Massachusetts Residential HVAC Net-to-Gross and Market Effects Study (TXC34)

Final Draft

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SUBMITTED TO:
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Executive Summary

Background

Study Purpose

The primary purpose of this study was to estimate and recommend net-to-gross ratios (NTGRs) for selected heating, cooling, and water heating measures that will receive Mass Save® Standard rebates in 2019-2021. Another purpose was to measure market effects indictors for evidence of progress toward market transformation that may be attributed to the program, and to set baselines for comparison with future measurements.

Study Description

NMR fielded participant and contractor quantitative web and phone surveys in 2017 and 2018. A Consensus Group used those results to recommend NTGRs for Massachusetts planning tools, such as the 2019-2021 Technical Reference Manual and benefit-cost ratio models. Surveys also asked about market effects and other topics.

Results

NTG Results

This study's recommended NTGRs differ from current TRM values, which are mostly based on a 2012 study. The recommended 2019-2021 NTGRs for ductless mini-split heat pumps (DMSHPs) and boilers increased from the 2016-2018 NTGRs. The recommended NTGRs for heat pump water heaters (HPWHs), central air conditioning (CAC), central heat pumps (CHP), and furnaces decreased.

Consensus Group Recommended 2019-2021 Net-to-Gross Ratios

Measure	Previous	Recommended
Ductless MSHP	0.62	0.77
Heat pump water heater	1.00	0.83
Central air conditioner	0.86	0.67
Central heat pump	0.86	0.60
Furnace	0.81	0.76
Hot water boiler	0.77	0.79
Condensing combination boiler	0.74	0.79

Market Effects Results

Contractors offered anecdotal evidence that, to some degree, the program's intended effects on stocking have occurred. Attribution question results for equipment costs provide anecdotal evidence that the programs played a modest role in effecting changes in the high-efficiency versus standard efficiency equipment prices that contractors incur. Additionally, customer demand for high-efficiency HVAC equipment has increased, and contractors attributed much of this change to the programs.

Contractor Influence Results

Both participant and contractor survey results indicate that contractors' recommendations have a strong influence on the models of equipment customers choose. Contractors perceived that their own recommendations, compared to other factors, have had the most influence on their non-program high-efficiency sales; moreover, the programs strongly influence their recommendations. This suggests that the programs have substantial indirect influence on what appears to be the strongest driver in the selection of qualifying equipment outside the program.

Note: Because the number of contractors asked these questions was small, this finding should be generalized with caution.

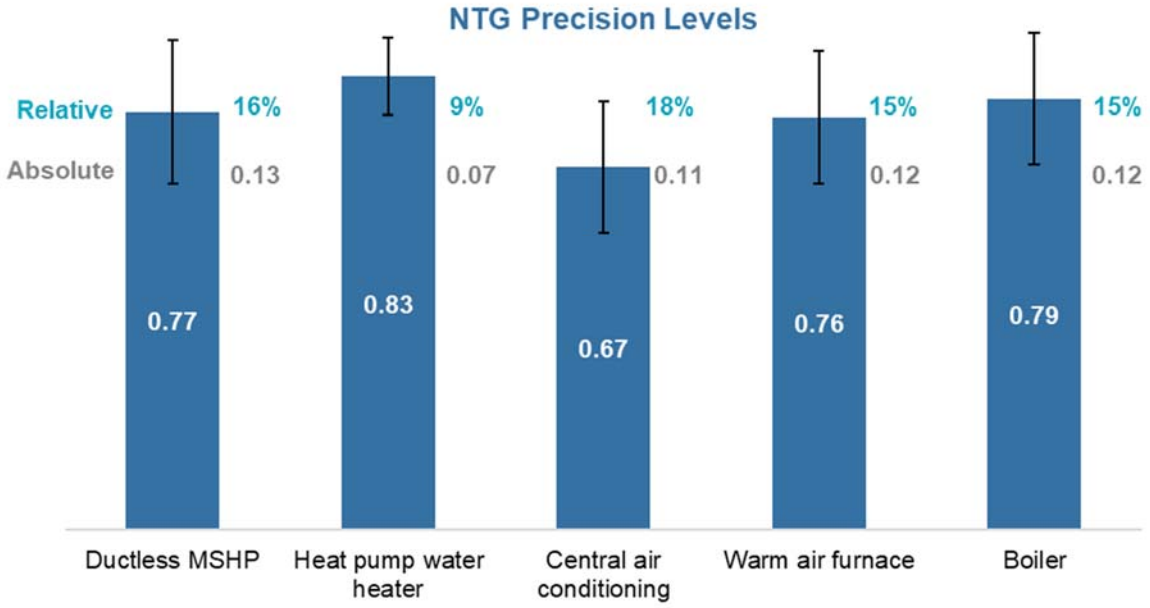
Quantitative Methods

Completed Surveys	Participants	Contractors
Ductless MSHP	66	51
Heat pump water heater	79	41
Central air conditioner	66	28
Central heat pump	35	16
Furnace	61	42
Boiler	60	49

Counts of completed NTG batteries

Methodological Limitations

Contractor and participant survey sample sizes were low because of poor response rates. Moreover, contractors struggled to interpret some NTG questions, which were excluded from the analysis. Sampling error among contractors was between +/-11% and 15% at the 90% confidence level, with the exception of CHPs (20%). Participant sampling error was narrower, ranging from +/-9% to 13%. Despite this, NTGRs passed Massachusetts' informal guidance that estimates should meet 10% absolute precision or 25% relative precision at the 90% confidence level.



Note: Absolute precision represents the NTGR standard error times the z-score for a 90% confidence interval (1.645), while relative precision compares those values as percentage changes from the recommended NTGR. Because the Consensus Group selected CHP NTGR (meaning it is not derived from raw data), we do not present it here. CHP NTGR in the raw data was 0.58 with 0.11 absolute precision and 18% relative precision.

Recommendations

- Incorporate the NTGRs recommended by the Consensus Group for equipment incented with "Standard" rebates into the 2019-2021 Technical Reference Manual.
- Measure the same market indicators in future studies of the programs' residential HVAC activities, and compare the results to track progress over time. Future measurements of reduced cost barriers should allow for a comparison between changes in costs of high-efficiency and standard equipment to assess whether contractors perceive prices of high-efficiency equipment as changing at faster, slower, or the same rates as those of standard standard-efficiency equipment. To claim savings from market effects, market share data must be available for analysis. Changes in the indicators assessed in this report could corroborate findings from market share data analysis.

- While the market effects results show that customer demand for high-efficiency equipment has increased over the last three years, and participant survey results indicate that contractors' recommendations have considerable influence on the models of equipment customers choose to install, customers are important drivers of decision making for certain equipment types. Given this, the programs should continue to target both customers and contractors.

Considerations

- The evaluation team has previously attempted to obtain Massachusetts HVAC market share data from manufacturers on behalf of the PAs, and is currently attempting to obtain Massachusetts unit sales data from distributors. The team has encountered considerable difficultly obtaining meaningful state-level data from HVAC industry players. There remain two ready sources of HVAC market share data that the PAs previously examined and may wish to consider using in the future: the national ENERGY STAR® shipment data and HARDI HVAC data from D&R International. The PAs have previously chosen not to rely on either data source because the data were not sufficiently representative of Massachusetts. Since the completion of this evaluation, D&R International has informed the evaluation team that they have successfully brought on board a distributor with many Massachusetts outlets. D&R estimates that the data they now have in hand for Massachusetts represents slightly over 35% of the state's market for furnaces, CAC, and ASHP equipment. This is more than double the previous representation, and the data go back several years.
- Another approach the PAs may want to consider in the future is to leverage national ENERGY STAR shipment data. This would involve asking manufacturers to estimate the Massachusetts market share of ENERGY STAR-qualified HVAC equipment in relation to the national data, with some consideration of attribution. While this would be less expensive than purchasing D&R data, and likely less expensive than the approach taken in this evaluation, it would not be as precise as either. ENERGY STAR also does not equate directly with Mass Save program capacity and efficiency requirements.
- Consider how changes in NTGRs may affect the PAs' benefit/cost ratio models and decisions to continue to support each of the measures at the current efficiency specification and rebate levels.
- Improve contractor contact information tracking (e.g., develop contractor IDs, require email addresses). It would better serve future evaluation efforts.
- In the future, consider using in-depth interviews rather than programmed surveys with contractors to estimate market shares and program influence. The complexity involved in these questions requires abstract consistency checks that are difficult to implement through a programmed survey with no trained expert guiding respondents to correctly interpret the questions.

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1 Section 1 Introduction & Background

This report summarizes the results of a study that measured net-to-gross ratios (NTGRs) for selected residential HVAC equipment supported by Mass Save. The study's goals were to (1) measure one-year retrospective NTGRs and develop estimates of three-year prospective NTGRs for the equipment, and (2) inform future measurement of the effects of Mass Save programs on residential HVAC markets. The study specifically focused on "standard" rebates – not early replacement rebates. The RES36 study evaluated early replacement rebates.

