in RFPs?

a. Never
b. Less than 25%
c. 25-50%
d. 51-75%
e. Over 75%
f. Don't know

QC8. [IF QC1 = "YES"] To your knowledge, how many of the [FIELD REFERENCE OF QS8 RESPONSE HERE] projects you worked on **between January 2018 and June 2019** were Passive House certified or pre-certified?

[PROVIDE NUMERIC FIELD, NUMBER CANNOT BE LARGER THAN QS8 RESPONSE]

QC9. [IF QC1 = "YES"] Of the different parties involved in your multifamily new construction projects, who typically drives the decision to pursue Mass Save incentives through the Passive House Offering?

a. Project Team (e.g., architects, MEP engineers, design/build contractors)
b. Owner or developer
c. Sustainability consultant
d. Owner's project manager
e. Local code or Municipality requirements (Please specify) [PROVIDE TEXT FIELD]
f. Other (Please specify) [PROVIDE TEXT FIELD]
g. Don't know

QC10. Please rate on a scale from 1 to 5, with 1 being never have implemented on a project and 5 being always implemented on projects, how often did you implement the following practices on your projects **between January 2018 and June 2019**?

a. Extremely air-tight construction (Passive House air infiltration requirements of 0.6 ACH50, 0.05 CFM@50 Pa/building shell area, or 0.08 CFM@50 Pa/Building shell area)
b. Using minimized HVAC systems (e.g., not over-sized, ductless configuration, etc.)
c. Using balanced heat and moisture recovery ventilation.
d. Window placement that optimizes solar gains in the winter and minimizes in the summer.
e. Applying continuous insulation around the entire envelope
f. Eliminating or significantly reducing thermal bridging

QC11. What percentage of the [QS8 Quantity] projects you worked on **between January 2018 and June 2019** had air-infiltration tests conducted to verify the airtightness of the building?

a. Percentage:___ [RESPONSE 0-100%]

Increased Feasibility of Passive Design

QM1. Please consider the definition of *high-performance building* we provided earlier [PROVIDE DEFINITION IN POP-UP WINDOW]. Based on your experience, a newly constructed high-performance multifamily building uses what percent of the energy that a newly constructed code-compliant multifamily building of the same type uses? [PROGRAMMING: SLIDER BAR 0%-100%]

a. Percentage

QM2. Please indicate which of the following statements best describes executing a high-performance [POP-UP WINDOW] project **compared to executing a code-compliant project of the same type**.

a. **No more technical difficulty** to execute a high-performance project than a code-compliant project of the same type

b. **Only a little more technical difficulty** to execute a high-performance project than a code-compliant project of the same type

c. **Somewhat more technical difficulty** to execute a high-performance project than a code-compliant project of the same type

d. **A lot more technical difficulty** to execute a high-performance project than a code-compliant project of the same type

e. Don't know

QF1. On a scale of 1 to 4, where 1 is "Not important" and 4 is "Very important", how important is it for you to push your projects to attain the highest level of energy performance possible in ways that are within your control?

a. Not at all important

b. Somewhat important

c. Important

d. Very important

e. Don't know

QF2. Do you believe it has become easier **since July 2019** to design and construct a high-performance multifamily building, such as a Passive House building?

a. Yes

b. No

c. No change

d. Don't know

Increased Adoption of Passive Design and Building Practices by Participant Market Actors

QR1. We are interested in understanding the barriers to demand for high-performance multifamily buildings in Massachusetts as they existed **before July 2019**. Below is a list of barriers. For each one, please think back to your experience with multifamily projects **before July 2019.** Using a scale from 0 (Not a barrier) to 3 (A major barrier). Based on your experience, tell us how substantial a barrier each of the following was to the demand for high-performance multifamily buildings in Massachusetts **before July 2019**.

[ALL OPTIONS BELOW WILL USE THE FOLLOWING RESPONSE STRUCTURE]

☐ 0 Not a barrier before July 2019

☐ 1 A minor barrier before July 2019

☐ 2 A moderate barrier before July 2019

☐ 3 A major barrier before July 2019

☐ Don't know

a. Higher upfront costs per sq. ft. for high-performance projects than for code-compliant projects

b. Lack of architects and engineers with training to design high-performance projects

c. Owners, developers, and tenants not valuing the energy benefits of a high-performance building.

d. Owners, developers, and tenants not valuing the non-energy benefits of high-performance buildings. [INCLUDE POP-UP WINDOW: non-energy benefits may include: increased thermal comfort, noise reduction, improved indoor air quality, improved resiliency to climate events and power outages.]

e. Lack of design/build firms that can execute high-performance construction.

f. Lack of HVAC equipment installers that can install high-efficiency equipment.

g. Limited focus on building envelope insulation, air tightness, and thermal bridging.

h. Lack of project financing options that consider differences in upfront costs and asset values of high-performance versus code-compliant buildings.

i. Tight project timelines prevent consideration of high-performance design

j. Other (Please specify) [PROVIDE TEXT FIELD]

QR2. Thinking back to **before July 2019**. On a scale from 1 to 4, where 1 is "Not at all" and 4 is "A great deal," how much would you say **owners and developers** valued having their projects achieve high-performance standards before July 2019?

☐ 1. Not at all ☐ 2. A little ☐ 3.Somewhat ☐ 4. A great deal ☐ Don't know

QR3. Do certain types of owners or developers place more value on high-performance buildings than others?

☐ Yes: Please describe: [PROVIDE OPEN-ENDED TEXT FIELD]

☐ No

☐ Don't know

QR4. **Before July 2019**, did you find multifamily project owners and developers perceived marketing advantages to high-performance buildings that made these buildings more competitive in real estate and rental markets?

a. **Yes**
b. **No**
c. **Don't know**

QR5. [IF QR4=1] Did the building owners and developers who perceived marketing advantages share any similar traits, for example geographic, size of project, or affordable/market-rate project type?

a. Yes: Please describe these traits: [PROVIDE OPEN-ENDED TEXT FIELD]
b. No
c. Don't know

QR6. To your knowledge, about how many of the [FIELD REFERENCE OF QS8 RESPONSE HERE] projects you worked on **between January 2018 and June 2019** employed a building commissioning contractor from the design phase through the building operation and occupancy phases?

[PROVIDE NUMERIC FIELD NUMBER MUST BE LOWER OR EQUAL TO QS8]

[DISPLAY TEXT PRIOR TO NEXT QUESTIONS] The next two questions form a series. The first asks how often you ***try*** to implement certain design or construction practices in your projects. The second asks how often your projects ***actually*** implement these practices.

Page break

QR7. **Thinking of your most recent projects**, on a scale of 1 to 4 where 1 is "Never" and 4 is "Always," how often do you or your project teams **try to implement** the following

high-performance design or construction practices in your projects, regardless of whether they are actually implemented? ('Trying' in this case could mean including these practices in initial planning discussions, feasibility studies or early design iterations, getting cost estimates, etc.)

[FOR ALL QUESTIONS IN THIS SERIES, USE THE ANSWER CATEGORIES BELOW.]

