MEMORANDUM

To: Massachusetts Program Administrators and Energy Efficiency Advisory Council Consultants

From: Matt Woundy, Lisa Wilson-Wright, and Zack Tyler, NMR Group; Ben Crosby, DNV

Date: November 1, 2022

Re: Recommended 2023 NTGRs for Fuel Switching Heat Pumps in Non-residential New Construction

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This memo is an interim deliverable for the ongoing Non-residential New Construction & Fuel Switching Net-to-Gross Study (MA22X02-B-NRNCHPNTG). In this memo the evaluation team recommends net-to-gross (NTG) ratios for fuel switching occurring in 2023.

Section 1 Background

The Department of Public Utilities approved the Massachusetts Joint Statewide Electric and Gas Three-Year Energy Efficiency Plan for 2022 – 2024 with explicit electrification goals designed to increase heat pump installations in participating NRNC projects. "Attachment D" of the October 25, 2021, Term Sheet for this plan calls for a study to determine NTG ratios for fuel switching savings that "account for those customers who would have installed a heat pump on their own, without program influence."[1] The Term Sheet additionally set a timeline for the study, noting that "the parties agree to use a negotiated value for 2022 and conduct a study during that year to arrive at a researched NTG value or values for the remainder of the Plan term."[2] The term sheet also stated that the Massachusetts Program Administrators (PAs) would use a natural gas baseline where service was present (within 100 feet of the property line) and a propane baseline where it was not and "that evaluation will not overturn the fuel type of a baseline in the future."[3]

Aggressive stretch codes and municipal mandates push the building sector in Massachusetts towards energy-efficient and low-carbon construction and equipment. The Non-Residential New Construction Program (NRNC) client base includes municipalities, universities, and technology firms that favor marketable, advanced buildings signifying a commitment to being green or fighting

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[1] *Term Sheet: Massachusetts Joint Statewide Electric and Gas Three-Year Energy Efficiency Plan for 2022-2024 – Delivering Savings and Transition Toward Climate and Equity Imperatives.* Page 28 of the PDF (Attachment D pages are not numbered). Available at https://ma-eeac.org/wp-content/uploads/2022-2024-Term-Sheet-10.26.21-Final-with-Exhibits.pdf.
[2] *Ibid.*
[3] *Ibid.*

climate change. Together, these factors suggest that at least some NRNC participants who adopted heat pump technologies for space heating would have done so without program intervention.

One of the study objectives was to estimate 2023 net-to-gross ratios (NTG) for fuel switched heat pumps installed through all pathways of the NRNC program.[4]

The Massachusetts Program Administrators (PAs) and the Energy Efficiency Advisory Council (EEAC) Consultants tasked NMR and subcontractor DNV with conducting research to achieve this and other objectives in the Non-residential New Construction & Fuel Switching NTG Study. Section 2 and Section 3 of this memo describe the study methodology and the fuel switching NTG results in more detail. In summary, we conducted in-depth interviews (IDIs) with 28 program participants or their design teams. Due to the need to provide a researched NTG value in 2022, coupled with the lengthy timelines for NRNC projects, NMR necessarily included projects that enrolled in the program before October 2021, when the fuel switching initiative was approved, and already included heat pumps. Since the PAs plan to claim fuel-switching savings for 13 of the 28 projects NMR interviewed, NMR limited the estimation of NTG to these 13 projects. Due to the timing of the interviews, none of the projects included in this analysis had yet received a fuel-switching incentive at the time of the interview[5]. (As Table 1 shows, the PAs adopted a fuel-switching incentive structure in April 2022 and revised them in July 2022.) The PAs plan to pay fuel switching incentives to 11 of the 13 projects as they progress through the program.

Table 1: NRNC Fuel Switch Incentives per Ton

Heat Pump Technology	April 2022 Incentives	July 2022 Incentives
Air Source	$300	$800
Ground Source	$600	$4,500
Variable Refrigerant Flow	$400	$1,200

The IDIs relied on a series of questions based on the existing commercial and industrial (C&I) self-report NTG methodology, with appropriate changes for the unique nature of fuel switching.[6] NMR applied the interview responses to a calculation algorithm to yield a NTG ratio.

The study estimated a NTG ratio of 7% (confidence interval of 1.5% to 12.4%) across all program pathways for projects that enrolled in the program prior to rolling out incentives in April 2022 but for which the PAs will claim fuel switching savings.

This low NTG ratio reflects that every respondent from projects for which the PAs will claim fuel switching savings stated that the project would have installed a heat pump in the same configuration and covering the same proportion of heating load without program incentives.

[4] This memo addresses only this objective. The broader MA22X02-B-NRNCHPNTG has additional objectives to address NTG and related topics for Paths 1 and 2 of the NRNC program.
[5] By necessity, the NMR team conducted the interviews in July and August 2022.
[6] For example, see Tetra Tech, DNV, and NMR. 2021. *C&I Prescriptive and Custom Net-to-Gross Omnibus Study (MA20X07-B-CIOMNINTG)*. Available at https://ma-eeac.org/wp-content/uploads/MA20X07-B-CIOMNINTG_CI-PrescrCustom-NTG-Report_Final_2021.09.13.pdf.

However, some respondents exhibited partial freeridership, explaining that program assistance helped to solidify decisions and secure stakeholder buy-in for the project. The PAs are claiming savings for 13 projects because their savings were or will be booked after the October 2021 approval of the 2022 – 2024 plan, the PAs had discussed fuel switching with the project, or the PAs plan to pay fuel-switching incentives as the projects progress.

The NMR team identified three types of challenges when conducting this study that may continue to affect future efforts to measure NTG for NRNC fuel switching heat pumps.

First, respondents found it nearly impossible to separate the decision to fuel switch from the decision to install high-efficiency heat pump technology, and for Path 1 and 2 projects, the decision to pursue low or reduced energy use intensity scores (EUIs). These decisions are closely related and interdependent, as pursuing heat pumps is one of the primary ways in which projects achieve EUI targets. In fact, the current program design may encourage fuel switching freeridership in Paths 1 and 2. Path 1 and 2 respondents also found it difficult to separate overall program assistance from assistance limited to fuel switching as they focus on the full package of incentives and TA assistance rather than incentives or assistance for specific measures. This may not be true of Path 3 and 4 projects, which have later engagement and lack EUI requirements.

Second, respondents found it difficult to assign a portion of heating load to specific fuel types even in cases where natural gas, diesel, or propane served as secondary or shared heating fuels. Respondents also had a difficult time thinking about the area served by the heat pump versus other fuels. This suggests the need to rethink how to measure program impacts on the planned heating load provided by heat pumps when using self-report data.

Third, the high incidence of municipalities among program participants may also inadvertently drive down NTG ratios. Many municipalities in Massachusetts have mandates or strategies in place that prioritize low-carbon designs for commercial new construction, causing them to be routinely classified as partial or full free riders. Yet, municipalities also face strong pressure to justify costly projects, be it through securing funds to offset the costs to taxpayers or by providing engineering analysis to support the soundness of the project design.

These and other factors discussed in the sections below lead the NMR team to offer the following recommendations and considerations. We expand on these in Section 4.

Recommendation 1: The PAs should claim a NTG ratio of 7% for 2023 (and beyond, if participation closing dates extend that far) for projects that enrolled in the program prior to dedicated fuel switching incentives being instituted (April 2022).

Recommendation 2: The PAs should claim a NTG ratio of 69% for 2023 for projects enrolled after the program instituted dedicated fuel switching incentives (April 2022) and until a new evaluated NTG ratio(s) is available. The 69% is consistent with the negotiated value fuel switching NTG ratio for 2022.

Recommendation 3: The PAs should update the NTG ratio for fuel switching as soon as an adequate number of projects enroll that will claim the fuel-switching incentive.[7] NMR offers two high-level project designs to consider for fulfilling this recommendation.

> **Study Design Option 1: Repeat the current study using a comparable instrument and algorithm when an adequate number of projects enroll that will claim the fuel-switching incentive.[8]**
>
> **Study Design Option 2: Fold the fuel switching NTG into the forthcoming modeled partial net approach planned for a later stage of this study, again when the program achieves enrollment of an adequate pre-determined number of projects with fuel-switching incentives.**

Consideration 1: The PAs should create a comprehensive tracking dataset and expand the participation database to include more detail about program participation. At a minimum, this should include project participation pathway, size, building type, enrollment date, and anticipated or distributed incentives.

Consideration 2: The PAs should examine whether it is appropriate to develop a separate – and perhaps deemed – NTG ratio for municipal buildings, for which several factors – including the use of program incentives to build support for high-performance designs and the presence of electrification goals and mandates – complicate the process of calculating NTG using traditional methods.

Consideration 3: Similar to Consideration 2, the PAs should explore whether it is appropriate to develop separate NTG ratios for buildings with different characteristics, such as building type, size, or program pathway.

Section 2 Methodology

The NMR team relied on IDIs with project customer representatives and design teams to measure NTG. We identified projects by reviewing individual project files (including applications, memoranda of understanding [MOU], technical assistance [TA] studies, minimum requirement documents, and equipment submittals) provided by the PAs.[9] We also pulled relevant project (e.g., building type, area, fuel types), measure (e.g., type of heat pump, capacity), and contact information from the project files. The sample frame includes projects active since the launch of the new program design in August 2020. As a result, the sample largely comprised participants who engaged with the program before the 2022 – 2024 plan cycle and the advent of the fuel switching initiative. None of the projects had received fuel switching incentives at the time of the IDIs (though the PAs plan to pay incentives to 11 of them), as the PAs rolled out these incentives in April 2022. While less than desirable, the NMR team had to rely on this sample to fulfill the obligations set forth in the term sheet and provide a researched NTG ratio by September 2022.