This report is organized as follows:

- This **Introduction and Background** section describes the program. It explains, via a logic model, how the program is expected to change end-user and market actor decision-making and HVAC equipment markets.
- **Research Methodology** (Section 2) details our research approach, which was primarily based on surveys with participating customers and contractors. We concluded our research with a Consensus Group to recommend retrospective and prospective NTGRs.
- **Net-to-Gross Results** (Section 3) walks readers through preliminary free-ridership (FR) and spillover (SO) results, NTG algorithms, and precision of results; reports contractors' market share predictions; describes the decision-making process that the Consensus Group undertook to arrive at the recommended NTGRs; and walks readers through the NTGR precision calculations.
- **Market Effects** (Section 4) explains how we operationalized indicators of the effects of the programs on residential HVAC equipment markets, including stocking, equipment costs, and customer attitudes and demand, and presents the results.
- **Contractor Influence, Equipment Replacement, and Fuel Switching** (Section 5) analyzes other important topics addressed by the surveys, including program awareness, influence of contractors on customer decision-making, price sensitivity, equipment replacement, fuel switching, and demographic characteristics.
- **Results, Recommendations, and Considerations** (Section 6) summarizes key results from the study and offers related recommendations and considerations to improve program design, outcomes, and processes.

The appendices include additional methodological details, background information, findings, participant demographics (Appendix A), and data collection instruments (Appendix B).

1.1 Equipment Addressed

This study presents results for the following equipment types installed in residential settings: central air-conditioning (CAC) systems, central heat pumps (CHPs), natural gas furnaces, natural gas boilers, ductless mini-split heat pumps (DMSHPs), and heat pump water heaters (HPWHs). We analyzed hot water boilers and condensing boilers with on-demand hot water (i.e., combination units) in aggregate.

1.2 PROGRAM BACKGROUND

The objectives of the Residential Heating and Cooling gas and electric initiatives (referred to collectively here as "the programs") are two-fold: (1) to encourage consumers to purchase the most efficient HVAC and HPWH technologies available, both when replacing older, less efficient equipment and when considering equipment in new construction, and (2) to encourage contractors to follow installation best practices. Section 2.3 shows participation levels.

Table 1 outlines the measures currently supported by the programs, efficiency requirements, rebate amounts, and savings assumptions.

Table 1: Residential Heating and Cooling Programs' Efficiency Requirements, Rebate Amounts, and Savings Assumptions, 2016 through 2018

Program Measures	Efficiency Requirement	Rebate Amount[1]	Savings Assumptions
Electric			**kWh**
Ductless MSHP	SEER ≥ 18, HSPF ≥ 9	$250	286
	SEER ≥ 20, HSPF ≥ 11	$500	330
Heat pump water heater[2]	55 gallons or less, ≥ 2.3 EF	$750	1,654
	More than 55 gallons, ≥ 3.0 EF	$150	Not published
Central air conditioning	SEER ≥ 16, EER ≥ 13	$250	198.8
Central heat pump	SEER ≥ 16, HSPF ≥ 8.5	$250	450.3
	SEER ≥ 18, HSPF ≥ 9.6	$500	1,077.8
Gas			**MMBtu**
Warm air furnace	≥ 95% AFUE rating equipped with Electronic Commutated Motor (ECM)	$300	8.1
	≥ 97% AFUE rating equipped with ECM	$600	9.2
Hot water boiler	≥ 90% AFUE rating	$1,000	11.4
	≥ 95% AFUE rating	$1,500	14.1
Condensing Boiler w/ On-Demand Hot Water Heater	≥ 90% AFUE boiler rating	$1,200	10.3
	≥ 95% AFUE boiler rating	$1,600	12.8

[1] Standard rebates only (not early replacement)

[2] The electric program added larger (>55 gallon) HPWHs in 2017; the TRM does not establish savings for this system size. In 2018, the minimum EF requirements decreased for both sizes, to 2.0 and 2.7, respectively. Rebate amounts did not change.

In addition to providing downstream rebates, the programs' outreach services include education and support in the field through visits and calls to HVAC distributors, supply houses, and contractors via a shared circuit rider. The circuit rider also participates in training, trade shows, and related industry events, and visits big box stores to educate partners and to support optimal stocking practices, sales training, and distribution of point-of-purchase rebate materials.

To qualify for a rebate, customers must work with a licensed contractor and include the contractor's invoice with their rebate application. This invoice must itemize the equipment purchased, show required proof of purchase, and indicate the equipment type, size, make, model, efficiency rating, name of purchaser, installation date and location, date of purchase, and total installed cost. (In practice, most contractors take the lead role in submitting this information for their customers, according to PA staff.) The electric program encourages, but does not require, customers installing electric equipment to use an Airflow and Charge (AC) Check-trained contractor to make sure the equipment is installed to manufacturer specifications. The program maintains a listing of AC Check-trained contractors. Such contractors are eligible to receive incentives for installation and verification work, as well as reimbursements for training and diagnostic tool purchases.

While both programs promote early replacement by offering larger Early Replacement rebates for certain equipment types, this study examined Standard rebates only.[1]

1.3 PROGRAM LOGIC MODEL

Figure 1 and Figure 2 depict program logic by fuel type. They also show how the programs are meant to affect decisions of market actors and, ultimately, the demand for high-efficiency residential HVAC equipment. The programs' long-term goals are to increase the market penetration of, and develop a sustainable market for, the equipment types.[2] The program activities seek to address the following barriers:

- Financial, such as higher initial cost of high-efficiency equipment
- Lack of target audience awareness of high-efficiency equipment
- Lack of market infrastructure for the equipment, such as weak distribution networks, lack of trained installer base, and contractor resistance to selling the highest efficiency equipment
- Aesthetics and appearance of equipment
- Product or service drawbacks

While they are not depicted in the logic models, external influences can affect the program outcomes. External influences include ENERGY STAR; Air Conditioning Contractors of America (ACCA); the Air-Conditioning, Heating, and Refrigeration Institute (AHRI); the Northeast Energy Efficiency Partnerships (NEEP); the Consortium for Energy Efficiency (CEE); and equipment manufacturers. Another external influence is the availability of rebates from other sources. As we describe in Appendix A.1.6, the Massachusetts Clean Energy Center (MassCEC) offers sizable rebates for some of the same models of air source heat pumps as the program. If respondents received rebates from both the CEC and Mass Save,

[1] The HVAC Early Replacement (RES36) study examined early replacement rebates for residential HVAC equipment. Customers who apply for an early replacement rebate must go through the Home Energy Services (HES) core initiative or receive an AC Check. The TXC34 and RES36 teams coordinated data collection and measurement and analysis methodology where appropriate and possible.
[2] The logic model also includes a quality installation component that is outside the scope of this study.

the survey asked them to consider only the effects of the Mass Save rebates, not the CEC rebates.