☐ 1. Never ☐ 2. Sometimes ☐ 3. Often ☐ 4. Always ☐ Don't know

a. Extremely air-tight construction (Passive House air infiltration requirements of 0.6 ACH50, 0.05 CFM@50 Pa/building shell area, or 0.08 CFM@50 Pa/Building shell area)

b. Envelope insulation levels beyond compliance with code [PROGRAMING NOTE POP-UP: Example wall R-values from real-world Passive House projects:

- Smaller-scale multifamily project, 2-4 stories, 30 units: ~R32,
- Medium-size multifamily project, 5-11 stories, 100-200 units: ~R24
- Large-scale multifamily project, 14-26 stories, 150-300 units: ~R20]

c. Passive design principles for managing solar heat gain (high efficiency windows, shading, glazing orientation)

d. Smaller capacity high-efficiency HVAC equipment (not over-sized equipment) due to lower heating load required from improved building envelope

e. Balanced mechanical ventilation or heat recovery ventilation systems

f. On-site renewable energy generation

g. Integrated building control or building management systems (e.g., HVAC, lighting, security, fire systems)

h. Indoor air quality considerations (building material selection, air filtration systems)

i. Other "green' building design considerations like cool or green roofs, reflective exterior paint or siding, greywater or rainwater harvesting systems, etc.

QR8. **Thinking of your most recent projects**, on a scale of 1 to 5 where 1 is "Never" and 4 is "Always," how often do you or your project teams **actually implement** the following high-performance design and construction practices in your projects? (By 'actually implement,' we mean they are included in final designs or construction, depending on the status of the project.)

[FOR ALL QUESTIONS IN THIS SERIES, USE THE ANSWER CATEGORIES BELOW]

☐ 1. Never ☐ 2. Sometimes ☐ 3. Often ☐ 4. Always ☐ Don't know

a. Extremely air-tight construction (Passive House air infiltration requirements of 0.6 ACH50, 0.05 CFM@50 Pa/building shell area, or 0.08 CFM@50 Pa/Building shell area)

b. Envelope insulation levels beyond code-compliance [PROGRAMING NOTE POP-UP: Example wall R-values from real-world Passive House projects:

- Smaller-scale multifamily project, 2-4 stories, 30 units: ~ R-32,
- Medium-size multifamily project, 5-11 stories, 100-200 units: ~R24
- Large-scale multifamily project, 14-26 stories, 150-300 units: ~R20]

c. Passive design principles for managing solar heat gain (high efficiency windows, shading, glazing orientation)

d. Smaller capacity high-efficiency HVAC equipment (not over-sized equipment) due to lower heating load required from improved building envelope

e. Balanced mechanical ventilation or heat recovery ventilation systems

f. On-site renewable energy generation

g. Integrated building control or building management systems (e.g., HVAC, lighting, security, fire systems)

h. Indoor air quality considerations (building material selection, air filtration systems)

i. Other "green' building interventions like cool or green roofs, reflective exterior paint or siding, greywater or rainwater harvesting systems, etc.

Baseline and Transfer of Skills or Practices from Participating to non-Participating Projects

QT1. [IF QS3=YES] Do you recall instances where you've gained new knowledge or experience on a project that participated in the Passive House Offering that you then carried over to projects that **did not** participate in the Passive House Offering? This could include, for example, working with new HVAC equipment types, using building energy modeling, or using more advanced envelope construction methods.

a. Yes

b. No

c. Don't know

QT2. [IF QT1=YES] Please indicate which of the following practices you've adopted on other projects because of working on a project participating in the Passive House Offering? [PROGRAMMING: CHECK BOX, ALLOW FOR MULTIPLE RESPONSE, RANDOMIZE]

a. Incorporate high-efficiency heating systems (above code-compliant efficiency)

b. Incorporate high-efficiency water heating system (above code-compliant efficiency)
c. Continuous insulation around the thermal envelope
d. Advanced air sealing techniques, including maintaining a continuous air barrier
e. Building energy modeling to inform project design
f. Feasibility studies to inform project efficiency goals
g. Increased insulation levels in the building shell beyond code or baseline market practices (for example, greater than R-15 for a mass wall or R-19 for wooden frame)
h. Thermal bridge free details
i. Use of thermal break products
j. Air infiltration testing
k. Energy or heat recovery ventilation
l. High-efficiency windows (U-value less than 0.32)
m. Optimized window-to-wall ratios to maximize solar gains
n. Minimized HVAC equipment capacity due to shell improvements
o. Other (not limited to one): [OPEN-ENDED RESPONSE]___

QT3. [IF QS3=No or QT1=NO] Please indicate which of the following practices, if any, you typically incorporate into your projects? [PROGRAMMING:CHECK BOX, ALLOW FOR MULTIPLE RESPONSE, RANDOMIZE]

a. Incorporate high-efficiency heating system (above code-compliant efficiency)
b. Incorporate high-efficiency water heating system (above code-compliant efficiency)
c. Continuous insulation around the thermal envelope
d. Advanced air sealing techniques, including maintaining a continuous air barrier
e. Building energy modeling to inform project design
f. Feasibility studies to inform project efficiency goals
g. Increased insulation levels in the building shell beyond code or baseline market practices (for example, greater than R-15 for a mass wall or R-19 for wooden frame)
h. Thermal bridge free details
i. Use of thermal break products
j. Air infiltration testing
k. Energy or heat recovery ventilation

l. High-efficiency windows (U-value less than 0.38)

m. Optimized window-to-wall ratios to maximize solar gains

n. Minimized HVAC equipment capacity due to shell improvements

o. Other (not limited to one): [OPEN-ENDED RESPONSE]___

QT4. Thinking about the projects you worked on **between January 2018 and June 2019**, what percentage of heating and water heating equipment types and fuels were used with the following end-uses?

[MATRIX STYLE QUESTIONS, PROGRAMMING: 100% ANSWER VALIDATION BY EQUIPMENT TYPE]

	Natural Gas %	Electric Heat Pump %	Electric Resistance%	N/A
a. Centralized system heating equipment				
b. Individual-unit heating equipment				
c. Centralized system water heating equipment				
d. Individual-unit water heating equipment				

QT5. Thinking about the projects you worked on **between January 2018 and June 2019**, what percentage of cooking equipment types and fuels were used on the following end-uses?