[7] The PAs, EEAC consultants and evaluators mentioned that 50 studies may be adequate, but the final number will be decided during future study planning.
[8] "Comparable" could mean the same instrument or one with a similar logic but revised to reflect such things as overall program influence and the complex decision-making process on NRNC projects.
[9] The Work Plan for this study also included a literature review of fuel switch heat pump NTG ratios. However, the literature review found zero completed studies that addressed this topic.

The original sample plan for this project accounted for program pathway, building type, and building area. We wanted to capture both customer and design team representatives from the same project. However, while reaching customer and design team representatives always presents challenges, fielding this study over the summer vacation months made the task even harder. Ultimately, only one contact was interviewed per site in almost all cases. The NMR team first attempted to contact all individuals associated with Path 3 and 4 projects before expanding the sample to include Path 1 and 2 projects.[10] NMR and DNV staff members conducted the interviews. Evaluation staff made multiple attempts to contact potential respondents via phone and email and set an interview time convenient to the respondent and the assigned interviewer. We offered respondents a $150 incentive to take part in the interview.

Between July 6 and August 26, 2022, the NMR team completed 28 interviews. When we conducted the interviews, the PAs had not provided evaluators with information on which projects they would or would not claim fuel switching savings. NMR requested and the PAs provided this information in September 2022. The PAs and EEAC consultants agreed to limit the NTG estimate to the 13 projects for which the PAs will claim fuel switch savings, either because the PAs discussed fuel switching with the project or the project is expected to receive these incentives as they progress through the program.

As shown in Figure 1, 11 of the 13 projects included in the NTG analysis were either municipal or K-12 school projects (most of which are also municipal buildings). The remaining two projects were an office and a university building.

Figure 1: Number of Projects by Building Type

(Source: Program Files)

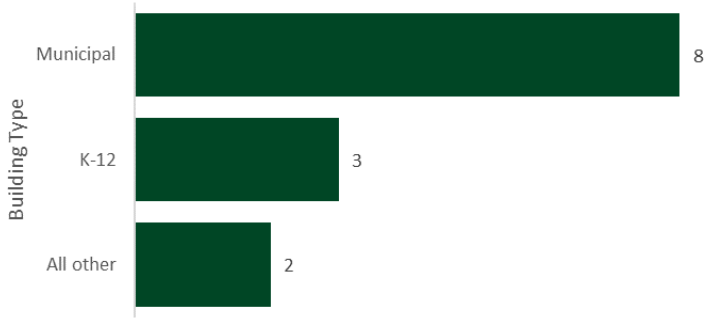


Table 2 lists the types of projects, their square footage, and the program pathway. Six of the projects were enrolled in Path 1, four in Path 3, two in Path 4, and one in Path 2. The smallest project was 19,900 square feet and the largest was 423,000. The median project size is 29,537 square feet, and the mean project size is 88,844 square feet.

[10] The initial evaluation plan involved waiting to interview Path 1 and 2 participants until the evaluation team was ready to field the separate Path 1 and 2 NTG questionnaire, which comprised the other phase of the study. To ensure sufficient sample to generate fuel switch NTG interview completes by the reporting deadline, the team began interviewing Path 1 and 2 projects for the fuel switch NTG earlier than planned and attempted to set follow-up calls to discuss the Path 1 and 2 NTG questionnaire.

Table 2: Building Type and Size by Program Path

(Source: Program Files)

Type	Size	Path
K-12	423,000	1
K-12	174,759	1
K-12	113,000	1
Municipal	30,000	1
Municipal	27,730	1
Municipal	26,000	1
Office	176,900	2
University	66,000	3
Municipal	29,537	3
Municipal	20,156	3
Municipal	19,900	3
Municipal	24,239	4
Municipal	23,745	4

Section 3 NTG Algorithm and Results

The NMR team developed an interview guide with questions to assess program influence over the decision for each project to use heat pumps over fossil fuels, adjust the portion of heating load designed for heat pumps, or use heat pumps over fossil fuels in new buildings that are not or will not be enrolled in a PA program. The first two topics were designed to capture freeridership and the third spillover.

This section describes the algorithm development. Appendix A and Appendix B include the interview guide and the final algorithm, respectively.

3.1 NTG Questions and Algorithm Development

The NMR team developed the NRNC Fuel Switch Heat Pump NTG questions and algorithm based on existing C&I self-reported NTG protocols. However, we had to make some substantial adjustments from the C&I protocol due to the nature of the fuel switch measure:[11]

- The C&I protocol focuses on retrofit for individual measures rather than whole-building or measure-specific new construction. The C&I protocol has been used to estimate NTG ratios for new construction in the past, but more recent studies (e.g., the Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study [TXC 49] [12] and C&I Prescriptive and Custom Net-to-Gross Omnibus Study [MA20X07-B-

[11] The NMR team is also striving to keep the fuel switching NTG questions consistent with the Pathway 1 and 2 protocols, which are still under development. Future Pathway 1 and 2 respondents will receive both the fuel switch and broader NTG question batteries.

[12] NMR, DNV, and Tetra Tech. 2018. Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study (TXC 49). https://ma-eeac.org/wp-content/uploads/TXC_49_CI-FR-SO-Report_14Aug2018.pdf.

CIOMNINTG][13]) have separated the two. The separation reflects differences in the decision-making process (who makes decisions and when) and, after the NRNC redesign, the whole-building focus of three of the four program pathways.

- The fuel switch incentive is meant to prevent customers from adopting fossil fuels. However, to do this, the customer selects heat pump technologies that receive equipment incentives. The NMR team developed language asking the respondent to consider the fuel switch separately from the equipment, as the latter will be addressed in the broader NRNC NTG study. The C&I protocol does not have a parallel line of questioning.
- The C&I protocol determines program influence on timing, quantity, and efficiency. Only quantity – the portion of heating load met by heat pumps – matters for fuel switching. The timing usually cannot be later, and efficiency relates to the heat pump equipment rather than the fuel switch. For quantity, we asked respondents about changes to heating fuel loads due to program influence.

After finalizing the questionnaire (which also includes background and contextual questions), NMR developed a calculation algorithm. Appendix B lists the full algorithm, but as an overview, the algorithm has the following components:

- Determination of whether the customer or design team (or other party) was the most influential in the decision to use heat pumps to displace fossil fuels for heat.
- Respondent self-report of whether the project would have used heat pumps to displace fossil fuels without program intervention.
- Respondent self-report of program-induced changes in planned or actual heat pump heating loads.
- Follow-up to identify degree of influence from incentives or TA assistance on decision to use heat pumps and/or adjust the heat pump heating load.
- Assessment of fuel switching spillover to other, non-program projects.
- Consistency checks to address contradictory responses.

The algorithm creates two FR components: one focused on the decision to use heat pumps to displace fossil fuels (FS FR) and the other focused on the portion of heating load from heat pumps (Load FR). We then averaged these two scores to produce the overall freeridership value. Each respondent received a single spillover score, limited to projects that used heat pumps to displace fossil fuels and that were not enrolled or do not plan to enroll in the program.

3.2 NTG Estimation

After completing the IDIs, the NMR team entered responses into an Excel spreadsheet and merged them with other critical information about the project (e.g., building type, pathway, square

[13] Tetra Tech, DNV, and NMR. 2021. *C&I Prescriptive and Custom Net-to-Gross Omnibus Study (MA20X07-B-CIOMNINTG)*. Available at https://ma-eeac.org/wp-content/uploads/MA20X07-B-CIOMNINTG_CI-PrescrCustom-NTG-Report_Final_2021.09.13.pdf.

footage). We then conducted quality control on the spreadsheet to identify potential data entry errors or unclear responses and corrected any problems based on interview notes and recordings. None of the 13 projects included in this assessment exhibited spillover, but we document the concept in the discussion below to inform future study replication.

The NMR team then applied the algorithm to the responses. We first calculated FR, SO, and NTG scores for every respondent and estimated the overall unweighted NTG ratio. The unweighted NTG ratio used the following equation:

$$Unweighted\ NTG\ Ratio = \frac{\sum(1 - FR + SO)_i}{n}$$

The unweighted estimate, however, treats all projects equally regardless of their size. Yet, projects ranged from 19,900 to 423,000 square feet. Therefore, the NMR team next developed project weights equal to their portion of the total square footage associated with the 13 projects in the analysis. The equation is as follows:

$$Weight_i = \frac{square\ footage_i}{\sum square\ footage}$$

NMR multiplied each unweighted NTG ratio by the project weight and then summed them across all projects to yield the weighted NTG ratio:

$$Weighted\ NTG\ Ratio = \sum(1 - FR + SO)_i\ x\ Weight_i$$

Table 3 summarizes the FR, SO, and NTG results. We also present the weighted FR and SO, calculated the same way as the weighted NTG ratio. The confidence intervals around the NTG ratios account for the use of weights and small sample size.