Figure 1: Program Logic Model – Gas Measures

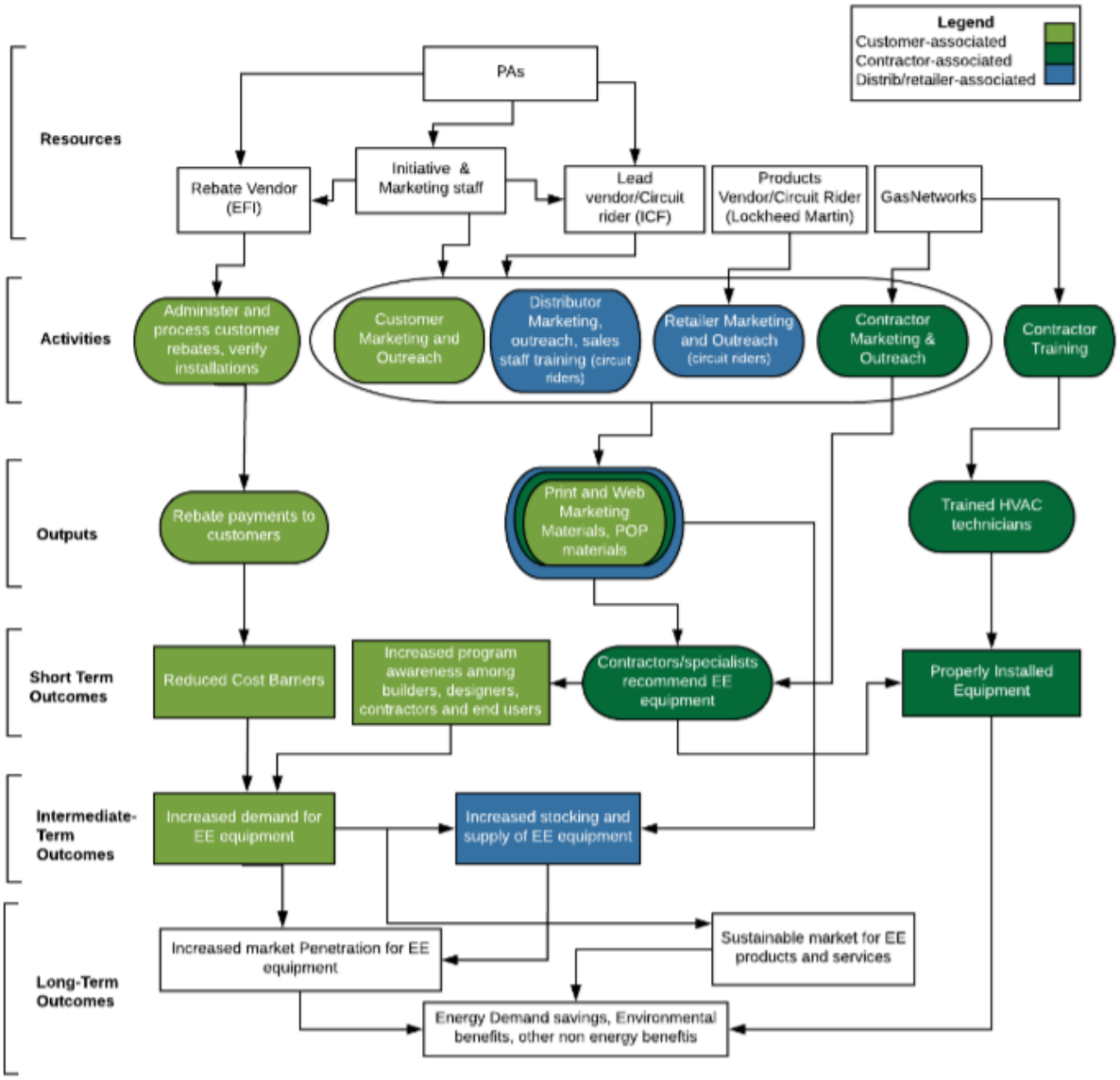
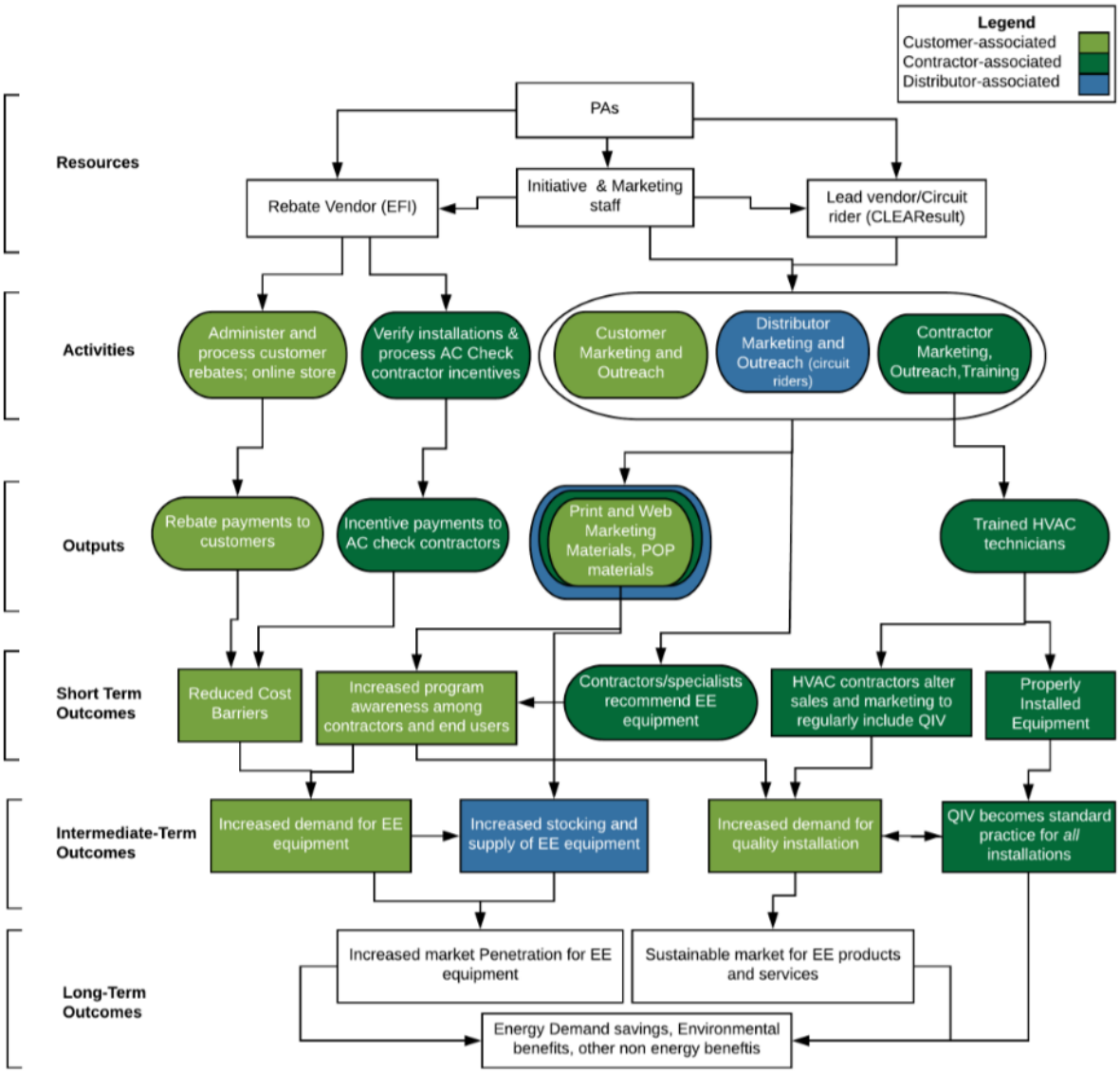


Figure 2: Program Logic Model – Electric Measures



1.4 Expected Program Changes

As the PAs explain in their Draft Three-Year Energy Efficiency Plan for 2019-2021, dated April 30, 2018, the Residential Heating and Cooling gas and electric initiatives will be redesigned and reorganized to better meet the core principle of the 2019-2021 program design, which is to keep the customer at the center of program design and evolution. Residential heating, cooling, and water heating equipment will continue to be supported with rebates through the new "Residential Coordinated Delivery" (RCD) and "Residential Retail" Initiatives. These initiatives will be fuel-blind, meaning customers can participate regardless of their current heating fuel type. The initiatives will potentially present customers with a broader array of rebate options for heating, cooling, and water heating equipment measures (as appropriate). These rebate options will be offered in conjunction with an HEA through RCD, directly through an HVAC contractor, and through retail and online outlets. Customers

and their contractors will be able to apply for equipment rebates as they had under the Residential Heating and Cooling gas and electric initiatives.

Streamlining the participant experience. Under the Residential Coordinated Delivery initiative, customers can expect more facilitated options to support them in making decisions to install high-efficiency heating, cooling, and water heating equipment, as well as other measures. To this end, the initiative will enhance relationships with trade allies to interact with customers at all entry points and help them to secure ancillary services. For example, the PAs are exploring new ways of partnering with such trade allies, including HVAC contractors and electricians. These new efforts may include helping customers secure service providers to eliminate barriers to installing certain measures, and inducements to encourage HVAC contractors and electricians to connect their customers to additional facilitated solutions the PAs plan to offer.

Improving customer education. To foster informed customer choices, customers participating in the Residential Coordinated Delivery initiative will also receive more education about their measure options and about available technology to help them operate their new systems optimally and efficiently.

2 Section 2 Research Methodology

For this study, the team conducted in-depth interviews with program staff and mixed-mode (web and telephone) surveys of customers and contractors. The team refined the NTGRs developed through this research via a "NTG Consensus Group" (i.e., a group of PA, EEAC, and consulting team representatives who come to a consensus on retrospective and prospective NTGRs). Each aspect of data collection served a specific purpose. The primary purpose of the interviews with program staff was to solidify our understanding of the program structure and inform evaluation planning. The primary purpose of the customer and contractor surveys was to collect inputs with which to develop initial estimates of NTGRs, and to establish initial measurements of market effects indicators with these market actors to use in future market effects evaluations. The surveys also obtained information about market shares and trends, established industry standard practices, and assessed the program's role in changes to standard practices. The surveys focused on customers who participated in the program in 2016 and the first part of 2017, and contractors who installed program equipment in 2016.

Table 2 shows the purpose of each data collection effort and the specific elements of NTG measured by each.