	Natural Gas %	Electric Resistance %	Induction Stove tops (range only) %
a. Cooking ranges (sum to 100%)			
b. Cooking ovens (sum to 100%)			

QT6. **Between January 2018 and June 2019** what percent of your projects were fully electrified (space heating, water heating, and cooking)?

a. None

b. Less than 25%

c. 25-50%

d. 51-75%

e. Over 75%

f. Don't know

QT7. **Between January 2018 and June 2019** What is the most typical end-use that does not end up being electrified on your projects?

a. Space heating
b. Water heating
c. Cooking
d. Not applicable, projects are all electric
e. Not applicable, projects use gas for these systems
f. Don't know

QT8. **Now thinking of your most recent projects,** what percent of your projects were fully electrified (space heating, water heating, and cooking)?

a. None
b. Less than 25%
c. 25-50%
d. 51-75%
e. Over 75%
f. Don't know

QT9. **Now thinking of your most recent projects,** what is the most typical end-use that is not electrified on your projects?

a. Space heating
b. Water heating
c. Cooking
d. Not applicable, projects are all-electric
e. Not applicable, projects use gas for these systems
f. Don't know

QT10. **Currently,** how frequently do you see requests for passive buildings, passive design, passive house levels of efficiency, or related language included in RFPs?

a. Never
b. On less than 25% of RFPs
c. On 25-50% of RFPs
d. On 51-75% of RFPs
e. On over 75% of RFPs
f. Don't know

QT11. What are potential non-energy impacts associated with high-performance multifamily building? Please indicate whether each potential non-energy impact has a positive impact or a negative impact using the sliders. Use a scale of -3 to +3, where -3

indicates a significant adverse impact of high-performance buildings and +3 indicates a significant positive impact of high-performance buildings. 0 indicates that there is no impact. [PROGRAMMING NOTE: SLIDER BAR SET TO SCALE FOR EACH; POP-UP DEFINITION AVAILABLE FOR NON-ENERGY IMPACT]

a. Indoor Air Quality
b. Thermal Comfort
c. Resilience to extreme weather events (maintaining livable temperatures)
d. Noise Reduction
e. Potential increased lifespan of mechanical equipment (due to reduced runtimes)
f. Building durability (attention to moisture and condensation issues within building components)

QT12. [DISPLAY MESSAGE FOR RESPONDENTS] Thank you for taking this survey! We appreciate you taking the time out of your busy schedule to provide these responses. We have some additional questions on building mechanical equipment and fuel choices that we'd appreciate your feedback on if you have time. **Can you answer some additional questions?** These are less essential to our study than the previous questions but are still topics of great interest. It should take about five minutes to complete the optional section.

a. Yes, I can answer some additional questions [GO TO QI1]
b. No thanks, I'd like to close out the survey and collect my incentive now [COLLECT EMAIL BELOW]

[DISPLAY if QT9=B] Thank you for your time! Please provide your preferred email address here and we will send you a link to collect the $50 electronic gift card to a place of your choice.

Email address: _____

Optional Survey Questions:

The following questions are optional questions to include in the survey.

Miscellaneous Questions:

QI1. About how many of the multifamily new construction projects you worked on **between January 2018 and June 2019** include on-site renewable energy generation?

a. None
b. Less than 25%
c. 25-50%
d. 51-75%
e. Over 75%
f. Don't know

Increased proportion of New Buildings that are Low Energy (Energy Use Intensity, EUI)

QE1. Before you encountered this survey, had you heard of the term energy use intensity (EUI)?

a. Yes

b. No [Skip to END OF SURVEY]

QE2. Which of the following definitions best matches your understanding of what the **Site** EUI metric represents? [RANDOMIZE RESPONSE OPTIONS, 'None of the above' AND 'Don't know' OPTIONS ALWAYS LAST, IN THAT ORDER]

a. The total amount of raw fuel that is required to operate the building, including all transmission, delivery, and production losses, expressed as kBtu/sq. ft./year.

b. Average daily building energy use, including all electric and fossil fuel consumption.

c. A measurement of total energy use at the building level expressed in kBtu/sq. ft./year.

d. A metric assigning a building energy score on a scale where 100 is equivalent to a reference building of the same type built in the year 2000.

e. None of the above.

f. Don't know

QE3. Which of the following statements most accurately describes your practical experience with EUI as a metric for measuring building energy consumption?

a. I have not worked on a project where EUI values were discussed in the RFP, design, or construction phases

b. I rarely work on projects where EUI values are discussed in the RFP, design, or construction phases.

c. My projects frequently include discussion of building EUI in the RFP, design, or construction phases.

d. My projects are always planned, designed, or constructed with an EUI target or target range in mind.

QE4. [IF QE3≠ a] When did you first become aware of the term energy use intensity (EUI)?

a. 2018 or before

b. Between January 2019 and June 2019

c. Between July 2019 and December 2019

d. 2020

e. 2021

f. I do not remember.

QE5. [IF QE3 = C or D] How many of the [LINK QS8 RESPONSE HERE] projects you worked on **between January 2018 and June 2019** set an EUI target in the RFP or design process?

[PROVIDE NUMERIC FIELD, NUMBER CANNOT BE LARGER THAN QS8 RESPONSE]

QE6. [IF QE5>=1] What were the EUI Targets for the buildings you mentioned? [LOOP BACK ANY RESPONSE FROM QE3, PROVIDE TEXT FIELD and Don't Know Option]

a. Building A: EUI Target(s)___

b. Don't Know

c. Building B: EUI Target(s)___

d. Don't know

QE7. [IF QE5>=1] Were the buildings with EUI targets participating in the Passive House Offering?

a. Yes

b. No

c. No, but they participated in the Mass Save Low-Rise or High-Rise Multifamily New Construction Programs

d. Mix of participant and non-participant projects

QE8. [IF QE5>=1] Did you assess measured energy performance relative to the EUI targets in any projects? If so, how did they compare?

a. We did not compare actual energy performance to EUI targets

b. Actual performance was worse than our EUI targets

c. Actual performance was better than our EUI targets

d. Actual performance varied relative to our EUI targets

QE9. [IF QE8=B,C, OR D] What factors contributed to any differences between actual performance and EUI targets?

a. [OPEN-ENDED RESPONSE]

[END OF SURVEY] Thank you for your time! Please provide your preferred email address here and we will send you a link to collect an electronic gift card of your choice.

Email address: _____

Appendix C Market Actor In-Depth Interview Guide

In this appendix, we present an interview guide submitted to the PAs on January 27, 2021.

C.1 MA20X11-B-PHMEB: Passive House MEB Market Actor IDI Guide – Developers, Design/Build Contractors, Architects, HVAC Engineers

The table below displays a simplified version of the market effects indicator table that was included in the work plan, which is based on the indicators identified in the PH PTLM. The table includes only the indicators for which it is appropriate to gather information from the market actor in-depth interviews (IDIs). The questions in this guide are intended to provide context for the baseline market effects indicators that will be addressed in the web survey and to meet the additional research objectives included in the table.