Table 3: Net-to-Gross Estimates

NTG Component	Unweighted Estimate	Weighted Estimate
FR	89%	93%
SO	0.0%	0.0%
NTG	11%	7%
Confidence Interval	5.4% to 17.9%	1.5% to 12.4%

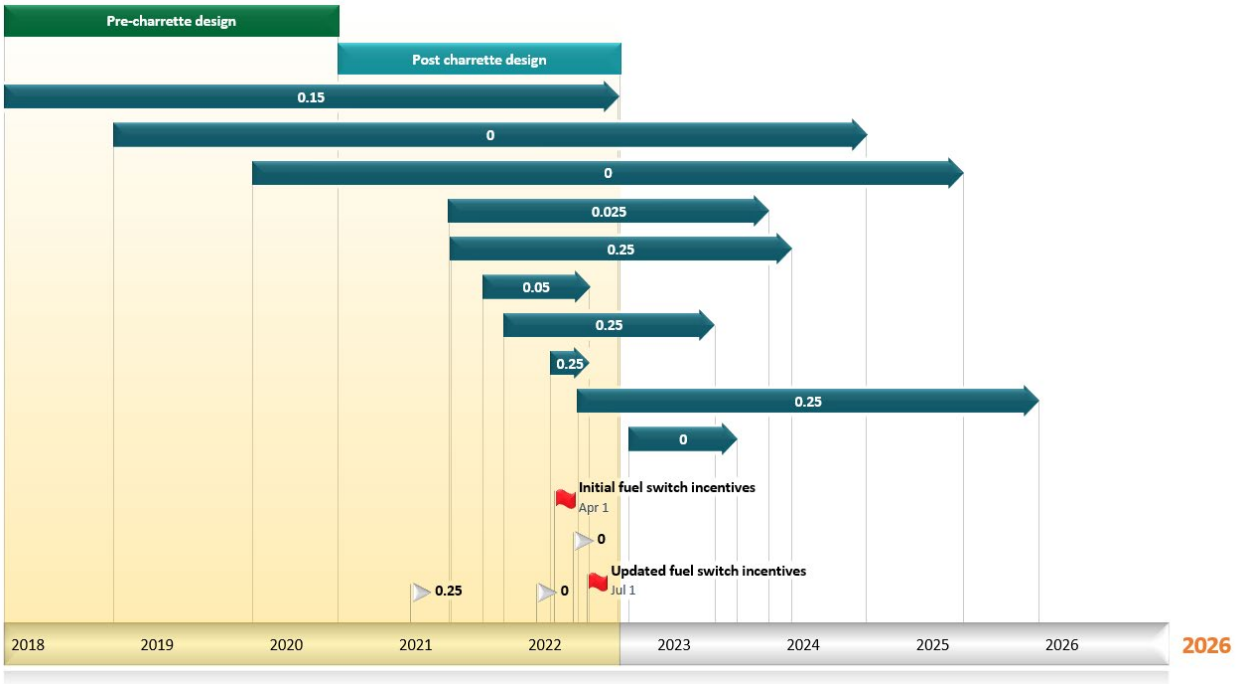
To help contextualize the NTG results, the NMR team worked with PA implementation staff to identify the timeline for each of the 13 projects included in the NTG analysis. The takeaway from Figure 2 is that the self-reported NTG ratios do not vary substantially based on when projects were initiated or their status. The three projects initiated before the August 2020 program redesign have NTG ratios of zero to 0.15, while those initiated after that date range from zero to 0.25. The paragraph below describes the content of the figure.

In Figure 2, the green and teal bars at the top of the figure indicate when the NRNC program moved from pre-charette to post-charette design incentives (August 2020). Red flags at the bottom of the figure indicate when the PAs initially instituted fuel switching incentives (April 2022) and revised them upwards (July 2022). The dark blue bars (ten projects) and the gray flags (three projects) represent the 13 projects included in the analysis. The project bars start when the MOU

was signed and end at the current expected completion and/or incentive payment date. The gray flags indicate when the MOU was signed, as these projects do not yet have an expected completion date. Their initiation dates range from 2018 through mid-2022 and completion dates from early 2022 through late 2025. The numbers within the bar or next to the gray flags are the projects' unweighted NTG ratios (i.e., not adjusted for relative square footage).

We discuss the possible reasons for these low NTG ratios in Section 4.

Figure 2: Project Timelines and NTG Ratios[1]



[1] Some of the dates are approximate.

3.3 Responses to Other Questions

NMR has not yet completed a full analysis of the contextual questions asked during the IDIs. However, we did produce counts for two of topics relevant to interpreting NTG ratios, as summarized below:

- **Reduction and Sustainability Mandates, Targets, and Goals**: Twelve of the 13 respondents told us that the projects were subject to some sort of municipal mandates or guidelines to pursue zero-net energy (ZNE) or low-carbon construction. Respondents were not always clear whether the town's desire for ZNE was strictly mandated or highly encouraged, but they made clear that ZNE targets and the input of sustainability committees were critical factors in their project designs. For several municipal buildings, respondents indicated that entities offering grant funding also had preferences for sustainable designs that impacted decision making.

- **Access to Natural Gas**: Twelve of the 13 respondents told us that gas was available at the project site (and two projects included natural gas measures), although running the lines was not always practical.

NMR will provide more detail on these and other contextual questions in the overall report to the broader NRNC NTG study.

Section 4 Recommendations and Considerations

The study results suggests that the NTG ratio for the 13 projects for which the PAs will claim fuel-switching savings was 7%. Every respondent claimed that the project would have installed a heat pump in the same configuration and covering the same proportion of heating load without program incentives. The NTG exceeds zero because some participants exhibited partial FR, explaining that program assistance helped to solidify decisions and secure stakeholder buy-in for the project.

This low NTG ratio should be understood within the current program and market context. The projects included in this study were well into project planning before fuel switch incentives became available. Seven of the 13 projects initiated contact with the PAs prior to the October 2021 approval of the 2022 – 2024 plan that introduced the fuel switching initiative. What remains unclear is whether these projects represent those that will enter the pipeline now that the PAs have active fuel switching incentives in place. The answer to this question must be answered at a later date when more projects that plan to access fuel-switching incentives have entered the program.

The NMR team identified a number of challenges when conducting this study that may continue to affect future efforts to measure NTG for NRNC fuel switching heat pumps.

First, respondents found it nearly impossible to separate the decision to fuel switch from the decision to install high-efficiency heat pump technology, and for Path 1 and 2 projects, the decision to pursue low or reduced EUIs. These decisions are closely related and interdependent. For example, while not required, projects functionally cannot meet Path 1 EUI targets without primarily relying on heat pumps for space heating. Therefore, projects that approach the PAs with the intention of pursuing Path 1 almost certainly will exhibit fuel switching freeridership. Likewise, opting for heat pumps offers an obvious method for reducing EUI per Path 2 requirements. These observations suggest that NTG ratios may vary by pathway and that the current program design may encourage fuel switching freeridership in Paths 1 and 2. Similarly, Path 1 and 2 respondents found it difficult to separate overall program assistance from assistance limited to fuel switching. Participants likely focus on the full package of incentives and TA assistance and not on the incentives or assistance for specific measures.

Second, respondents found it difficult to assign a portion of heating load to specific fuel types even in cases where natural gas, diesel, or propane served as secondary or shared heating fuels. Respondents also had a difficult time thinking about the area served by the heat pump versus other fuels. This suggests the need to rethink how to measure program impacts on the planned heating load provided by heat pumps when using self-report data.

Third, the high incidence of municipalities among program participants may also inadvertently drive down NTG ratios. Many municipalities in Massachusetts have mandates or strategies in place that prioritize low-carbon designs for commercial new construction, causing them to be

routinely classified as partial or full free riders. Yet, the municipalities in this study explained that they also attempt to take advantage of as many grant and incentive opportunities as possible to reduce taxpayer burden and build support for efficient designs when approval is required. Additionally, technical assistance helps to assuage the concerns of stakeholders skeptical of the effectiveness of heat pump technologies. In short, municipalities represent a unique participant group with decision-making processes and priorities that set them apart from the private companies and non-profit organizations that also take part in the program.

Given the results of this study, the challenges faced in estimating fuel-switching NTG ratios, and the timing of this study relative to the introduction of fuel-switching incentives, the NMR team offers the following recommendations and considerations.

Recommendation 1: The PAs should claim a NTG ratio of 7% for 2023 (and beyond, if participation closing dates extend that far) for projects that enrolled in the program prior to dedicated fuel switching incentives being instituted (April 2022).

The projects included in this study were well into the planning process by the time the PAs instituted the fuel-switching initiative or began offering incentives for fuel switching. Given the long planning times for most new construction projects, the same situation will likely apply to other projects that enrolled in the program prior to the introduction of incentives and will close (i.e., final incentives will be paid, and savings will be booked) in 2023.

Recommendation 2: The PAs should claim a NTG ratio of 69% for 2023 for projects enrolled after the program instituted dedicated fuel switching incentives (April 2022) and until a new evaluated NTG ratio(s) is available.

The PAs began to offer fuel switching incentives in April 2022. The introduction of fuel-switching incentives may lead to a greater program impact on the decision to adopt fuel-switching heat pumps, reducing freeridership as a result. Given the recent roll-out of these incentives and the timing of this study, no studies that received incentives could be included in this study's sample. Lacking a researched value to apply to projects that will receive the incentives, NMR recommends applying a NTG ratio of 69% to projects enrolled after the introduction of incentives. This NTG ratio is consistent with the negotiated value fuel switching NTG ratio for 2022.