Table 2: Primary Purpose of Research Tasks

Task	n	Free-Ridership	Spillover	Market Effects	Program Information
In-depth interviews	5 PAs				✓
Participant surveys	346 end-users	✓	✓ (PSO)	✓	
Contractor surveys	166 participant contractors	✓	✓ (NPSO)	✓	
Consensus Group	3 constituent groups	✓	✓		

We based our decision to collect the elements of NTG from each group (as shown above) on previous Massachusetts studies:

- We considered the recommendations outlined in the 2011 Massachusetts study *Cross-Cutting Net to Gross Methodology Study for Residential Programs – Suggested Approaches*.[3] This study encourages the use of (1) self-report counterfactual customer and contractor surveys to measure free-ridership (FR) and spillover (SO) and (2) contractor and supplier interviews in comparison areas to measure market effects by gathering sales levels and market share of efficient

[3] NMR, Tetra Tech, and KEMA. "Cross-Cutting Net to Gross Methodology Study for Residential Programs – Suggested Approaches." July 20, 2011.

equipment. We conducted the former, but not the latter. This study also noted that conducting market sales data analysis of sales and shipment data is an ideal approach to measuring NTG, but acknowledges the difficulty of obtaining market-wide sales and shipment data. The study outlined key survey design elements that we employed, such as using multiple questions to limit potential for misunderstanding, incorporating consistency check questions, and allowing for the capture of partial FR and SO (e.g., quantities, efficiency level, and timing).

- In 2012, Cadmus estimated NTGRs for four of the same equipment types: DMSHPs, CAC, furnaces, and boilers in their *Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing* report.[4] They also estimated an NTGR for water heaters, but we looked at HPWHs, specifically, for TXC34. They did not study CHPs. We looked to their NTG estimation method as a guide to remain consistent. The most notable difference was the addition of PSO and contractor FR in TXC34 (described in Section 3).

When applicable, we coordinated our fielding and analysis methods with the HVAC Early Replacement study (RES36), which was undertaken concurrently by the Navigant Residential HVAC evaluation team. For example, we jointly fielded our contractor surveys. We also studied each other's NTG analysis methodology to make the studies' approaches as consistent as possible, given the inherent differences between how Standard and Early Replacement HVAC rebates are administered and the differing goals of the two studies.

2.1 In-Depth Interviews

In July 2017, NMR conducted a total of two roundtable interviews via web and phone with six PA representatives who were involved with the management of the programs. The interviewees included program managers representing Cape Light Compact, Columbia Gas, Eversource, National Grid, and Unitil.[5] Most interviewees had been involved with their companies' residential HVAC programs for between two and five years and were responsible for other programs, as well as for one or more of the Residential Heating and Cooling gas and electric initiatives.[6]

As part of the interviews, we presented interviewees with the logic models created for the initiatives in 2014 and asked for help in refining and updating them. In addition to updating and improving the logic models, we used the information from the interviews to ensure that we could design the customer and contractor surveys in a way that accurately reflected the current structure of the initiatives from the perspectives of these audiences.

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[4] The Cadmus Group, Inc. "2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing." June 2013.
[5] The TXC34 PA Study Lead also attended one of the roundtables but did not share program information. One of the National Grid interviewees focuses on program strategy and is not specifically a program manager.
[6] We originally planned to include interviews with program implementation vendors in this task; however, PA representatives' responses were comprehensive enough that we deemed it unnecessary. Instead, we emailed implementation vendors – CLEAResult, Lockheed Martin, and ICF – the program logic models and a description of our understanding of the program; they confirmed that our depictions were correct.

2.2 CONTRACTOR SURVEYS

In December of 2017 and January of 2018, the team surveyed a sample of 166 participating Standard (i.e., not Early Replacement) program contractors by telephone and web. To maximize the representativeness of our results, we focused our initial recruiting on the most active contractors, based on number of program units installed, and contractors who had installed the least common measures (CHPs and CACs). Due to poor response rates after many contact attempts over several weeks, we ultimately attempted surveys with all participating contractors, resulting in a simple random sample. To limit survey fatigue, we conducted NTG batteries for up to two measures with each respondent. At the start of fielding, contractors who had installed more than two measure types were asked about the measures they installed that were less common in the sample frame. Though infrequent, it meant that a few of the very active furnace, boiler, and DMSHP contractors were not asked about those measures when they responded to the survey.

Table 3 shows sampling error by measure for contractor non-participant spillover (NPSO). The absolute sampling error ranged from 11% to 15% across measure types, with the exception of CHPs (20%). Throughout this report, sample sizes vary because some contractors terminated the survey after answering NTG questions, or gave answers that appeared to be invalid, implying that they misunderstood some questions. We weighted survey responses by the number of standard rebated units that contractors verified installing, unless noted otherwise.

Table 3. Contractor Survey Non-Participant Spillover Sampling Error

Measure	Surveyed Population[1]		Total Population		Sampling Error (90% CI)	
	Contractors	Rebates[2]	Contractors	Rebates	Absolute	Relative
DMSHP	51	458	995	7,757	11%	23%
HPWH	41	82	970	1,633	13%	25%
CAC	28	287	315	2,256	15%	30%
CHP	16	46	118	311	20%	39%
Furnace	42	165	804	3,891	13%	25%
Boiler	49	127	1,640	4,520	12%	23%

[1] Counts include those completing NPSO module (intended as the key contractor-derived NTG contribution).
[2] Represent the verified number of Standard program rebates submitted by each contractor.

The contractor population consisted of 3,191 unique contractors who had installed at least one rebated Standard program unit (for the measures of interest) in the 2016 EFI project database. Removing records without usable contact information resulted in a sample frame of 2,741 Standard program contractor contacts – a 14% loss of potential contacts. The amount of work required to clean the contractor data to develop a sample for evaluation purposes demonstrates the need for a better system of tracking contractor contact information (such as consistently using unique company *and* contact identification numbers).

The response rate across all measures was 9%.[7] Table 4 shows sample disposition and response rate by measure.

Table 4. Contractor Survey Disposition and Response Rate by Measure

Disposition	DMSHP	HPWH	CAC	CHP	Furnace	Boiler	Total
Request call back	167	108	59	27	157	234	**469**
Completed[1]	79	51	32	18	57	69	**166**
Not familiar	18	28	5	3	17	30	**70**
No response	377	370	109	31	251	446	**1,097**
Refused	154	136	56	16	130	195	**436**
Screened out	34	24	11	5	26	47	**95**
Timed out online	5	3	3	4	4	3	**7**
Total contacted[2]	**834**	**720**	**275**	**104**	**642**	**1024**	**2,340**
Response Rate	**9%**	**7%**	**12%**	**17%**	**9%**	**7%**	**9%**

[1] Includes those who may have completed the survey but were not included in the NPSO analysis due to invalid responses.
[2] Table excludes contacts whose dispositions implied they did not receive an email, voice message, or any type of "successful" contact (e.g., no answering service and email bounce back). Contractors may have installed more than one measure type through the standard rebate program, so columns sum to more than the Total. Respondents were not necessarily asked about each measure type they verified installing through the program.

2.3 PARTICIPANT SURVEYS

At the same time as the contractor survey, the team fielded surveys with customers who had received program rebates in 2016 and early 2017. While we invited most participants to respond to the web-based survey via email, we made a few exceptions: our pre-test effort used letters to invite 100 participants to respond online; CHP participants did not have email addresses in program data, so we mailed them invitations; and we conducted telephone calls with less responsive strata and telephone callbacks with some participants who had initially screened out of the survey (explained below).

We asked each participant about up to two measure types. We weighted survey responses by the number of units that participants verified installing, unless noted otherwise.

Table 5 shows sampling error by measure for FR. Absolute sampling error ranged from 9% to 13% across measure types. Throughout this report, sample sizes vary because some participants terminated the survey after answering NTG questions or may have given invalid responses.

[7] Response rates are the ratio of completed surveys to number of contractors "successfully" reached, such as contacts with delivered emails without bounce back.

Table 5. Participant Survey Free-Ridership Sampling Error

Measure	Survey Completes[1]		Total Population		Sampling Error (90% CI)	
	Participants	Units[2]	Participants	Units	Absolute	Relative
DMSHP	66	85	8,169	10,539	10%	20%
HPWH	79	80	1,967	2,054	9%	18%
CAC	66	72	2,653	2,920	10%	20%
CHP	35	41	385	423	13%	27%
Furnace	61	68	4,435	4,866	11%	21%
Boiler	60	69	6,181	7,071	11%	21%

[1] Counts include those completing FR module (intended as the key participant-derived NTG contribution).
[2] Represent the number of units the participant verified installing.

One key takeaway from the program staff interviews was that it may be difficult for customers to discern the difference between the HES energy specialist who conducted their HEA and the HVAC installation contractors who may facilitate or promote the rebates. For this reason, we initially elected to limit the chances of double counting by excluding customers who had participated in HES or received Early Retirement incentives (which we discerned through the program database) from the sample frame. However, after we began fielding the survey, we found that many HES participants remained in the sample frame, primarily because the program rebate data did not reflect their participation in previous years.[8] Given this, as well as concerns that we may be excluding an important subset of participants, it was decided mid-fielding that we should include HES participants in the sample after all. We modified the survey instrument to this end and re-contacted participants who had previously been screened out (because they self-reported as HES participants), offering them a $10 Amazon gift card as an apology for the inconvenience. We did not reach everyone who had been screened out, and ultimately the final sample underrepresented HES participants, especially those who installed electric measures. Table 6 shows the percentage of participating customers who reported receiving an HEA through HES. In Appendix A.1.4, we discuss differences between HES and non-HES respondent FR and why we believe that the differences between the groups do not warrant concern.