Table 50: Market Effects Indicators and Research Objective Question Map

#	Outcome	Indicator of Outcome	Indicator Priority Level (Preliminary)	IDI Guide Question
Short-term (1 to 3 years)				
1	High program awareness and participation	Rates of program awareness	High	1, 3
		Rates of program penetration	High	1
2	Increased understanding and awareness of PH certification, practices, and benefits	Participant awareness of PH design principles	High	8, 13, 14
		Participant awareness of PH certification processes	Low	2
3	Increased adoption of passive design and building practices by participant market actors	Self-reported building/operation practices of participants	High	1, 2, 13
Mid-term (4 to 6 years)				

6	Increased demand for PH buildings in the multifamily market overall	Increased requests for passive designs in RFPs	Medium	9, 10, 14
		Increased mentions of PH accreditation in advertisements and real estate listings	Low	11
7	Increased number of PH-certified and skilled market actors	Self-reported levels of skill in PH practices (e.g., air-sealing, thermal bridge detail, etc.)	High	13
9	Passive design and construction practices carried over to non-participant projects	Reports of applying knowledge/skills for high-performance bldg./operation learned through program	High	3, 13
11	Increased proportion of new buildings that are low Energy Usage Intensity (EUI)	Proportion of buildings that are low EUI (or extremely efficient)	High	9
12	Increased feasibility of Passive Design	Market actor attitudes toward passive design feasibility	High	8
Other Research Objectives				
Identifying non-program projects and market actors				1, 3, 4, 1
Perceptions of high-performance buildings				7, 8
Feedback on market effects indicators				13, 14
Additional or alternative market effects indicators				15
Market actor cross-over				18

C.1.1 Recruitment Email Script

[Subject Line] Mass Save: Passive House Study Opportunity

Dear XY,

[**BODY**] We are reaching out to you regarding an opportunity to participate in a Mass Save® study supporting the Passive House Offering for newly constructed multifamily buildings. This program is designed to help meet the state's climate goals. **We are offering a $100 incentive to participate in the study**, to be paid directly to you or your company.

What you have to do to receive the incentive: Participate in an interview about your experience and perspectives on the multifamily new construction market in Massachusetts, passive buildings, and high-performance construction. The interview will last approximately 45 minutes to one hour.

Why we are reaching out to you: You have been identified as someone with expertise in the multifamily new construction market. By sharing your knowledge of the marketplace, you will help the Sponsors of Mass Save enhance their understanding of market conditions so that they can improve the program and better assess its impacts on statewide progress toward climate goals. We are targeting both passive house and non-passive house experts to gain a broad perspective.

About the Study: NMR Group has been contracted by the Sponsors of Mass Save to conduct this study in support of the Mass Save Residential New Construction Program. Berkshire Gas, Cape Light Compact, Eversource, Liberty Utilities, National Grid and Unitil work together as Mass Save to help residents and businesses across Massachusetts save money and energy, providing energy-efficiency programs and services while simultaneously leading the state to a clean and energy-efficient future.

All the information you provide will be treated as confidential and reported in aggregate. If you have additional questions regarding the study, please contact:

Contact	Organization	Phone	Email
Adam Wirtshafter	National Grid	(781) 907-5862	Adam.Wirtshafter@nationalgrid.com

C.1.2 Introduction

Name: _____ Title: _____

Company: _____ Telephone: _____

Email for Electronic Incentive: _____ Declined Incentive: _____

Interview date: _____ Time: _____

[**INTERVIEWER**] Thank you for your interest in this interview for Mass Save! This interview should last 45 minutes to an hour. Upon completion of this interview NMR will send a $100 incentive to you.

My firm, NMR Group has been contracted by the Massachusetts Program Administrators to interview industry professionals like you for a better understanding of the multifamily new construction market.

The Program Administrators began offering incentives for Passive House projects in July of 2019. These incentives are currently focused on multifamily projects. Passive House is a design and construction concept that achieves extremely low space conditioning loads by emphasizing design principles like a well-insulated building envelope with minimal air leakage, optimized window performance, optimized solar and internal gains, balanced heat and moisture recovery ventilation, and minimized HVAC systems. There are two certification bodies associated with Passive House. [IF NEEDED: The certification bodies are PHIUS and PHI.]

The primary goal of this study is to assess the multifamily market before the Passive House Offering began in July of 2019. This information will help the Program Administrators understand the impact of the Passive House Offering on the multifamily market in Massachusetts.

The Passive House Offering includes financial incentives at various stages of projects, including a feasibility study, energy modeling subsidies, Passive House pre-certification incentives, final certification incentives, and net-performance bonuses for participating projects. The program also offers training for market actors and subsidizes third-party training. In addition to the Passive House Offering, Mass Save offers additional multifamily new construction programs targeting high-rise and low-rise construction. During the interview I will refer to these additional programs specifically as the high-rise and low-rise programs. I will also talk about market actors or players throughout the interview—these are professionals involved in a project including: developers or owners, architects, builders or general contractors, and engineers. Please do not hesitate to ask me any questions if something is not clear.

I would like to record the interview for transcription purposes. Is that OK? *[IF NEEDED: We will use the recording for transcription purposes only, in order to make sure we accurately represent your responses. Only study team members will listen to the recording.]*

C.1.3 Multifamily Market Experience

First, we would like to know about your background in the multifamily new construction market.

1. What type of multifamily new construction projects do you and your company most commonly work on? [PROBE: differences between interviewee and company as a whole]
    a. What is your current role, and what are your day-to-day responsibilities?
    b. What are the typical building sizes you work on? [Probe: Sq. ft., units]

c. What are the typical building energy performance levels your projects achieve? [code, percentage above code, Passive House, zero net energy, etc.]

d. What is the most energy-efficient multifamily project that you have participated in? What were the important energy-efficiency features in this project?

e. [If 1.B is anything above code] What design and construction practices and what building systems do you typically use to achieve above-code levels of performance? [Probe on ECMs: heat pumps, insulation types, reduced thermal bridging, optimized solar gains, renewables, etc.]

f. What additional market segments do you operate in? (e.g., non-residential new construction, low-rise multifamily, housing authority, cooperative/condo, rental properties, etc.)

2. Are you familiar with high-performance building standards such as Passive House? Others?

a. [IF YES] Have you studied or been trained in any of these building practices? When? [Confirm type of training received]

b. [IF YES] Have you worked on any projects in Massachusetts that have pursued Passive House certifications or incorporated related design strategies? When?

3. How many newly constructed multifamily projects have you worked on in the last two years? What is the total number of units that resulted from these projects?

a. How many of these projects participated in the Passive House program?

b. How many of these projects participated in either the Mass Save high-rise or low-rise multifamily new construction programs?

c. [IF A and B = NOT ALL PROJECTS] Why did some (or all) of the projects *not* participate in a Mass Save program? [PROBE: Which Projects, Project Contacts for non-program sample]

d. [IF A and B = NOT ALL PROJECTS] For your projects that did *not* participate in the Passive House program, did you apply any Passive House design or construction methods to the project? What were they? [IF NO: probe other ***very high-efficiency*** design or construction methods used]

C.1.4 Awareness and Market Penetration of Program

4. [IF participated in Mass Save] In your experience on projects that participated in Mass Save, do core project team members always know when they are working on a project that is participating in a Mass Save program? [Core project team members

may include: developer/owner/OPM, architects, design/build contractors, HVAC engineer, sustainability consultant]

a. Who typically interacts with the program on projects? This may include the PA energy-efficiency consultant, training vendor, or other program partners.

5. [IF NOT participated in Mass Save] In your experience, are core project team members aware that there is a Mass Save program that could be used to support their project if it Passive House standards? What about other Mass Save programs?

a. How are project efficiency goals discussed with the project team?