Recommendation 3: The PAs should update the NTG ratio for fuel switching as soon an adequate number of projects enroll that will claim the fuel-switching incentive. NMR offers two high-level project designs to consider for fulfilling this recommendation.

The projects included in this study engaged the program before the advent of the fuel-switching initiative and incentives. Their experiences may not accurately reflect how the program will influence fuel switching now that the PAs are actively promoting fuel switching and have begun offering incentives for the practice. The negotiated NTG ratio of 69% may or may not reflect the actual program influence on fuel switching. The PAs, EEAC consultants and evaluators mentioned that 50 studies may be adequate, but the final number will be decided during future study planning.

Study Design Option1: Repeat the current study using a comparable instrument and algorithm when an adequate number of projects enroll that will claim the fuel-switching incentive.

Using the same instrument would allow for direct comparisons between the current study and the future one to see if the program's efforts to encourage fuel switching leads to different conclusions using the same methodology and data collection protocols. However, this approach would still likely face similar challenges surrounding the difficulty in separating fuel switching from other program decisions and assistance, thinking about program influence on heating load or reflecting the complex decision-making process on NRNC projects. Revising questions to capture these broader influences may better reflect project decision making but could limit comparisons between studies.

Study Design Option 2: Fold the fuel switching NTG into the forthcoming modeled partial net approach planned for a later stage of this study, again when the program achieves enrollment of an adequate pre-determined number of projects with fuel-switching incentives.

This study design recognizes the interconnectedness of project decisions and the difficulty in parsing out the decision to fuel switch from the decision to pursue a low EUI or otherwise decrease project energy usage (and thus increase program incentives). The modeled partial net approach is designed to drill down on measure-level decision-making and determine if system types or efficiencies would have changed in the absence of program assistance. This approach may be a more effective way to determine how fuel switching incentives are influencing projects.

Consideration 1: The PAs should create a comprehensive tracking dataset and expand the participation database to include more detail about program participation. At a minimum this should include project participation pathway, size, building type, enrollment date, and anticipated or distributed incentives.

This consideration builds on similar ones made in at least three recent NRNC studies: the Massachusetts NRNC Market Characterization Study (MA19C08-B-NRNCMKT), the Non-Residential New Construction Net-to-Gross Report (MA20X09-B-NRNCNTG), and the Non-Residential New Construction Baseline Study of Market Effects Report (MA20X12-B-NRNCMEB).[14] These studies, completed in 2021 and 2022, drew attention to the lack of a centralized tracking database and detailed information needed to conduct program evaluations. **The current study further stresses the importance of tracking pathway, size, building type, enrollment date, and anticipated or distributed incentives.** The

[14] DNV 2021. *Massachusetts NRNC Market Characterization Study: MA19C08-B-NRNCMKT.* https://ma-eeac.org/wp-content/uploads/MA19C08-B-NRNCMKT-NRNC-Market-Characterization-Study-Final-Report.pdf.

NMR, DNV, Cadmus. 2021. *Non-Residential New Construction Net-to-Gross Report (MA20X09-B-NRNCNTG).* https://ma-eeac.org/wp-content/uploads/MA20X09-B-NRNCNTG-Non-Res-NC-NTG_Final_2021.10.12.pdf.

NMR, DNV. 2022. *Non-Residential New Construction Net-to-Gross Report (MA20X09-B-NRNCNTG).* https://ma-eeac.org/wp-content/uploads/MA20X12-B-NRNCMEB_NRNC-Mkt-Effects-Indicators-Baseline_FINAL-2.28.22.pdf.

lack of this information created inefficiencies in sampling, analysis, and reporting. We present the considerations below so that all four exist together in a single location.

MA19C08-B-NRNCMKT: Consider expanding the PA program participation database to include more detailed information about program participation. The PA program participation database provides limited details on the specific measures incentivized by the programs. Additional detail on participation could help improve our classification of program participation and enable more detailed comparisons of participants and non-participants beyond lighting measures. This may be a substantial undertaking as it would require explicit recording of each measure identified in a TA study and subsequent tracking of its installation status.

MA20X09-B-NRNCNTG: Create a more comprehensive program tracking dataset. Throughout this study, the lack of centralized, comprehensive datasets detailing participating projects slowed the project workflow and caused the team to adjust our analytical approach. Given the complexity of the NRNC market and the data demands of NTG measurement, a more complete program tracking dataset would help avoid methodological constraints and support more robust evaluations in the future. With Paths 1 and 2 using EUI as a basis for savings, projects can remain as single-line tracking entries. However, the addition of the proposed EUI, the base case EUI, the building type, and building square footage to tracking databases would facilitate research tasks in multiple ways. For Path 3 and 4 projects with a measure- or system-level focus, data on the measure type and efficiency would be useful additions. **The team suggests all sites have building type, building square footage, and Program pathway in the tracking data to facilitate granular analyses by building type and to support measurements of program penetration on a square footage basis.** All these data are available in project files already housed by the PAs, just decentralized in applications, calculators, and engineering studies (Emphasis in the original).

MA20X12-B-NRNCMEB: Centralize data on participating project square footage to facilitate accurate tracking of program penetration over time. Square footage for program participants was not available in the program tracking data provided to the evaluation team. Without accessible square footage data, it is not possible to calculate program penetration accurately. (Condensed from the original)

Add participating market actor contact information from the project files to the program tracking data. Project files stored by the PAs (e.g., TA studies, applications, invoices, and equipment cut sheets) typically contain contact information for key market actors involved in various stages of the project. If the program were to extract this information from the project files and add the contacts to the program tracking data, this would yield additional data to assess the proportion of the market the program reaches. [Collecting contact information] would [also] allow the evaluation team to compare survey respondent groups and their companies to a roster of known program participants and assign a participation status to this group. This would improve the accuracy of comparisons of response data between survey respondent groups important to measuring and tracking the program's effects on the market. (Condensed from the original)

Consideration 2: The PAs should examine whether it is appropriate to develop a separate – and perhaps deemed – NTG ratio for municipal buildings, for which several factors—including the use of program incentives to build support for high-performance designs and the presence of electrification goals and mandates—complicate the process of calculating NTG using traditional methods.

Many projects in the sample were municipal buildings. As noted above, municipal projects often adopt ZNE or low-carbon designs to abide by city mandates or adhere to strategic plans. Yet, they also face pressures to reduce taxpayer burden by taking advantage of all grants and incentives available to them and to ease the concerns of skeptical stakeholders. These situations set them apart from many other NRNC program participants seeking to build all- or mostly electric energy-efficient buildings. This leads NMR to suggest that the PAs and EEAC consultants consider a negotiated NTG for municipalities that acknowledges their high likelihood to fuel switch with or without program incentives while recognizing the advantages their participation secures for all taxpayers and ratepayers.

Consideration 3: Similar to Consideration 2, the PAs should explore whether it is appropriate to develop separate NTG ratios for buildings with different characteristics, such as building type, size, or program pathway.

The final study sample size was too small to draw conclusions about NTG ratios by pathway. Above we raise the issue of Path 1 participation and how the low EUI requirements of that pathway might affect fuel switch free ridership measurements moving forward. If the PAs remain interested in understanding variations in NTG by pathway, we encourage the inclusion of this analysis in future research. However, small sample sizes by pathway could continue to be an issue, depending on new construction trends and project enrollments.

Appendix A In-depth Interview Questions

NMR used the questions below to guide the IDIs. Please note that we adjusted this version of the instrument based on decisions made during algorithm development.

Section 1 Recruitment Scripts

1.1 Phone and Email Recruitment Script

[SCRIPT MAY BE ADJUSTED DEPENDING ON NUMBER OF CONTACT ATTEMPTS AND INCLUDE OTHER CUSTOMIZATIONS.]

(Email: Dear [IntervieweeName]) (Phone: Hello, can I speak with [IntervieweeName]?),

I am reaching out to you on behalf of the sponsors of the Mass Save energy efficiency programs. NMR Group is conducting interviews with **owners and developers of non-residential new construction projects in Massachusetts along with the design teams who work on those projects**. The sponsors of Mass Save want to learn more about the decision-making processes that influence energy efficiency in these projects. We are specifically interested in the decision to install heat pump technologies for space heating. If you **are the appropriate contact at your company to talk about the [**PROJECT NAME**] project and you** participate in a **45-minute interview,** we can offer you a **$150 incentive.** If you are not the appropriate contact, we would appreciate you forwarding this message to the correct contact at your organization.

Your input will be held completely confidential and will help the Mass Save sponsors continue to provide support to contractors like you.

Are you available in the next week for in an interview? Please feel free to call me if you would like to discuss the study further. If you have any questions about the legitimacy of the study, please contact [PA CONTACT] of [PA] at [PA CONTACT EMAIL] or [PA CONTACT PHONE].

Thank you for your time.

Sincerely,
[InterviewerName]
[InterviewerPhone]
[InterviewerEmail]

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.

1.2 SCHEDULING CONFIRMATION EMAIL SCRIPT

[SCRIPT MAY BE ADJUSTED DEPENDING ON NUMBER OF CONTACT ATTEMPTS AND INCLUDE OTHER CUSTOMIZATIONS.]

Dear [IntervieweeName]

Thank you for agreeing to speak with me. I have you scheduled for [InterviewTime] on [InterviewDate] and will (IF PHONE PREFERRED: call you at [IntervieweePhone] from [InterviewerPhone]; IF EMAIL PREFERRED speak with you via Microsoft Teams through the invite you will receive from [INTERVIEWER EMAIL]. We anticipate the call will take about 45 minutes.