[8] Additionally, at the time of survey fielding, the RES36 Early Replacement study was conducting surveys with early replacement program participants. We excluded participants who received any type of early replacement measure from our sample to reduce confusion and the chances of angering customers. We also excluded participants who appeared to be commercial customers.

Table 6: Percentage of HVAC Participants Receiving Home Energy Assessments

Program Measures	Population		Completes (self-reported)	
	N	Percentage	n[1]	Percentage
Ductless MSHP	8,169	61%	66	35%
Heat pump water heater[2]	1,967	48%	79	3%
Central air conditioning system	2,653	58%	66	18%
Central heat pump	385	55%	35	20%
Warm air furnace	4,435	35%	61	26%
Boiler	6,181	37%	60	30%

[1] Counts include those completing FR module (intended as the key participant-derived NTG contribution).
[2] HPWH response rates were excellent from the start and the stratum closed early, so we did not include them in the HES callbacks.

Across all measures, the participant response rate was 8%.[9] Because response rates were initially very low, we took the opportunity during follow-up calls to ask participants why they had not yet responded to the survey; they said they either had not noticed the email or letter or simply had not gotten around to it. Table 7 shows survey disposition and response rates by measure. Six respondents reported installing the measures but were not aware of receiving a rebate for them. These respondents are excluded from sampling error calculations but included in these response rates since they completed the survey, despite being excluded from NTG analysis.

Table 7. Participant Survey Disposition and Response Rate by Measure

Disposition	DMSHP	HPWH	CAC	CHP	Furnace	Boiler	Total
Requested callback	0	0	11	15	13	4	29
Completed[1]	69	83	74	37	63	60	346
No response	769	639	606	98	971	1,138	3,961
Refused	1	1	9	9	9	4	23
Screened out[2]	2	27	2	2	5	3	38
Timed out online	22	24	10	16	8	18	90
Unsubscribed	1	1	4	1	3	1	11
Total contacted[3]	**864**	**775**	**716**	**178**	**1,072**	**1,228**	**4,498**
Response Rate	**8%**	**11%**	**10%**	**21%**	**6%**	**5%**	**8%**

[1] Includes respondents who may not have been included in the NTG analysis but did complete the survey.
[2] Respondents were screened out if they were not familiar with the installation and/or were unable to connect us with household members who were. HPWH screen out includes the HES respondents who were initially excluded.
[3] Table excludes contacts whose dispositions implied they did not receive an email, voice message, or any type of "successful" contact (e.g., no answering service and email bounced back). Participants may have installed more than one measure type, so columns sum to greater than the Total.

[9] Response rates are the ratio of completed surveys to number of contractors "successfully" reached, such as contacts with delivered emails without bounce back.

2.4 CONSENSUS GROUP

After analyzing the data collected and developing a series of NTGR recommendations using a variety of methods, the team presented the ratios to a Consensus Group of PA, EEAC, and NMR Cross-cutting evaluation team representatives with options for consideration. The primary strength of the consensus approach to estimating NTG is the balancing of the diverse set of strengths, weaknesses, potential biases, and threats to validity associated with the various individual methods used to estimate NTG. Relying on a single approach to estimating NTG comes with its own limitations; however, drawing on estimates from multiple approaches requires a consensus group to consider, weigh, and triangulate the different methods based on their relative strengths and shortcomings.

In early February 2018, the team issued a memo to the Consensus Group with the following information:

- Preliminary NTG estimates drawing on results from participant and contractor surveys (Sections 3.1 through Section 3.5)
- Contractors' estimates of program market effects on the Massachusetts HVAC market (Section 3.6)
- NTG estimates from residential rebate program evaluations carried out in other jurisdictions (Appendix A.1.6)
- Recent and upcoming changes in federal standards, ENERGY STAR specifications, and Consortium for Energy Efficiency (CEE) tiers for residential HVAC equipment (Appendix A.5)

After reviewing the memo, Consensus Group members requested additional analysis. After several iterations, the team ultimately presented three NTG "options" to the Consensus Group. Each constituent group (PAs, EEAC, and evaluators) then developed retrospective and prospective NTG estimates by equipment type, offering explanations for each of their recommendations. NMR collected and compiled each constituent group's estimates and facilitated a webinar to review and discuss the results. The webinar compared each constituent's responses by measure and offered them the opportunity to discuss the rationales behind their recommendations. During this webinar, the group members achieved agreement on retrospective 2016 NTG estimates and prospective 2019-2021 NTG estimates. Section 3.7 outlines the reasoning behind the Consensus Group's recommendations.

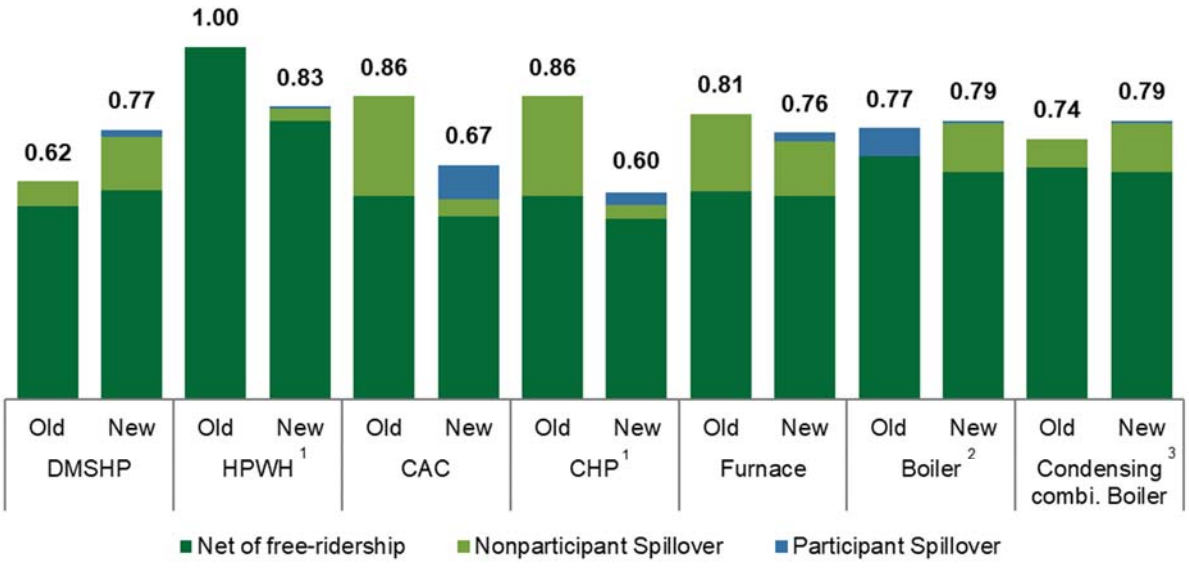
3 Section 3 Net-to-Gross Results

Figure 3 presents the 2019-2021 NTGRs resulting from this study. These ratios are based on four inputs: (1) estimates of free-ridership (FR) among participating customers (participants) adjusted by (2) estimates of participating contractors, (3) non-participant spillover (NPSO) among participating contractors, and (4) participant spillover (PSO) among participating customers. We used the following formula:

$$NTGR = (1 - FR) + NPSO + PSO$$

Figure 3 compares the 2019-2021 NTGRs developed by the Consensus Group with those of the 2016-2018 TRM. The NTGRs in the TRM for DMSHP, CAC, furnaces, and boilers come from Cadmus's 2012 *Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing* study.[10] The TRM assumed an NTGR of 1.0 for HPWHs and set the CHP NTG equal to that of CACs. The 2019-2021 NTGRs for DMSHPs and boilers have increased from 2016-2018. NTGRs for HPWHs, CAC, CHPs, and (to a lesser extent) furnaces have decreased from 2016-2018.

Figure 3: 2019-2021 Net-to-Gross Recommendations Compared to 2016-2018 Technical Reference Manual



[1] HPWH and CHP were not studied in 2012.
[2] The TRM NTG for 85% AFUE hot water boilers (0.76) is slightly higher than 90% AFUE boilers (0.77).
[3] TXC34 did not study combination boilers separately from hot water boilers.
Old refers to 2016-2018 TRM values and *New* refers to the recommended 2019-2021 values

Table 8 shows FR, NPSO, and PSO by measure. The following subsections describe how we estimated these inputs and came to these recommendations.

[10] The Cadmus Group, Inc. "2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing." June 2013.

Table 8: Recommended Free-Ridership, Spillover, and Net-to-Gross Ratios
(2019-2021)

Program Measures	FR	NPSO	PSO	NTGR[1]
Ductless MSHP	0.41	0.15	0.02	**0.77**
Heat pump water heater	0.21	0.04	0.01	**0.83**
Central air conditioning	0.48	0.05	0.10	**0.67**
Central heat pump	0.47	0.04	0.02	**0.60**
Warm air furnace	0.42	0.16	0.02	**0.76**
Boiler	0.35	0.14	0.01	**0.79**

[1] Values do not always sum due to rounding.