6. [IF both participant and non-participant] Are there certain points in the project timeline that distinguish a program project from a non-program project in the eyes of the project team? This could include things like a design review process, specific inspections, or specific testing.

C.1.5 High-Performance Buildings and Certifications

High-performance buildings may be defined by certifications such as Passive House, Zero Net Energy, LEED, or ENERGY STAR, or by achieving a certain percentage of energy savings above code or a certain energy use intensity (or EUI) metric.

7. Can you identify a recent project that you did not work on that you consider a high-performance multifamily building?

a. What leads you to consider that project as high performance? [Probe: certifications, ECMs in the building, design strategies, NEIs]

b. How widely shared is this definition across market actors operating in the multifamily market segment? Why or why not? [PROBE: differences between market actor types, project teams, geographic locations]

8. The Passive House program was launched in July 2019. Thinking back to the multifamily new construction market before the program launched, how widely understood would you say Passive House design and construction principles were among project teams working in Massachusetts then?

a. And how widely understood would you say they are today?

9. Is energy use intensity, or EUI, a common metric used in the Massachusetts multifamily new construction market? [Probe: changes over the past two to three years, differences between high-rise and low-rise markets]

a. Are you aware of project RFPs that include EUI goals, or project teams that pursue specific EUI targets?

b. How common is it for EUI to be a project-defined goal?

10. Based on your experience, are owners and developers generally aware of Passive House certifications? [PROBE: other high-performance certifications]

    a. Is the level of awareness different in different market segments, such as developers of high-rise versus low-rise multifamily projects? How so?

    b. Based on your industry experience, how frequently are project RFPs requesting Passive House levels of performance?

    c. By how much has that increased, decreased, or stayed the same over the past two years? [Example quantification: 1 in 5 RFPs to 1 in 3 RFPs]

11. How much value do you think building owners and developers place on high-performance building projects and any resulting certifications? How has this changed in the past two years?

    a. How much value do you think renters and condo buyers place on high-performance buildings and any resulting certifications? How has this changed in the past two years?

12. Earlier you told me about the most energy-efficient multifamily project that you have participated in. Was that project marketed differently from other properties of similar size? How so?

    a. Did the project rent or sell its units slower, at similar rates, or faster than these other properties? [if not faster] Why?

    b. Did the properties rent or sell for lower, similar, or higher prices than other similar properties?

C.1.6 Baseline Indicators

In this final set of questions, we are looking for feedback to develop a web survey for professionals in your field. So, I'm looking at how comfortable you are assessing your own personal experience and knowledge and how that has changed over the past two years. I also want to see what types of questions can get a meaningful market-level viewpoint. By market-level viewpoint, I mean what types of questions could be asked to an individual about the multifamily market that can be answered by the individual with a certain degree of confidence.

13. [IF YES TO Q2] Here are some example baseline market progress indicator questions that we are testing for the web survey. Please answer the following:

    a. On a scale from 1 to 5, with one being completely unaware and five being very aware, how would you rate your awareness of Passive House design and construction principles prior to the program inception in July of 2019? [Probe: when they first heard of PH principles]

b. Were you incorporating Passive House design and construction principles into your projects before July 2019? Can you give any examples?

c. On a scale from 1 to 5, with one being inexperienced and five being highly experienced, how would you rate your experience level in executing Passive House design and construction principles on projects before July 2019? How does that compare to the present?

d. How confident are you in your answers to these questions, given that they were about situations that may have occurred two years ago?

14. On a scale from one to five, with one being not confident at all and five being very confident, please rate how confident you are that *most* individual market actors can provide market-level feedback on the following topics:

a. General industry awareness

b. Market awareness of Passive House design and construction principles

c. Market awareness prior to July of 2019

d. Increased adoption of passive design and building practices

e. Industry demand (among industry professionals) for high-performance multifamily building (i.e., Passive House, zero net energy)

f. Market demand (among owners, purchasers, and renters) for high-performance multifamily buildings (developer, owner, tenant)

g. Market actor skill levels relative to high performance construction

h. Impacts of zero-net energy stretch code

i. Do you think that certain market actor groups are better able to provide market-level feedback than others? (For example, architects compared to HVAC contractors.)

15. As I mentioned earlier, we are trying to understand how the Passive House Offering may be changing the multifamily market in Massachusetts. We have come up with some progress indicators to measure this over time but are looking for additional ideas. Can you think of any metrics or indicators that we should consider tracking to measure change in the multifamily market toward Passive House levels of efficiency? What about net-zero? [Note: if interviewee is not familiar with Passive House or Net-zero, apply their definition of high-performance construction here]

16. Recent legislation in Massachusetts may allow towns to adopt a net-zero stretch code. Do you anticipate Passive House design and construction practices will be leveraged by project teams to achieve net-zero performance? Why or why not?

[IF TIME PERMITS, ELSE SKIP TO END]

17. What sources of information would be useful to identify multifamily buildings currently in design or under construction?

    a. What sources can be used to identify market players that work on these non-program projects? [e.g., trade ally groups, company organizations, membership organizations, etc.]

18. In your experience, how common is it for market actors to work in more than one market segment, such as C&I, multifamily high-rise or low-rise, single-family? [IF NEEDED: Compared to operating in only one market segment.]

    a. What percent of market actors would you say cross over between multifamily high-rise and commercial (non-residential) projects?

    c. Are there certain types of market actors or market actor firms that are more likely to cross over than others?

[CONCLUDE INTERVIEW]

19. We are thinking of reviewing the wording of our web survey with a few experts like yourself before we send it out. Would you be interested in completing the web survey instrument with us when it is ready? [IF NEEDED: We can offer an additional $50 incentive for this.]

    a. [IF YES] Great, we are a couple months away from developing the survey instrument. We will reach out to you once we have developed the survey.

Thank you again for participating in this interview. We appreciate your feedback on our questions, the insights from these interviews will help refine the upcoming web survey. [Ensure that address is collected for $100 incentive check]

Appendix D Indicator Memo

In this appendix, we present a memo that was submitted to the PAs on May 4, 2021. The team made updates to the memo which include: (1) updates to the market effects outcome scheme from numbers to letters to align with this report and (2) streamline repeated tables and sections from this memo that are included in the main body of the report. (The indicators measured in this study covered in Section 1.3.1.)

D.1 Background for Reviewers

This memorandum summarizes the evaluation team's plan for measuring baselines for each market effects indicator in the Passive House Market Effects Baseline (MA20X11-B-PHMEB) study. It also presents insights from in-depth interviews (IDIs) with program staff, implementation staff, and market actors, and from preliminary reviews of program tracking data and secondary data sources that inform the operationalization of the baseline measurements.

Below we present a summary of conclusions and key considerations from the IDIs and initial exploration of program tracking data.

Key considerations for the program staff and the web survey are ordered as they relate to outcomes defined in Table 2 in Section 1.3.1 in the main body of the report. Appendix D.3 provides additional details about the considerations for program staff and Appendix D.4 provides more results and insights related to the web survey.