We will be speaking about your experience on the [PROJECT NAME] project and the factors that influenced the decision to install heat pump technologies for space heating in the project. Your input will remain confidential, and we will not share your name or the name of your company. We're looking forward to speaking with you.

Sincerely,
[InterviewerName]

Section 2 Customer Interview Guide

2.1 Project Details

Table to be populated for each interview.

NAME	
RESPONDENT TYPE	
COMPANY NAME	
PHONE	
EMAIL	
PROJECT NAME	
BUILDING TYPE	
BUILDING SIZE	
PROGRAM PATHWAY	
ELECTRIC PA	
GAS PA	
HEAT PUMP EQUIPMENT[1]	
FOSSIL FUEL EQUIPMENT[2]	
PROJECT NOTES	
[1] For space heating. Do not include cooling or water heating. [2] For any end use.	

2.2 Introduction

[Note to reviewers: the following represents an example introduction that an interviewer might use. Interviewers will not follow a set script and will not be expected to follow this introduction verbatim. Interviewers will adjust the script subject to time constraints and the responses of the interviewee.]

Thank you for speaking with us today regarding your work at [COMPANY NAME]. Today, we are hoping to ask you about your experience with the [PROJECT NAME] project and participation in the Mass Save New Buildings and Major Renovation Program through [PA 1] and [IF APPLICABLE: PA 2]. We'd like to know more about the decision-making processes that led to

the installation of heat pump technology over fossil fuels for at least some of the space heating load for this project.

This interview will take approximately 45 minutes to complete, and we will send you a $150 electronic gift card to thank you for your time and feedback. We will confirm your email address during our conversation, and we will send you an email with a link to claim your gift card within a few days of your interview. Your responses will remain confidential and will only be used for research purposes and will be reported in aggregate – we will not use your name or your company's name in any public materials or provide them to the Mass Save sponsors. I would like to record our conversation so that I can focus on our discussion rather than worry about trying to write everything down in my notes as we go. Do I have your permission to record our call? Do you have any questions before we begin?

2.3 QUESTIONNAIRE

1) To begin, I'd like to confirm a few key details for the [PROJECT NAME] project. Project documents from Mass Save indicate that [TA VENDOR] is providing technical assistance as part of program participation [IF APPLICABLE] and the design team working with you on the project consisted of the architecture firm [ARCHITECT] and the engineering firm [MEP ENGINEER]. This project participated in the Mass Save New Buildings and Major Renovations Program path [PROGRAM PATH], with [PA 1] as the electric utility and [IF APPLICABLE: PA 2] as the gas utility. Our records indicate this was a [BUILDING TYPE] consisting of approximately [SQUARE FOOTAGE] [IF NECESSARY: excluding parking garage spaces]. Does this all sound correct to you?
    a. [IF NO] Could you provide updates for any out-of-date information?
2) At what point in the project timeline is this project [PROBE: SCHEMATIC DESIGN, DESIGN DEVELOPMENT, CONSTRUCTION DOCUMENTS, CONSTRUCTION IN PROGRESS, CONSTRUCTION COMPLETED, OR POST-OCCUPANCY]?
3) Could you begin by describing your organization's initial approach to this project? For example, were there specific goals the design was meant to achieve in terms of energy efficiency, comfort, or occupant experience?

2.3.1 Non-Program Design and Equipment Influences:

4) Does your company have any formal requirements or informal guidelines for pursuing low carbon or carbon neutral designs or moving away from the use of fossil fuels?
    a. [IF YES] Can you explain a bit more about these policies? How did they impact this specific project? [PROBE ON FORMAL REQUIREMENTS VERSUS INFORMAL GOALS OR MARKETING APPROACHES]
5) Were there any municipal regulations or mandates for pursuing low carbon or carbon neutral designs or moving away from the use of fossil fuels?
    a. [IF YES] Do you think you would have moved forward with the same design if these regulations were not in place? [IF NECESSARY: ASSUMING NO PROGRAM ASSISTANCE]

2.3.2 Building Design and Baseline Assumption Check

6) Our records indicate the project [uses OR will use] an HVAC system that includes [TYPE 1], [IF APPLICABLE: TYPE 2], [IF APPLICABLE: TYPE 3], [IF APPLICABLE: TYPE 4]. Is this information still accurate? [IF NOT] Could you provide an overview of the latest HVAC design for this project?

7) At what point in the project timeline did you engage with the Mass Save program [IF APPLICABLE read and their technical assistance] through [PA 1] and [IF APPLICABLE: PA 2] to pursue incentives through path [PROGRAM PATH]? [PROBE: DURING DESIGN, CONSTRUCTION, POST-CONSTRUCTION.]

8) At what point in the project timeline did you decide to use heat pumps over fossil fuels for any portion of the space heating load?

9) Does/Will this project use natural gas or propane for any portion of the load for the following? If so, which fuel? [INDICATE YES / NO FOR EACH USE]

    a. Space heating
    b. Water heating
    c. Cooking
    d. Process loads
    e. Emergency or backup generators

10) [IF 9a = YES] Will natural gas / propane be used as a primary (used regularly) or supplemental (used when electric system can't meet demand) heating fuel source?

11) [IF NO NATURAL GAS IN DESIGN] Do any other buildings on the project site use utility piped natural gas for any of the following purposes? [INDICATE YES / NO FOR EACH USE]

    a. Space heating
    b. Water heating
    c. Cooking
    d. Process loads
    e. Emergency or backup generators

12) [IF NO NATURAL GAS IN DESIGN] To your knowledge, was natural gas service an option at the project site (meaning that there are utility natural gas lines nearby (within about 100 feet) that could have been extended to serve the project?

2.3.3 Free Ridership

13) Please think back to the earlier design phases of the project. What factors motivated your business to choose heat pumps over fossil fuels for some/all of the space heating load?
    a. [PROBE FOR]:
        i. Influence of the design team
        ii. Program incentives
        iii. Program technical assistance vendor
        iv. Internal company carbon reduction/neutrality or electrification goals
        v. [IF APPLICABLE] Municipal mandates for carbon reduction/neutrality or electrification

14) Who was MOST responsible for actually recommending heat pumps over fossil fuels for some/all of the space heating load?
    a. [PROBE FOR]:
        i. Respondent/Respondent company/Internal guidance
        ii. Design team representatives (e.g. architect, engineer)
        iii. Program staff from [PA 1] and/ or [PA2]
        iv. Mass Save Technical assistance vendor
    b. [IF NOT THE RESPONDENT OR THEIR COMPANY] On a scale of 0 to 10, with 0 being no influence and 10 being a great deal of influence, how much influence did the [MOST RESPONSIBLE ENTITY] have on your company's decision to pursue heat pumps over fossil fuels for some/all of the space heating load?

15) Would your business have opted to use heat pumps over fossil fuels for some/all of the project's space heating needs if the program assistance was not available?
    a. [IF YES] To confirm, you are saying that to your knowledge the project would have been designed to use heat pumps instead of fossil fuels for at least some of space heating needs even if the Mass Save program was not involved?

16) On a scale of 0 to 10, with 0 being 'no influence' and 10 being a 'great deal of influence', how much influence did the incentive for fuel switching – opting for heat pumps over fossil fuels for space heating - from [PA 1] (and if applicable) [PA2] have on your decision to pursue heat pumps for at least some of the space heating needs? [INTERVIEWER: STRESS THAT THIS IS THE INCENTIVE FOR THE FUEL SWITCH, NOT THE EQUIPMENT TYPE. RESPONDENTS MAY NOT BE FAMILIAR WITH AN INCENTIVE SPECIFIC TO FUEL SWITCHING – SKIP TO NEXT QUESTION IF THAT IS THE CASE]

17) [IF APPLICABLE] On a scale of 0 to 10, with 0 being 'no influence' and 10 being a 'great deal of influence', how much influence did the technical assistance available from [PA 1] (and if applicable) [PA 2] through [TA VENDOR], including the energy modeling and design charrettes, have on your decision to opt for heat pumps over fossil fuels for at least some of the space heating needs?

18) [ASK IF NOT COVERED ABOVE] On a scale of 0 to 10, with 0 being 'no influence' and 10 being a 'great deal of influence', how much influence did the project design team have on your decision to pursue heat pumps over fossil fuels for at least some of the space heating needs? This includes your architect, MEP engineer, and any outside energy consultants you hired in addition the program's technical assistance.

Now I would like you to think about what you would have done if this same program assistance had not been available.

19) Would your business have opted for the same heat pump space heating load as currently designed if the program assistance was not available? [IF NEEDED: Load = proportion of the heating fuel needed to maintain the indoor temperature at established levels]

    a. [IF YES] To confirm, you are saying that to your knowledge the project would have been designed with the same heat pump space heating load and fossil fuel space heating load even if the Mass Save program was not involved? [IF STILL YES, GO TO Q25 IF NEEDED OR Q27]

20) [IF Q19 = NO] I'd like to talk about how the space heating load designed for heat pumps has evolved over time. Please tell me the approximate portion of your total heating load designed to be met by heat pumps at these stages of the design process. If you have not yet reached a stage, let me know. [IF APPLICABLE] When answering this question, please consider any anticipated use of backup/supplemental fossil fuel systems. [FOR EXAMPLE, if you expect to use a back-up system 2% of the year, your heat pump load is 98%] [INTERVIEWER: Accept responses in terms of square footage served if respondent is unable to answer in terms of % load.]