3.1 PARTICIPANT FREE-RIDERSHIP

To estimate FR, we began by estimating retrospective FR among participants. Table 10 shows the FR results. Leveraging the approach taken in Cadmus's 2012 NTG study, we calculated participant FR as a function of three credits: efficiency, timing, and quantity. The values of the credits range from 0% to 100%, where 0% is associated with the highest FR and 100% is associated with the lowest FR. Those fractions are inversed in the FR calculations themselves. Figure 4 illustrates the algorithm in full.

We applied four sensitivity methods, which toggled between maximum and mean scoring and leniency with timing credits as shown in Table 9. Methods 1 and 3 applied the maximum likelihood and influence scores into the efficiency credit, and Methods 2 and 4 applied the *mean* scores. Methods 1 and 2 use increments of 0%, 50%, and 100% when establishing the timing credit, but Methods 3 and 4 more leniently assigned 66% instead of 50% for the partial timing score.

Table 9: Participant Free-Ridership – Sensitivity Analysis Methods

Input	Method 1	Method 2	Method 3	Method 4
Influence scores/rating	Maximum	Average	Maximum	Average
Timing credit for units that would have been replaced within 6-12 months	50%	50%	66%	66%

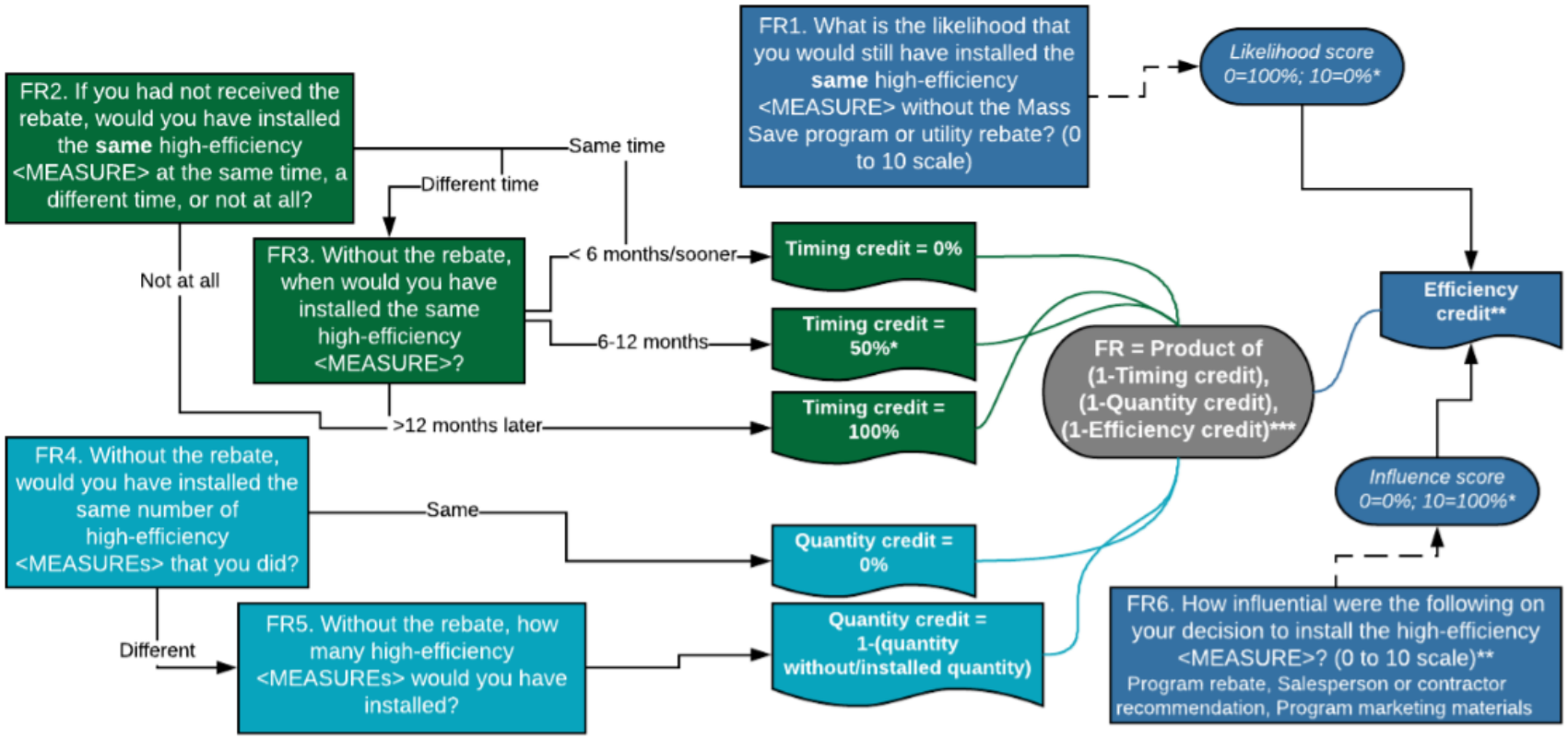
The results from Methods 3 and 4 did not differ from those from Methods 1 and 2, respectively, so we excluded them from further analysis. **The Consensus Group agreed to use the Maximum Method alone because, in their opinion, the Means Method unfairly penalized the program.** Section 3.3 explains the rationale behind this decision. This approach is consistent with the industry trend towards using a maximum versus mean scoring approach.

Table 10: Participant Free-Ridership Results

Program Measures	n[1]	Quantity (units)	FR by Sensitivity Method		
			Maximum Method (1)	Means Method (2)	Average
Ductless MSHP	66	85	0.21	0.51	**0.36**
Heat pump water heater	79	80	0.08	0.21	**0.14**
Central air conditioning	66	72	0.23	0.57	**0.40**
Central heat pump	35	41	0.31	0.54	**0.43**
Warm air furnace	61	68	0.15	0.44	**0.29**
Boiler	60	69	0.11	0.32	**0.21**

[1] The sample underrepresented HES participants despite a mid-fielding pivot (Section 2.2), but this did not appear to impact FR results (Appendix A.1.4).

Figure 4: Participant Free-Ridership Algorithm



* Two sensitivity analysis methods apply a timing credit of 66% instead of 50%. Influence/likelihood scores incrementally change by 10% per rating point.
** Depending on the sensitivity analysis, we use maximum or average influence/likelihood scores.
*** If participants installed only one measure through the program, the quantity credit will be excluded from the formula

3.2 CONTRACTOR FREE-RIDERSHIP

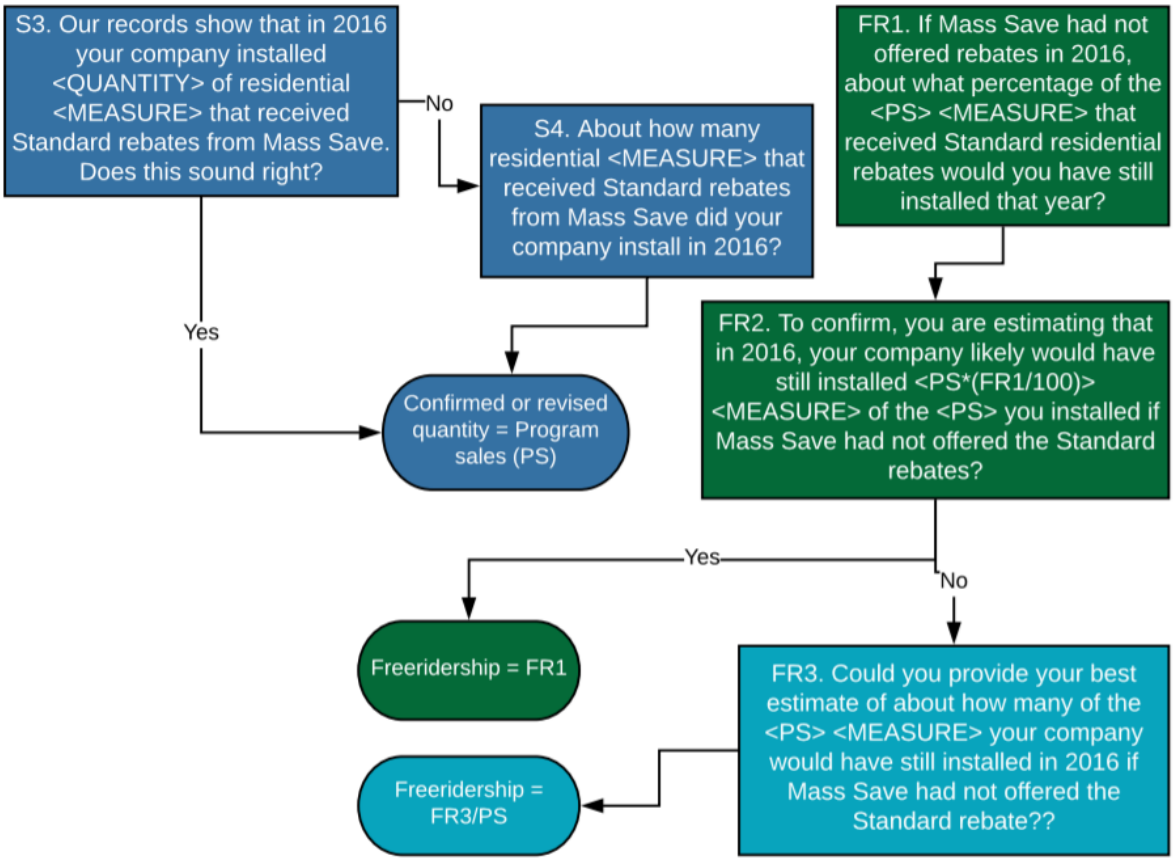
Next, we estimated retrospective FR among participating contractors. After confirming their 2016 program sales, contractors estimated the percentage of program sales that would have occurred had program rebates not been offered. Some contractors struggled to interpret these questions; we excluded these contractors from the NTG analysis or revised their responses if needed and appropriate. (See Appendix A.1.3.2 for details.) Table 11 shows the results of these calculations, weighted by the quantity of program units that contractors verified installing. Figure 5 maps the algorithm.