Key Considerations from Program and Implementation Staff IDIs:

- **Outcome F:** The program staff indicated they have been involved with the development and crafting of request for proposal (RFP) language for a limited pool of multifamily projects. The program may consider expanding program efforts to influence RFP language and document the use of EUI targets and PH-related requirements in RFPs to enhance the impacts of the program.
- **Outcome L:** The incremental cost to build to PH levels of efficiency is considered one of the primary barriers to market adoption. The program staff confirmed that the program will collect cost data, but collection methods and which costs are not yet developed. The PAs, implementation, and evaluation could work together to develop a consistent cost data collection form for program participants that balances the needs of the program, implementation, evaluation, and marketing.
- **Outcome L:** Implementation staff noted that program participants often struggle to get construction loan financing to account for the increased costs of high-performance construction. An appraisal that accounts for energy-efficiency and sustainability features may help secure loans that accommodate the incremental costs of constructing a high-performance building. The program may consider a programmatic intervention to encourage the development of a "green appraiser" market within the appraiser industry.
- **Outcome M:** There is no plan or anticipated effort to track carbon emissions beyond what is currently executed by the program, which involves providing

information on avoided carbon emissions based on the energy savings achieved. It is unclear to the evaluation team whether recently passed legislation in Massachusetts will cause the program to reconsider its carbon tracking plans. The evaluation team expects to revisit this outcome in a future study.

- **Outcome O:** Implementation staff noted that a potential barrier to adoption of PH in low-rise multifamily projects was that program delivery relies on HERS raters, which often engage with the project too late in the project lifecycle for developers to realistically consider participating. Program and implementation staff could develop marketing materials and increase outreach efforts to broaden awareness of the PH Offering to the low-rise multifamily market.

- **Outcome O:** The program has not considered expanding offerings that achieve PH levels of efficiency in the renovation market. The PAs, implementation, and evaluation staff could work together to target the remaining market segments that could support programmatic offerings for achieving PH levels of efficiency.

- **Outcome P:** The program will support the Department of Energy Resource's (DOER) efforts to investigate and propose a PH and ZNE stretch code by providing to the DOER technical and economic data that the program gathers from participants. The PAs could document any increased effort or advocacy related to supporting the adoption of an updated stretch code.

- **Outcome S:** The PH Offering may lead to developers applying newer technologies and energy conservation measures (ECMs) for which the program does not currently claim savings. The PAs, implementation, and evaluation could work together to develop a list of measures and potential ECMs that are not considered in the current UDRH, and prioritize which, if any, should be included in a future iteration of the UDRH for the PH Offering.

KEY CONSIDERATIONS FOR THE WEB SURVEY:

- The web survey will ask respondents who indicate they have worked on both participant and non-participant projects to answer specific questions about their experience with program projects and specific questions about their experience outside of the program.

- The survey will define high-performance construction as a building that achieves low energy consumption.

- The evaluation team will investigate sources suggested by market actors to identify multifamily projects, project teams, or companies operating beyond the purview of the Mass Save program.

- The evaluation team will work with the non-residential new construction (NRNC) Market Effects Baseline (MA20X12-B-NRNCMEB) study team to align the sample development efforts and communicate which market actors cross over between markets.

D.2 Market Effects Indicator Measurements

Please refer to Table 2 in Section 1.3.1 of the main body of the report for details on the market effects indicators measured in this study, by evaluation activity.

D.3 Program Staff and Implementation Staff Interview Findings

The evaluation team conducted IDIs with program staff and implementation staff. The evaluation team used the interviews to ensure we had the most recent information about the following topics:

- Programmatic changes
- Status of relevant market effects indicators
- General program insights and trends (reserved for draft report)
- Additional information to inform the web survey and the program and secondary data analysis research tasks (not reported in this memo)

The results and findings relevant to operationalizing market effects indicators are combined from both interviews and presented below. All other insights will be summarized in the final report.

D.3.1 Programmatic Changes

The PH Offering has changed in two ways since its inception in July 2019. (1) In January 2020, the offering expanded from only including MFHR projects to including all multifamily buildings with five or more units. (2) The energy modeling incentive component of the offering of $500 per unit was capped at $20,000 per building. This change was to encourage a cost-sharing model between the program and the project participant. The program and implementation staff did not anticipate any additional changes in the near term.

D.3.2 Status of Longer-Term Market Effects Indicators

As part of the interviews, the evaluation team asked the program and implementation staff about some of the mid- and longer-term market effects indicators that are mostly not yet slated for measurement. The interviews provided insight on whether current program planning activity and discussions could lead to impacts on selected mid- and long-term outcomes and, if relevant, how the indicators for those outcomes are being tracked. The findings are summarized below and include suggestions on what efforts to track and document to ensure evidence for market transformational activities can be attributed to the program in the future.

These interviews did not reveal any additional market effects indicators outside of what is currently outlined in the PTLM.

Interview findings are presented below by outcome, as outlined in Table 2 in the main body of the report. The subsections are ordered based on the outcome number.

D.3.2.1 Outcome F: Increased demand for PH buildings in the multifamily market overall

Consider documenting efforts, tracking use by projects, and expanding PA efforts to influence RFP language as an indicator for Outcome 6. The PAs indicated that they had been involved in the development and crafting of RFP language for a limited pool of multifamily projects. This has allowed the PAs to have some influence over projects before the design teams are involved. The goal is to create RFPs that make developers and design teams more likely to be selected based on their ability to achieve PH levels of efficiency. The RFPs included EUI targets and goals that would make the pursuit of PH-level projects more likely. This effort began in 2019 but has only impacted a small number of projects to date.

PA staff could document and expand program efforts to influence RFP language, and track use of EUI targets and PH-related requirements in RFPs. In addition, the PAs could track the number of projects and market actors directly impacted by this effort. Maintaining a database of impacted projects and market actors would allow for potential follow-up interviews or surveys. The PAs should consider expanding this effort to intervene earlier in the project lifecycle. The evaluation team estimates the effort to execute the tracking and documentation for RFP development is low; however, efforts required to expand the effort will be greater and will likely include additional outreach through developer lunch-and-learn meetings, implementation account manager contacts, and marketing this as a program service.

D.3.2.2 Outcome L: Increased feasibility of passive design

In the Passive House Assessment,[2] the incremental costs to build to PH levels of efficiency was cited as one of the primary barriers to adopting PH levels of efficiency in the multifamily market. The PA and implementation staff confirmed that cost data will be collected upon completion of a project in the PH Offering to assess incremental costs and provide marketing materials to future participants. Implementation staff indicated the current plan is to request cost data at the energy conservation measure (ECM) level, since some projects are market rate, and some projects are affordable housing projects. (Cost data at the project level would include costs unrelated to program components that impact energy usage. For example, the impact of interior finishes on total project cost may differ substantially between affordable housing and market-rate projects.) Acquiring costs at the ECM level instead of the total project level will help disaggregate where potential incremental costs exist for specific measures. In addition, collecting cost data at the ECM level will help the program, implementation, and evaluation teams understand how incremental costs change throughout the program.

The PAs, implementation, and evaluation could work together to develop a consistent cost data collection form for program participants that balances the needs of the program, implementation, evaluation, and marketing. This should require a modest level of effort to execute.