Stage	Heat Pump % of Load
20.a Early concept – pre-program engagement)	
20.b Initial program engagement – design phase	
20.c Current design (if design process not complete)	
20.d Final design (if design process complete)	
21.a Actual load (if project complete and occupied)	

21) [SKIP IF DESIGN PROCESS NOT COMPLETE] Has the project been completed and the building(s) occupied for at least one heating season?

    a. [YES] What is the approximate actual space heating load carried by heat pumps?

    b. [IF 21.a < 20.d] Why do you think the actual heat pump load is lower than designed?

    c. [IF 21.a > 20.d] Why do you think the actual heat pump load is higher than designed?

22) On a scale of 0 to 10, with 0 being 'no influence' and 10 being a 'great deal of influence', how much influence did the incentive for fuel switching – opting for electric over fossil fuels for space heating - from [PA 1] (and if applicable) [PA2] have on your decision to increase the heat pump's portion of the heating load? [INTERVIEWER: STRESS THAT THIS IS THE INCENTIVE FOR THE FUEL SWITCH, NOT THE EQUIPMENT TYPE. RESPONDENTS MAY NOT BE FAMILIAR WITH AN INCENTIVE SPECIFIC TO FUEL SWITCHING – SKIP TO NEXT QUESTION IF THAT IS THE CASE]

23) [IF APPLICABLE] On a scale of 0 to 10, with 0 being 'no influence' and 10 being a 'great deal of influence', how much influence did the technical assistance available from [PA 1] (and if applicable) [PA 2] through [TA VENDOR], including the energy modeling and design charrettes, have on your decision increase the heat pump's portion of the heating load?

24) On a scale of 0 to 10, with 0 being 'no influence' and 10 being a 'great deal of influence', how much influence did the project design team have on your decision to increase the heat pump's portion of the heating load? This includes your architect, MEP engineer, and any outside energy consultants you hired in addition the program's technical assistance.

2.3.4 Free-ridership Consistency Check

[FOR 100% FREE RIDERSHIP]

25) [ASK IF THEY INDICATED PROGRAM DID NOT IMPACT FUEL SWITCH (Q15 = "YES" AND THAT PROGRAM INCENTIVE WAS INFLUENTIAL (>7 ON 1-10 SCALE IN Q16)] You said that you would have opted for using heat pumps instead of fossil fuels for space heating as designed without assistance from the program, but you also said that program incentives were influential in your decision to install heat pumps for some/all of the project's space heating needs. Which of these is more accurate?

26) [ASK IF THEY INDICATED PROGRAM DID NOT IMPACT FUEL SWITCH (Q15 = "YES" AND THAT PROGRAM WAS INFLUENTIAL (>7 ON 1-10 SCALE IN Q17)] You said that you would have opted for using heat pumps instead of fossil fuels for space heating as designed without assistance from the program, but you also said that program technical assistance was influential in your decision to install heat pumps for some/all of the project's space heating needs. Which of these is more accurate?

2.3.5 Spillover

27) Since enrolling [PROJECT NAME] in the program, has your organization started design or construction on additional projects in Massachusetts that are not currently enrolled in the program? [IF NO, SKIP TO PRIOR EXPERIENCE]

    a. [IF YES] Was this more recent project designed to use heat pumps over fossil fuels for at least some of the heating load? [IF NO, SKIP TO PRIOR EXPERIENCE]

    b. [IF YES to 29a] Do you plan to enroll this recent project in the Mass Save program? [IF YES, SKIP TO PRIOR EXPERIENCE]

    c. [IF YES TO 29a BUT NO TO 29b] What is the approximate square footage of this more recent project? What is the square footage or percentage of heating load you anticipate being served by heat pumps?

28) Did a recommendation by the contractor, engineer, or designer who you worked with under the program influence your decision to pursue heat pumps over fossil fuels for at least some of the heating load in this recent project?

29) Did your experience with the fuel-switching process implemented through the program influence your decision to pursue heat pumps over fossil fuels for at least some of the heating load in the more recent project?

30) On a scale of 0 to 10, where 0 is “no influence at all” and 10 is “a great deal of influence,” how much influence did your participation in the program through the [PROJECT NAME] project have on your decision to pursue heat pumps over fossil fuels for at least some of the heating load in the more recent project?

31) Why don’t you plan to enroll this project through a Mass Save program?

2.3.6 Prior Program Experience

32) Now I’d like you to think back to the [PROJECT NAME] project. Had your business participated in an energy-efficiency program offered by any Massachusetts service provider or Mass Save before you enrolled the [PROJECT NAME] project in the program? [IF YES, CONTINUE; OTHERWISE, END INTERVIEW]

33) On a scale of 0 to 10, with 0 being 'not at all important and 10 being 'very important’, how important was your previous experience with a Massachusetts service provider or Mass Save program when making the decision to use heat pumps over fossil fuels for any portion of the space heating load in the [PROJECT NAME] project?

34) I’m going to read you several statements. For each statement, please tell me whether you agree or disagree that this statement applies to your business. There are no right or wrong answers; we just want your honest opinion.

    Our previous experience implementing energy-efficient projects through a Massachusetts service provider or Mass Save program …

    a. Has made our firm more likely to consider heat pumps over fossil fuel equipment for space heating

b. Has made our firm more likely to install heat pumps over fossil fuel equipment for space heating

c. Has given us more confidence in the financial benefits of relying on heat pumps for space heating needs

d. Has given us more confidence in the nonfinancial benefits relying on heat pumps for space heating needs

Section 3 Design Team Interview Guide

3.1 Project Details

Table to be populated for each interview.

NAME	
RESPONDENT TYPE	
COMPANY NAME	
PHONE	
EMAIL	
PROJECT NAME	
BUILDING TYPE	
BUILDING SIZE	
PROGRAM PATHWAY	
ELECTRIC PA	
GAS PA	
HEAT PUMP EQUIPMENT[1]	
FOSSIL FUEL EQUIPMENT[2]	
PROJECT NOTES	
[1] For space heating. Do not include cooling or water heating. [2] For any end use.	

3.2 Introduction

[Note to reviewers: the following represents an example introduction that an interviewer might use. Interviewers will not follow a set script and will not be expected to follow this introduction, or the interview guide itself verbatim. Interviewers will adjust the script subject to time constraints and the responses of the interviewee.]

Thank you for speaking with us today regarding your work at [COMPANY NAME]. Today, we are hoping to ask you about your experience with the [PROJECT NAME] project and participation in the Mass Save New Buildings and Major Renovation Program through [PA 1] and [IF APPLICABLE: PA 2]. We'd like to know more about the decision-making processes that led to

the installation of heat pump technology over fossil fuels for at least some of the space heating load for this project.

This interview will take approximately 45 minutes to complete, and we will send you a $150 electronic gift card to thank you for your time and feedback. We will confirm your email address during our conversation we will send you an email with a link to claim your gift card within a few days of your interview. Your responses will remain confidential and will only be used for research purposes and will be reported in aggregate – we will not use your name or your company's name in any public materials or provide them to the Mass Save sponsors. I would like to record our conversation so that I can focus on our discussion rather than worry about trying to write everything down in my notes as we go. Do I have your permission to record our call? Do you have any questions before we begin?

3.3 QUESTIONNAIRE

1) To begin, I'd like to confirm a few key details for the [PROJECT NAME] project. Project documents indicate you represented [COMPANY NAME], which served as the [RESPONDENT TYPE] on the project. The customer for this study was [CUSTOMER NAME]. This project participated in the Mass Save New Buildings and Major Renovations Program path [PROGRAM PATH], with [PA 1] as the electric utility and [IF APPLICABLE: PA 2] as the gas utility. Our records indicate this was a [BUILDING TYPE] consisting of approximately [SQUARE FOOTAGE] [IF NECESSARY: excluding parking garage spaces]. Does this all sound correct to you?
    a. [IF NO] Could you provide updates for any out-of-date information?
2) At what point in the project timeline is this project [PROBE: SCHEMATIC DESIGN, DESIGN DEVELOPMENT, CONSTRUCTION DOCUMENTS, CONSTRUCTION IN PROGRESS, CONSTRUCTION COMPLETED, OR POST-OCCUPANCY]?

3.3.1 Non-Program Design and Equipment Influences:

3) Were there any municipal regulations or mandates for pursuing low carbon or carbon neutral designs or moving away from the use of fossil fuels?
    a. [IF YES] Could you speak to the extent these requirements impacted the design concept, if at all?
4) Did the customer communicate any guidelines or requirements on their end that impacted the decision to use heat pumps over fossil fuels for at least some of the heating load? How did this impact the early design concept? [PROBE ON FORMAL REQUIREMENTS VERSUS INFORMAL GOALS OR MARKETING APPROACHES]

3.3.2 Building Design and Baseline Assumption Check

5) Our records indicate the project [uses OR will use] an HVAC system that includes [TYPE 1], [IF APPLICABLE: TYPE 2], [IF APPLICABLE: TYPE 3], [IF APPLICABLE: TYPE 4]. Is this information still accurate? [IF NOT] Could you provide an overview of the latest HVAC design for this project?