Table 11: Contractor Free-Ridership Results

Program Measures	n	Sum of 2016 Verified Program Sales (units)	Weighted FR
Ductless MSHP	53	462	**0.50**
Heat pump water heater	38	80	**0.32**
Central air conditioning	23	260	**0.58**
Central heat pump	16	44	**0.58**
Warm air furnace	33	256	**0.53**
Boiler	34	108	**0.41**

[1] Respondents who did not appear to understand the question series were removed from the analysis; therefore, sampling error for some measures changed for this module: absolute sampling error increased to 16% for CHPs and 14% for furnaces and boilers.

Figure 5: Contractor Free-Ridership Algorithm



3.3 CONTRACTOR FREE-RIDERSHIP ADJUSTMENT

While contractor FR was notably higher than customer FR, and contractor FR sample sizes were small, customers' responses emphasized the importance of contractors' recommendations to the customers' decision-making processes. Therefore, we explored adjusting participant FR by contractor FR. We used six different methods for this exploration, which we refer to as Methods A through F. Methods A through D adjust the participant FR resulting from averaging the Maximum and Means Method results. Methods A and B set high thresholds for adjusting participant FR. As Figure 6 shows, we developed three adjusted FR options using the averages of two of each of the methods. The methods are as follows:

- **"Selected Equipment Method" (A).** This method conservatively follows NMR's 2010 approach in the *Massachusetts High-Efficiency Heating Equipment (HEHE) Process and Impact*[11] study. Participants who said they did their own research and selected their equipment, or whose contractor presented them with a variety of models and they (the participants) chose which model to install, kept their original FR rate. In

[11] NMR Group, Inc., "HEHE Process and Impact Evaluation," Submitted to *GasNetworks*, October 27, 2010, http://ma-eeac.org/wordpress/wp-content/uploads/High-Efficiency-Heating-and-Water-Heating-Program-Process-and-Impact-Evaluation-Final-Report.pdf.

cases where the contractor presented the participant with just one model, and they selected that model, we averaged the participant's FR with the overall contractor FR.[12]

- **"Top Rating Method" (B).** If a participant rated the salesperson or installation contractor's recommendations a 10 on the 0 to 10 importance scale and did not provide a rating of 10 for either the program rebate or marketing materials, then the contractor FR replaced that participant's FR.

Methods C through F lowered the threshold for adjusting participant FR with contractor FR.

- **"Selected or Recommended Equipment Method" (C).** This method mimics NMR's 2010 approach in the *Massachusetts High-Efficiency Heating Equipment (HEHE) Process and Impact* study. Participants who said they did their own research and selected their equipment kept their original FR rate. For those who said that the contractor presented them with a variety of models and they (the participants) chose which model to install, we averaged their FR with the overall contractor FR rate. Finally, in cases where the contractor selected and presented the participant with just one model, we replaced the participant's FR with the overall contractor FR.
- **"High Rating Method" (D).** If a participant rated the salesperson or installation contractor's recommendations a 7 or higher on the 0 to 10 importance scale, then the contractor FR replaced that participant's FR.
- **"Selected or Recommended Method" (E).** The general approach was similar to Method C. As with Method C, participants who said they did their own research and selected their equipment kept their original FR rate. For those who said that the contractor presented them with a variety of models and they (the participants) chose which model to install, we averaged their FR with the overall contractor FR rate. If the contractor selected and presented the participant with just one model, we replaced the participant's FR with the overall contractor FR. The difference from Method C is that the original participant FR rate that we considered for adjustment was that of participant FR Method 1, the *maximum* method, only (not the average of Methods 1 and 2).
- **"High Rating Method" (F).** This was similar to Method D. As with Method D, if a participant rated the salesperson or installation contractor's recommendations a 7 or higher on the 0 to 10 importance scale, then the contractor FR replaced that participant's FR. However, like Method E, the original participant FR rate that we considered for adjustment was that of participant FR Method 1, the *maximum* method only.

[12] Figure 12 in Section 5.1 illustrates their responses.

Figure 6: Free-Ridership Adjustment Methods

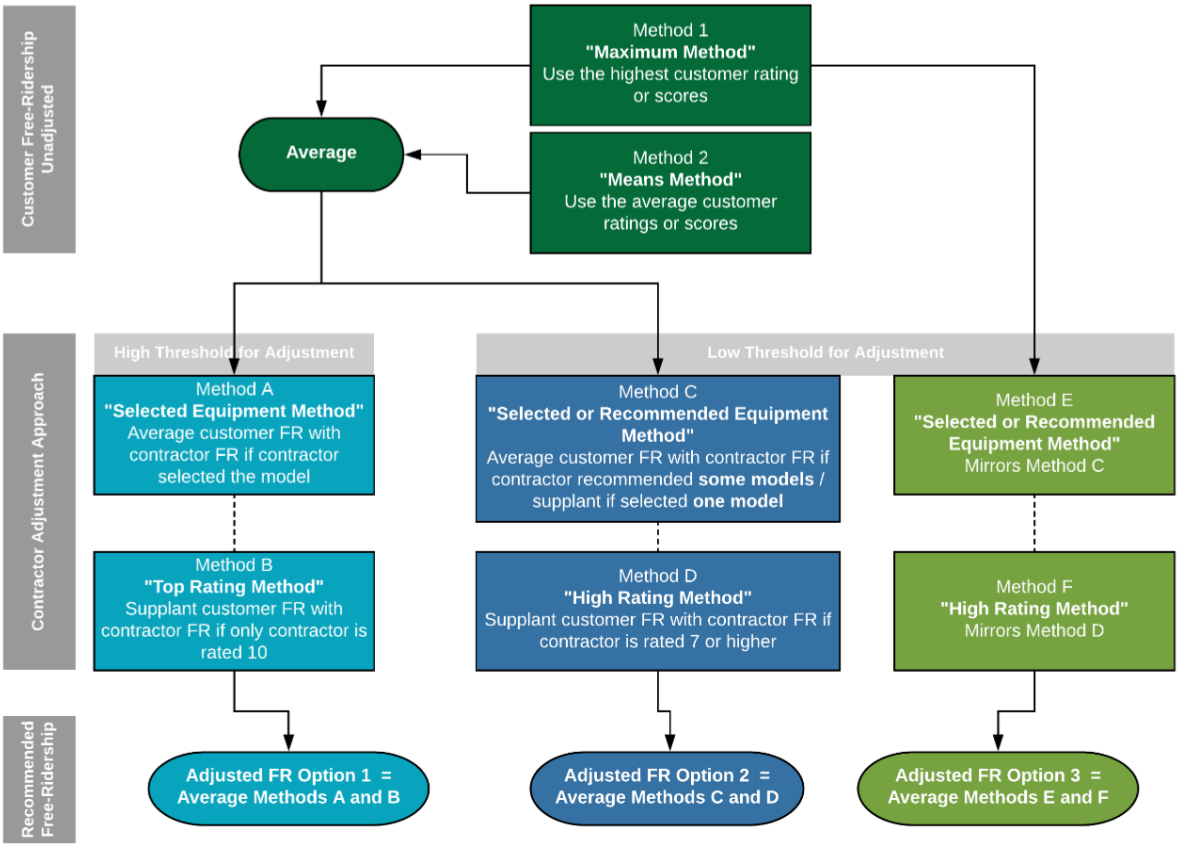


Table 12 shows the adjusted FR resulting from each of the three options. **The Consensus Group favored the Adjusted FR Option 3, which averages two low-threshold adjustment methods (E and F) after they have been applied to the participant FR Maximum Method.** There were two primary reasons for this decision:

1. **Averaging the means in Options 1 and 2 unfairly penalizes the program.** While the participant might attribute a great deal of importance to the program rebate, they could still give a low rating to the importance of program materials for any number of reasons, such as not being well emphasized or compelling. (Indeed, the program materials consistently received the lowest rating of importance to decision-making.) Averaging the participants' assessments of the rebates with those of the materials would lessen a high rating for the rebate, the key feature of the program.
2. **The Top Rating Method (B), which is incorporated into Option 1, does not strike an adequate balance between participant and contractor perspectives.** Many participants assigned a great deal of influence to the contractor. Using the Top Rating Method would undervalue the contractors' influence and not adequately reflect contractors' assessments of the program's importance. In the words of one Consensus Group member, Option 1 would "ascribe high program influence in a fair number of cases when all that is really going on is that the contractor is doing business as usual, and the participant is doing what the contractor recommends."