Interviewees identified one potential programmatic intervention, regarding the development of a "green appraiser" market. Implementation staff noted program participants often struggle to get construction loan financing to account for the increased costs to achieve high-performance construction. They indicated an appraisal that accounts for the energy-efficiency and the sustainability features of a project would help secure construction loans that value the increased costs associated with building to a higher performance standard.

The PAs and implementation staff could expand efforts to make "green-certified" appraisers available in the market to help the construction financing of projects pursuing PH levels of efficiency. The program already targets real estate agents as a part of the workforce development component. The program should track efforts to target appraisers if appraisers in the multifamily market are considered and ultimately targeted as a part of workforce development. The evaluation team estimates the level of effort needed to make green appraisers available in the market will likely be high. However, the program may be able to leverage existing third-party training and certification programs to focus program efforts on marketing rather than on developing training sessions.

D.3.2.3 Outcome M: Emissions reductions

There is no plan or anticipated effort to track carbon emissions beyond what is currently executed by the program, which involves providing information on avoided carbon emissions based on the energy savings achieved. There are no current plans to account for carbon emission reductions related to embodied carbon in materials or societal benefits to reducing carbon from the atmosphere.

The evaluation team plans to revisit this outcome with PA staff in a future study.

D.3.2.4 Outcome O: Development of additional PH Offerings

The PAs indicated that there will likely be a programmatic expansion to incentivize one-to-four-unit homes that achieve near PH levels of efficiency. However, this offering will likely not have any certification requirements; rather, it will likely be based on prescriptive requirements like those developed by the Passive House Institute U.S. (PHIUS) for one- and two-unit buildings. At the time of the interview, the PAs were still developing the program details, but planned to include an offering for one-to-four-unit homes that achieve PH levels of efficiency in the upcoming three-year plan.

The PAs have expanded their presence in the NRNC market through the NRNC programs' Path 1 incentive structure, which includes PH levels of efficiency. This is not a technical requirement for participation. This program pathway was added to the NRNC program in July 2020.

Implementation staff noted that a potential barrier to adoption for low-rise multifamily projects was that HERS raters engage with the project too late in the project lifecycle for project developers to realistically consider PH. The current program delivery for the low-rise new construction program, which includes single-family homes and multifamily buildings three stories or less that have individually metered HVAC systems, is primarily through HERS raters. In addition, low-rise developers and builders do not work directly with implementation account managers; however, account managers are a common practice in the Multifamily High Rise (MFHR) market segment. This allows for the program to engage much earlier in the project timeline for MFHR projects, while low-rise projects do not have that built in early engagement. Interviewees also cited smaller-scale and less-frequent projects as hurdles to increasing adoption in the low-rise multifamily market segment. At the time of the interview, there was only one participant in the PH Offering that classified as a low-rise multifamily project.

The program has not considered expanding offerings to achieve PH levels of efficiency in the renovation market. Program staff were unaware of PH pathways for renovations, such as the EnerPhit path from the PHI. This is a standard for achieving quality energy retrofits with PH components. However, this may be something for the PAs to explore as they look to expand deep-energy savings opportunities into the largely untapped residential renovations market.

The PAs, implementation, and evaluation staff could work together to identify into which of the remaining market segments it may be possible to expand programmatic offerings to achieve PH levels of efficiency. This might include looking at measure-specific aspects associated with PH construction (i.e., PH certified windows, ventilation systems). The evaluation team sees this is a working group activity that would likely require a moderate level of effort.

The PAs and implementation staff could develop marketing materials and increase outreach efforts to broaden awareness of the PH Offering to the low-rise multifamily market. This might include training HERS raters on how to communicate the value of the PH Offering to market actors on their current projects to encourage future adoption.

D.3.2.5 Outcome P: Advances in building codes and regulations

Currently, the program will support the Department of Energy Resources (DOER) efforts to investigate and propose a PH and ZNE stretch code by providing technical data and economic data that the program gathers from participants on whether building to PH levels of efficiency is feasible. Note that due to the long project timelines associated with designing and constructing multifamily buildings, the initial participants of the PH Offering have yet to achieve PH levels of efficiency on completed projects.

The PAs could document any increased effort or advocacy related to supporting the adoption of an updated stretch code that requires ZNE or PH levels of efficiency. This could include contributions to code updates, code advocacy, and presentations that support increased stretch code adoption. In addition, the PAs could document any data or evidence the program provides to support DOER efforts for the adoption of an increased stretch code. The level of effort to track and document this is low; however, the level of effort could increase if the PAs change their stance to be more involved in the process to adopt a ZNE or similar building energy code.

D.3.2.6 Outcome S: Savings from non-regulated loads and non-traditional measures

The PAs, implementation staff, and evaluation staff could work together to develop a list of measures and potential ECMs that are not considered in the current UDRH and prioritize which, if any, should be included in a future iteration of the UDRH for the PH Offering. The evaluation team sees this as a working group activity and estimates that the level of effort will be medium-to-high.

The PH Offering may lead to application of newer technologies and ECMs for which the program does not currently claim savings. The PA and implementation staff anticipate these projects will employ newer or more nascent technology for heating, cooling, and water heating, such as electric central domestic water heating systems. Due to limited information about nascent

technologies, such as using a centralized heat pump for water heating, evaluating their baselines may be challenging. Interviewees discussed an example ECM of appliances. There is a wide range of energy consumption among ENERGY STAR® appliances, but no way to distinguish the difference with the current UDRH (as savings from appliances are not currently claimed). To achieve PH levels of efficiency, project teams will likely need to consider top-tier appliance products, and the program may have an opportunity to find some savings even with an ENERGY STAR appliance baseline.

The general sentiment from the PA and implementation interviews was that the PH Offering may generate unevaluated ECMs. One interviewee's interpretation was that standard energy modeling provides a standard lens to understand which measures have been historically important for calculating energy savings. The PH lens is now zoomed in. This focused view on the design and construction of projects that aim to achieve PH levels of efficiency can be incorporated into energy modeling software that considers the intricate interactions of the building's energy consumption, potentially identifying energy savings that previously could not be measured.

D.4 Market Actor In-depth Interview Findings

The team completed seven IDIs with market actors. The market actor demographic consisted primarily of developers and sustainability consultants that were participants in either the PH Offering or the MFHR program. Two of the seven interviewees had not participated in the PH Offering, and one had completed the feasibility assessment but the project team did not move forward with PH.[3] The interviewees had a high-level understanding of the multifamily market as the developers' experience with their projects and project teams provided a broader understanding of project teams and roles within a project, while the sustainability consultants' exposure to multiple projects provided them with experience from a variety of project teams. However, the interviewees had not worked on projects that did not participate in either the PH Offering or MFHR program within the past two years.

The interviews aimed to achieve four goals:

- Aid in the development of the web survey.
- Determine the extent to which market actors can discuss market-level topics.
- Provide input on market effects indicators.
- Identify sources for recent projects not in the purview of the program.