6) At what point in the project timeline did you engage with the Mass Save program [IF APPLICABLE read and their technical assistance through] [PA 1] and [IF APPLICABLE: PA 2] to pursue incentives through path [PROGRAM PATH]? [PROBE: DURING DESIGN, CONSTRUCTION, POST-CONSTRUCTION.]

7) At what point in the project timeline did project decision makers decide to use heat pumps over fossil fuels for any portion of the space heating load?

8) Does/Will this project use natural gas or propane for any portion of the load for the following? If so, which fuel? [INDICATE YES / NO FOR EACH USE]

    a. Space heating
    b. Water heating
    c. Cooking
    d. Process loads
    e. Emergency or backup generators

9) [IF YES 8a] Will natural gas / propane be used as a primary (used regularly) or supplemental (used when electric system can't meet demand) space heating fuel source?

10) [IF NO NATURAL GAS IN DESIGN] Do any other buildings on the project site use utility piped natural gas for any of the following purposes? [INDICATE YES / NO FOR EACH USE]

    a. Space heating
    b. Water heating
    c. Cooking
    d. Process loads
    e. Emergency or backup generators

11) [IF NO NATURAL GAS IN DESIGN] To your knowledge, was natural gas service an option at the project site (meaning that there are utility natural gas lines nearby (within about 100 feet) that could have been extended to serve the project?

3.3.3 Free Ridership

12) Please think back to the earlier design phases of the project. What factors motivated project decision makers to choose heat pumps over fossil fuels for some/all of the space heating load?

    a. [PROBE FOR]:

        i. Influence of the design team

        ii. Program incentives

        iii. Program technical assistance vendor

        iv. Internal company carbon reduction/neutrality or electrification goals

        v. [IF APPLICABLE] Municipal mandates for carbon reduction/neutrality or electrification

13) Who was MOST responsible for actually recommending heat pumps over fossil fuels for some/all of the space load?

    a. [PROBE FOR]:

        vi. Respondent/Respondent company/Internal guidance

        vii. Design team representatives (e.g. architect, engineer)

        viii. Program staff from [PA 1] and/ or [PA2]

        ix. Mass Save Technical assistance vendor

    b. [IF NOT THE RESPONDENT OR THEIR COMPANY] On a scale of 0 to 10, with 0 being no influence and 10 being a great deal of influence, how much influence did the [MOST RESPONSIBLE ENTITY] have on the decision to pursue heat pumps over fossil fuels for some/all of the space heating load?

14) Would your business have opted to use heat pumps over fossil fuels for some/all of the project's space heating needs if the program assistance was not available?

    a. [IF YES] To confirm, you are saying that to your knowledge the project would have been designed to use heat pumps instead of fossil fuels for at least some of space heating needs even if the Mass Save program was not involved?

15) On a scale of 0 to 10, with 0 being 'no influence' and 10 being a 'great deal of influence', how much influence did the incentive for fuel switching – opting for heat pumps over fossil fuels for space heating - from [PA 1] (and if applicable) [PA2] have on the decision to pursue heat pumps for at least some of the space heating load? [INTERVIEWER: STRESS THAT THIS IS THE INCENTIVE FOR THE FUEL SWITCH, NOT THE EQUIPMENT TYPE. RESPONDENTS MAY NOT BE FAMILIAR WITH AN INCENTIVE SPECIFIC TO FUEL SWITCHING – SKIP TO NEXT QUESTION IF THAT IS THE CASE]

16) [IF APPLICABLE] On a scale of 0 to 10, with 0 being 'no influence' and 10 being a 'great deal of influence', how much influence did the technical assistance available from [PA 1] (and if applicable) [PA 2] through [TA VENDOR], including the energy modeling and design charrettes, have on your decision to opt for heat pumps over fossil fuels for space heating?

17) [ASK IF NOT COVERED ABOVE] On a scale of 0 to 10, with 0 being 'no influence' and 10 being a 'great deal of influence', how much influence did your firm and the rest of the project design team have on the decision to pursue heat pumps over fossil fuels for at least some of the space heating load? This includes [ADJUST BASED ON TYPE OF RESPONDENT] the architect, MEP engineer, and any outside energy consultants you hired in addition the program's technical assistance.

Now I would like you to think about what you would have done if this same program assistance had not been available.

18) Would project decisions makers have opted for the same heat pump space heating load as currently designed if the program assistance was not available? [IF NEEDED: Load = proportion of the heating fuel needed to maintain the indoor temperature at established levels]

    a. [IF YES] To confirm, you are saying that to your knowledge the project would have been designed with the same heat pump space heating load and fossil fuel space heating load even if Mass Save was not involved? [IF STILL YES, GO TO Q24 IF NEEDED OR Q26]

19) [IF Q18a OR Q18b = NO] I'd like to talk about how the space heating load designed for heat pumps has evolved over time. Please tell me the approximate portion of your total heating load designed to be met by heat pumps at these stages of the design process. If you have not yet reached a stage, let me know. [IF APPLICABLE] When answering this question, please consider any anticipated use of backup/supplemental fossil fuel systems. [FOR EXAMPLE, if you expect to use a back-up system 2% of the year, your heat pump load is 98%] [INTERVIEWER: Accept responses in terms of square footage served if respondent is unable to answer in terms of % load.]

Stage	Heat Pump % of Load
19.a Early concept – pre-program engagement)	
19.b Initial program engagement – design phase	
19.c Current design (if design process not complete)	
19.d Final design (if design process complete)	
20.a Actual load (if project complete and occupied)	

20) [SKIP IF DESIGN PROCESS NOT COMPLETE] Has the project been completed and the building(s) occupied for at least one heating season?

    a. [YES] What is the approximate actual space heating load carried by heat pumps?

    b. [IF 20.a < 19.d] Why do you think the actual heat pump load is lower than designed?

    c. [IF 20.a > 19.d] Why do you think the actual heat pump load is higher than designed?

21) On a scale of 0 to 10, with 0 being 'no influence' and 10 being a 'great deal of influence', how much influence did the incentive for fuel switching – opting for electric over fossil fuels for space heating - from [PA 1] (and if applicable) [PA2] have on the decision to increase the heat pump's portion of the heating load? [INTERVIEWER: STRESS THAT THIS IS THE INCENTIVE FOR THE FUEL SWITCH, NOT THE EQUIPMENT TYPE. RESPONDENTS MAY NOT BE FAMILIAR WITH AN INCENTIVE SPECIFIC TO FUEL SWITCHING – SKIP TO NEXT QUESTION IF THAT IS THE CASE]

22) [IF APPLICABLE] On a scale of 0 to 10, with 0 being 'no influence' and 10 being a 'great deal of influence', how much influence did the technical assistance available from [PA 1] (and if applicable) [PA 2] through [TA VENDOR], including the energy modeling and design charrettes, have on your decision increase the heat pump's portion of the heating load?

23) On a scale of 0 to 10, with 0 being 'no influence' and 10 being a 'great deal of influence', how much influence did the project design team have on the decision to pursue increase the heat pump's portion of the heating load? This includes the architect, MEP engineer, and any outside energy consultants hired in addition the program's technical assistance.

3.3.4 Free-ridership Consistency Check

[FOR 100% FREE RIDERSHIP]

24) [ASK IF THEY INDICATED PROGRAM DID NOT IMPACT FUEL SWITCH (Q14a = "YES" AND THAT PROGRAM INCENTIVE WAS INFLUENTIAL (>7 ON 1-10 SCALE IN Q15)] You said that the project decision maker would have opted for using heat pumps instead of fossil fuels for space heating as designed without assistance from the program, but you also said that the program incentives were influential in the decision to install heat pumps for some/all of the project's space heating needs. Which of these is more accurate?

25) [ASK IF THEY INDICATED PROGRAM DID NOT IMPACT FUEL SWITCH (Q14a = "YES" AND THAT PROGRAM ASSISTANCE WAS INFLUENTIAL (>7 ON 1-10 SCALE IN Q16)] You said that the project decision maker would have opted for using heat pumps instead of fossil fuels for space heating as designed without assistance from the program, but you also said that program technical assistance was influential in the decision to install heat pumps for some/all of the project's space heating needs. Which of these is more accurate?

3.3.5 Spillover

26) Since the [PROJECT NAME] was enrolled in the program, has your organization started design or construction on additional projects in Massachusetts that are not currently enrolled in the program? [IF NO, SKIP TO PRIOR EXPERIENCE]

a. [IF YES] Was this more recent project designed to use heat pumps over fossil fuels for at least some of the heating load? [IF NO, SKIP TO PRIOR EXPERIENCE]

b. [IF YES to 28a] Do you believe this project will be enrolled in the Mass Save program in the future? [IF YES, SKIP TO PRIOR EXPERIENCE]

c. [IF YES TO 28a BUT NO TO 28b] What is the approximate square footage of this more recent project? What is the square footage or percentage of heating load you anticipate being served by heat pumps?

27) Did you or someone else on the design team make a recommendation that influenced the decision to pursue heat pumps over fossil fuels for at least some of the heating load in this recent project?

28) Did your experience with the fuel-switching process implemented through the program influence your decision to recommend heat pumps over fossil fuels for at least some of the heating load in the more recent project?

29) On a scale of 0 to 10, where 0 is “no influence at all” and 10 is “a great deal of influence,” how much influence did your participation in the program through the [PROJECT NAME] project in the program have on your decision to pursue heat pumps over fossil fuels for at least some of the heating load in the more recent project?

30) Why don’t you plan to enroll this project through a Mass Save program?