Note that the evaluation team will conduct the remaining three IDIs to test the web survey for clarity and effectiveness among market actors. The evaluation team will report the general findings and insights from the IDIs in the draft report.

Note: these icons indicate an evaluation team action that will be incorporated in the web survey.

D.4.1 Market Actor Crossover into Commercial Markets

Market actors engaged in the commercial market may cross over to multifamily markets depending on the type of projects they undertake. Market actors that work on larger projects in urban centers are more likely to work in both commercial and multifamily markets. Interviewees noted that a subset of multifamily developers that operate as merchant builders and only pursue multifamily projects of between 100 and 400 units, which may include a small retail component. Interviewees also noted that this subset of developers are not likely to cross over into the commercial market. Market actors that work on smaller multifamily projects are more likely to cross over into the single-family market rather than the commercial market.

The evaluation team will work with the Non-Residential New Construction Market Effects Baseline (MA20X12-B-NRNCMEB) study team to align the sample development efforts and communicate which market actors cross-over between markets. In addition, the web survey will include a screening question to determine whether the market actor or their firm works in both the NRNC and the multifamily space. The team will add a question to encourage participants that cross-over between market segments to participate in the NRNC market effects web survey

D.4.2 Non-program Sample Development

The Interviewees provided some insights to help build out the non-program sample:

- Inquire about project information from HERs raters.
- Use data sources to identify projects in the pipeline. Those may include Costar, Curbed, and Build Up.
- Request information from multifamily sale brokers.
- Review federal construction cost-tracking documents.
- Review state funding agencies' data.
- Inquire about project information with pre-development lenders.

The evaluation team will review the suggested sources to assess how they could be used to identify projects, project teams, or companies that are operating beyond the purview of the Mass Save programs.

D.4.3 Web Survey Development

Interviewees suggested that core project team members, such as developers, architects, sustainability consultants, and general contractors, are likely aware that they participated in a Mass Save project. However, that awareness may decrease the further the team member is removed from the core project team. For instance, engineers, HVAC sub-contractors, and other

trades are less likely to know which, if any, of their projects are participants in a Mass Save program. The interviewees suggested information about the project participating in the program may not always be communicated to the entire project team. The evaluation team will build a screening process into the web survey to determine the market actor type and participant type. The web survey respondents will be cross-checked with the program participant sample and the non-participant sample to ensure they are identified in the appropriate sample.

Overall, the interviewees indicated most individuals could determine when they learned of concepts such as PH and could answer questions that require them to draw upon experiences from more than two years prior. The evaluation team asked market actors to assess their personal experience and knowledge of PH prior to program inception (July 2019). The interviewees noted that if market actors worked on both non-program and program projects, they would likely be able to distinguish between those projects to answer questions in the web survey.

The evaluation team will ask web survey respondents that indicate they have worked on participant and non-participant projects to answer specific questions about their experience with program projects and specific questions about their experience outside of the program.

Interviewees were confident that market actors would be able to provide market-level feedback, depending on their hierarchical position in design firms and their individual roles on projects. Interviewees indicated that, in general, most market actors would have at least some awareness of the multifamily new construction market and survey respondents would likely have insights into and be comfortable answering questions about the broader multifamily market. The web survey will include questions about the role of the respondent as well as questions about the broader multifamily market.

Market actors commonly associated the term "high-performance building" with the building energy performance, whether the building is a carbon-sink, and the operating costs of the building rather than other aspects of the building such as material selection, non-energy benefits, and other sustainability features. The energy performance should be verified by actual energy usage values, but in absence of verified building energy consumption some certifications can provide insights on whether the project is high-performance. Three of the interviewees suggested that net-zero, net-positive, and buildings that act as carbon sinks are high-performance These interviewees also suggested that metered energy use was an important aspect of a high-performance building. Five of the interviewees, including those that had not participated in the PH Offering, noted that they associate PH certification with high-performance buildings, but that not every certification is created equal. These five interviewees noted that certifications such as LEED, which may have broader market awareness among market actors than PH, have less stringent energy-efficiency requirements than PH. Therefore, these interviewees only considered certifications, such as PH, to indicate a high-performance building.

In the web survey, the evaluation team will define high-performance construction as a building that achieves extremely low energy consumption.

EUI metrics are not commonly part of multifamily new construction project goals or RFPs. All interviewees indicated that EUI metrics and goals are not common, and two interviewees were not aware of the term. Most interviewees indicated that some designers may be aware of EUI terminology, but most project teams are not using EUI as an energy metric in their projects, likely because of lack of awareness. This may be due to limited information on what EUI targets are considered standard or high-performance in the multifamily market. Two interviewees suggested that incorporating EUI goals, as opposed to more vague terms like energy-efficient building, directly into the RFP would raise awareness in the industry. The evaluation team will provide definitions for terms like EUI in the web survey to ensure a consistent definition among respondents.

The evaluation team notes that incorporating EUI goals into RFPs will help broaden awareness of EUI metrics throughout the market. Using an EUI metric may be one avenue to move the program away from a certification standard.

D.4.4 Market Effects Indicator Insights

The evaluation team asked interviewees to suggest market effects indicators that could offer evidence that the program contributed to transformation of the new construction multifamily market to PH levels of efficiency. The evaluation team did not provide the interviewees with a list of indicators currently included in the PH PTLM but did offer some examples if requested. This allowed the interviewee to help the evaluation team assess the appropriateness of indicators included in the PTLM and provide information that could lead to possible additional market effects indicators.

The IDIs did not identify additional market effects to consider for inclusion in the PTLM. However, four of the interviewees did emphasize certain indicators already identified in the PTLM and provided insights on measurement strategies.

It is important to track the skill levels of both design and construction market actors, especially contractors and subcontractors, but to do so separately. All the interviewees who suggested tracking indicators identified ones already included in the PTLM, such as the number of PH-certified buildings, number of trained market actors, and market actor awareness and skill levels. The impression of some of the interviewees was that designers may be more aware and have more exposure to PH principles than the construction side of the project team. They noted that this could lead to higher construction quotes, making it more expensive to pursue a PH project.

The evaluation team will include questions about market actor skill level in the web survey. The skill level of market actors involved with construction could be assessed by counting program participants that go from pre-certification to certification. This would only be one approach to identify the skill level of market actors as participants may not pursue final certification.

The interviewees suggested expanding upon tracking which incentive level a program participant achieved. The interviewees suggested tracking how many of the initial program participants that do not make it to the pre-certification incentive pursue a PH project next. The implementation team is currently tracking the level of incentive the participant project achieves, which will allow for this type of cross check. This would require an additional effort to review the participation history for new PH Offering participants or to assess historic program participation data against new project enrollments, likely on an annual basis.

Some market actors suggested tracking how many of the projects that complete an initial feasibility assessment, but do not continue participating in the PH Offering, incorporate one or more of the PH principles into their projects. Implementation could administer follow-up surveys with participants who drop out of the PH Offering to understand why they dropped out and whether they are incorporating any PH principles into the project that dropped out. The results from this type of survey could improve program processes and provide data for future market effects studies.