3.3.6 Prior Program Experience

31) [IF APPLICABLE PER Q13] On a scale of 0 to 10, with 0 being 'not at all important and 10 being 'very important’, how important was your previous experience with a [PA1] (if applicable) or [PA2] program when making the decision to recommend heat pumps over fossil fuels for any portion of the space heating load in the [PROJECT NAME] project?

PLACE HOLDER FOR THE ALGORITHM TABLES AND FLOWCHARTS

Appendix B NTG Calculation Algorithm

The tables below document the NMR team's scoring and algorithm for estimating NTG for fuel switch heat pumps in NRNC. We have used the Commercial and Industrial Self-Report NTG (C&I NTG) approach to guide development of this algorithm. However, the algorithm required modifications to fit the nature of fuel switching.

Table 4: Participant Guide Scoring

Topic	Question #	Response Type	Suggested Scoring
Influential Party	Q14a/b	a. Categorical b. Scale	If 14a = Design Team (14a) and 14b > 6 **and** the Design Team concurs (13b > 6 on DT guide), Design Team responses supersede participant responses.
Program influence on fuel switch	Opted for HP over FF: Q15a	Yes/No	Yes = 1.0; No = 0; either response = continue
	Incentive: Q16 (0 to 10, zero = no influence)	Scale	If Q15a = Yes and Q16 / 10 ≥ 0.7 will receive manual review of consistency checks All others = 1.0 – (Q16 / 10)
	TA: Q17	Scale	If Q15a = Yes, Q17 / 10 ≥ 0.7 will receive manual review of consistency checks All others = 1.0 – (Q17 / 10)
	DT: Q18	Scale	Ask if 14a ≠ Design Team; same rules apply as above for 14b but apply to incentive influence only
	Consistency Incentives: Q25	Qualitative	Manual review: Scoring depends on context of the response. Indicate no influence = 1.0; remains inconsistent = 0.5; influence = 1.0 - (Q16 / 10).
	Consistency TA: Q27	Qualitative	Manual review: Scoring depends on context of the response. Indicate no influence = 1.0; remains inconsistent = 0.5; influence = 1.0 – (Q17 / 10).

FUEL SWITCH FREERIDERSHIP (FS FR)

Note: Below, to ease review, we assume Q16 and Q17 have already been divided by 10 to produce responses that range from 0 to 1.0.

- ***Q15a = Yes; Q16 and Q17 = 0; FS FR = 1.0***
- ***Q15a = Yes; Q16 and Q17 > 0 < 0.7 FS FR = 1.0 – max(Q16, Q17)***
- ***Q15a = Yes; Q16 and Q17 ≥ 0.7 FS FR = Min(Q25, Q27)***

Topic	Question #	Response Type	Suggested Scoring
• ***Q15a = Yes; Q16 or Q17 ≥ 0.7 (but not both) = FS FR Lowest of any applicable 1.0 – max(Q16, Q17) or Min(Q25, Q27)*** • ***Q15a = No; FS FR = 1.0 – max(Q16, Q17)*** **Note: Score based on Q15a, Q16, and Q25 only if no technical assistance provided (Paths 3 and 4 only)**			
Program influence on load served by HP	Same Load: Q19a	Yes/No	Yes = 1.0 / No = 0.0; Yes, FR = 1; No go to Q20
	% Load over time: Q20	Percentage	FR = Ratio of % Load Pre-program to % Load Most Recent Design
	% Load actual: Q21a	Percentage	FR = Ratio of % Load Pre-program to % Load Actual
	Incentive: Q22	Scale	For Q19a = No, 1.0 – (Q22 / 10)
	TA: Q23	Scale	For Q19a = No, 1.0 – (Q23 / 10)
	DT: Q24	Scale	Ask if 14a ≠ Design Team; same rules apply as above for 14b but apply to tech assistance only
HEAT PUMP LOAD FREERIDERSHIP ***Score has two components: influence on load (FR1) and proportion of load in question (FR2)*** **Note: Below, to ease review, we assume Q22 and Q23 have already been divided by 10 to produce responses that range from 0 to 1.0.** • ***Q19a = Yes; FR1 = 1.0*** • ***Q19a = No; FR1 = 1.0 – max(Q22, Q23)*** **Note: FR1 Score based on Q19a and Q22 only if no technical assistance provided (Paths 3 and 4 only)** ***FR2 = Q20 or Q21a from above as applicable*** ***Load FR = FR1 * FR2*** ***Total FR*** • ***If FS FR = 0, Total FR = 0*** • ***If FS FR > 0, then Total FR = average FS FR and Load FR***			

Topic	Question #	Response Type	Suggested Scoring
Program influence on fuel switch spillover	New Project Not Enrolled: Q27	Yes/No	No = 0.0; Yes, continue
	Heat Pumps: Q27a	Yes/No	No = 0.0; Yes, continue
	Plan to Enroll: Q27b	Yes/No	Yes = 0.0; No, continue
	Project Size: Q27c	Area served by HP	Post calculation weighting (have for participants so not asked in FR series)
	Vendor Rec Inf: Q28	Yes/No	No = 0.0; Yes = 0.5
	Program Exp Inf: Q29	Yes/No	No = 0.0; Yes, continue
	Program Exp Inf Check: Q30	Scale	Q30 / 10
SO = 0 if Q27 or Q27a = No or Q27b = Yes; Otherwise SO = Max(Q28, Q29, and Q30 / 10)			

Table 5: Design Team Guide Scoring

Topic	Question #	Response	Suggested Scoring
Influential Party	Q13a/b	a. Categorical b. Scale	If Participant 14a = Design Team (14a) and 14b > 6 **and** the Design Team concurs (13b > 6 here), Design Team responses supersede participant responses.
Program influence on fuel switch	Opted for HP over FF: Q14a	Yes/No	Yes = 1.0; No = 0; either response = continue
	Incentive: Q15	Scale	If Q14a = Yes and Q15 / 10 ≥ 0.7 will receive manual review of consistency checks All others = 1.0 – (Q15 / 10)
	TA: Q16	Scale	If Q14a = and Q16 / 10 ≥ 0.7 will receive manual review of consistency checks All others = 1.0 – (Q16 / 10)
	DT: Q17	Scale	Ask if 13a ≠ Design Team; same rules apply as above for 13b but apply to incentive influence only
	Consistency Incentives: Q24	Qualitative	Manual review: Scoring depends on context of the response. Indicate no influence = 1.0; remains inconsistent = 0.5; influence = 1.0 - (Q15 / 10).
	Consistency TA: Q26	Qualitative	Manual review: Scoring depends on context of the response. Indicate no influence = 1.0; remains inconsistent = 0.5; influence = 1.0 - (Q16 / 10).

FUEL SWITCH FREERIDERSHIP (FS FR)

Note: Below, to ease review, we assume Q15 and Q16 have already been divided by 10 to produce responses that range from 0 to 1.0.

- ***Q14a = Yes; Q15 and Q16 = 0; FS FR = 1.0***
- ***Q14a = Yes; Q15 and Q16 > 0 < 0.7FS FR = 1.0 – max(Q15 or Q16***
- ***Q14a = Yes; Q15 and Q16 ≥ 0.7 FS FR = Min(Q24, Q26)***
- ***Q14a = Yes; Q15 or Q16 ≥ 0.7 (but not both) = FS FR Lowest of 1.0 – max(Q15, Q16) or Min(Q24, Q26)***
- ***Q14a = No; FS FR = 1.0 – max(Q15, Q16)***

Note: Score based on Q14a, Q15, and Q24 only if no technical assistance provided (Paths 3 and 4 only)

Topic	Question #	Response	Suggested Scoring
Program influence on load served by HP	Same Load: Q18a	Yes/No	Yes = 1.0 / No = 0.0; Yes, FR = 1; No go to Q19
	% Load Actual Q19	Percentage	FR = Ratio of % Load Pre-program to % Load Most Recent Design
	% Load Actual Q20a	Percentage	FR = Ratio of % Load Pre-program to % Load Actual
	Incentive: Q21	Scale	For Q18a = No, 1.0 – (Q21 / 10)
	TA: Q22	Scale	If Q18a = No, 1.0 – (Q22 / 10)
	DT: Q23	Scale	Ask if 13a ≠ Design Team; same rules apply as above for 13b but apply to tech assistance only
	Consistency Incentives: Q25	Qualitative	Manual review: Scoring depends on context of the response. Indicate no influence = 1.0; remains inconsistent = 0.5; influence = 1.0 – (Q21 / 10).
	Consistency TA: Q27	Qualitative	Manual review: Scoring depends on context of the response. Indicate no influence = 1.0; remains inconsistent = 0.5; influence = 1.0 – (Q22 / 10).

HEAT PUMP LOAD FREERIDERSHIP

Score has two components: influence on load (FR1) and proportion of load in question (FR2)

Note: Below, to ease review, we assume Q21 and Q22 have already been divided by 10 to produce responses that range from 0 to 1.0.

- ***Q18a = Yes; FR1 = 1.0***
- ***Q18a = No; FS FR = 1.0 – max(Q21, Q22)***

Note: FR1 Score based on Q18a and Q21 only if no technical assistance provided (Paths 3 and 4 only)

FR2 = Q19 or Q20a from above as applicable

Load FR = FR1 * FR2

Total FR

- ***If FS FR = 0, Total FR = 0***
- ***If FS FR > 0, then Total FR = average FS FR and Load FR***