Table 12: Free-Ridership Results – Adjusted with Contractor Estimates

Program Measures	Contractor Adjustment Method		
High Threshold Adjustments[1]			
Adjusted FR Option 1: Averaging *Maximum* and *Means Methods*	**Selected Equipment (A)**	**Top Rating (B)**	**Average A and B**
Ductless MSHP	0.38	0.39	**0.39**
Heat pump water heater	0.17	0.14	**0.16**
Central air conditioning	0.42	0.44	**0.43**
Central heat pump	0.46	0.45	**0.46**
Warm air furnace	0.34	0.32	**0.33**
Boiler	0.27	0.22	**0.24**
Low Threshold Adjustments[2]			
Adjusted FR Option 2: Averaging *Maximum* and *Means Methods*	**Selected or Recommended (C)**	**High Rating (D)**	**Average C and D**
Ductless MSHP	0.42	0.48	**0.45**
Heat pump water heater	0.21	0.25	**0.23**
Central air conditioning	0.49	0.57	**0.53**
Central heat pump	0.52	0.56	**0.54**
Warm air furnace	0.45	0.47	**0.46**
Boiler	0.37	0.39	**0.38**
Adjusted FR Option 3: Averaging *Maximum Methods*	**Selected or Recommended (E)**	**High Rating (F)**	**Average E and F**
Ductless MSHP	0.36	0.45	**0.41**
Heat pump water heater	0.19	0.23	**0.21**
Central air conditioning	0.43	0.53	**0.48**
Central heat pump	0.46	0.52	**0.49**
Warm air furnace	0.40	0.44	**0.42**
Boiler	0.34	0.37	**0.35**

3.4 NON-PARTICIPANT SPILLOVER

Table 13 shows contractor self-reported program-eligible non-program sales and the resulting NPSO by the sensitivity methods described in Appendix A.1.2. Some contractors appeared to struggle to interpret these questions, so we excluded these contractors from the analysis or revised their responses (Appendix A.1.3.2). We used the average value across the four sensitivity methods (described below) because of the degree of variation of results across methods for some measures. Figure 7 depicts our methodology for calculating NPSO among participating contractors.

Results indicate that there is program influence on sales outside the program. This is particularly true when it comes to furnaces, DMSHPs, and boilers, for which NPSO are 0.16, 0.15, and 0.14, respectively. Contractors often explained that program-eligible non-program

installations do not receive program rebates because customers who were influenced by the program do not follow through with the application process.

Table 13: Contractor Non-Participant Spillover Results

Program Measures	n	Non-program Sales (units)[1]	NPSO by Sensitivity Method[3]				Average NPSO across Methods (Recommended)
			Method 1	Method 2	Method 3	Method 4	
DMSHP[2]	51	153	0.23	0.16	0.15	0.08	**0.15**
HPWH	41	14	0.08	0.05	0.01	0.00	**0.04**
CAC	28	22	0.06	0.05	0.05	0.04	**0.05**
CHP	16	8	0.05	0.05	0.05	0.04	**0.04**
Furnace	42	81	0.25	0.17	0.14	0.07	**0.16**
Boiler	49	63	0.23	0.14	0.11	0.06	**0.14**

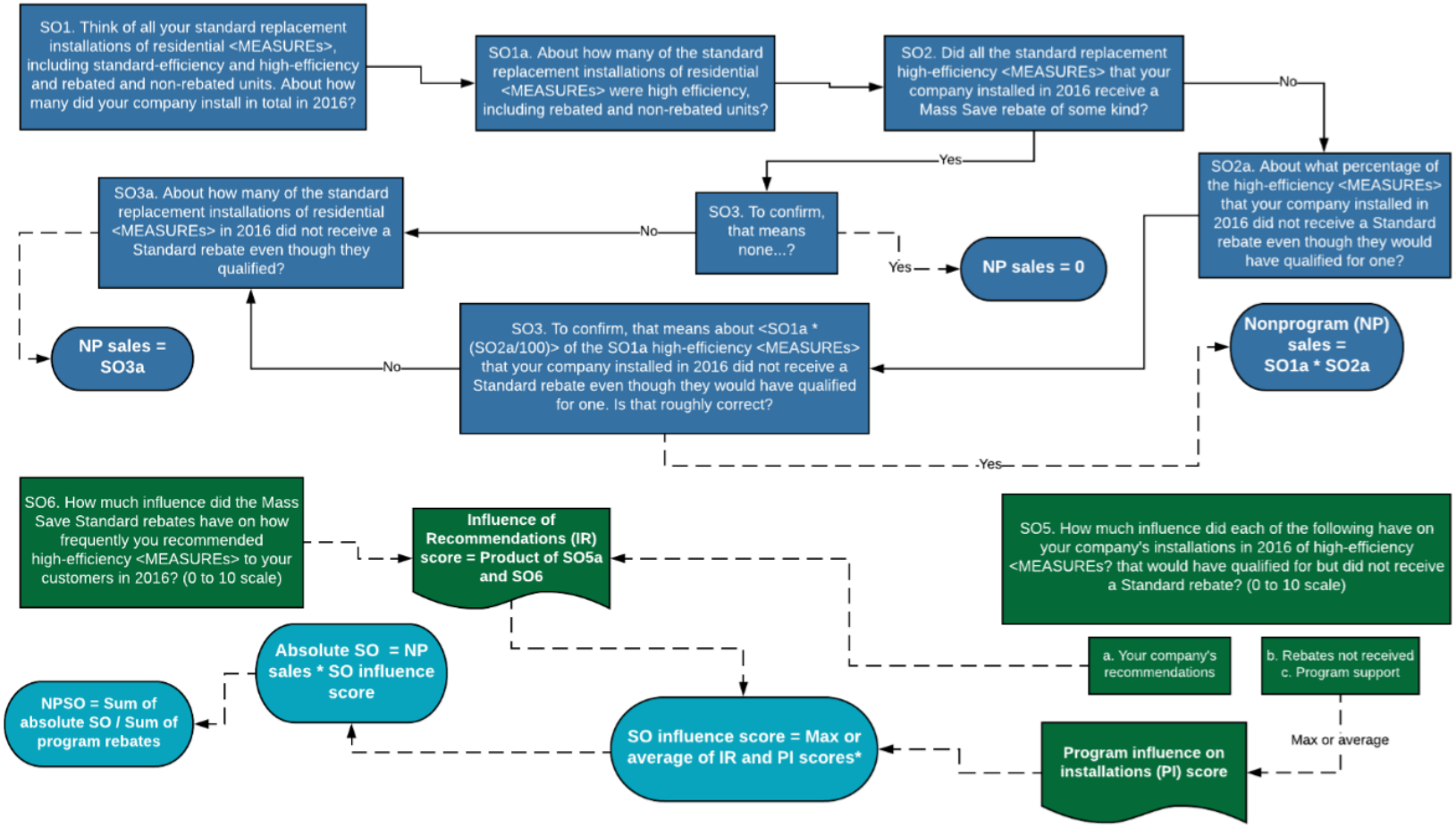
[1] Refers to *program-eligible* non-program sales.
[2] Fewer DMSHP contractors answered this question compared to the FR series because some discontinued the survey after answering the FR series. This did not affect precision.
[3] Sensitivity analysis methods toggle between using maximum and mean scoring and the thresholds for assigning those scores.

The methodology modifies the 2012 approach. NPSO is a function of the number of non-program unit sales by contractor respondents (i.e., total high-efficiency unit sales that did not receive program rebates) and the level of influence that the program had on the non-program sales. After calculating contractors' 2016 non-program sales, we applied their responses to other questions to produce three scores:

- **Influence of Recommendations (IR)**. Using responses to two 0 to 10 rating questions, the IR score is a function of the program's influence on the frequency with which contractors recommend high-efficiency equipment *and* the influence of their own recommendations on their high-efficiency non-program sales.
- **Program Influence (PI) on Installations**. Using responses to another 0 to 10 rating question, we associate the PI score with the level of influence on their sales that contractors report is from program rebates and support, such as marketing.
- **Spillover Influence**. Depending on the sensitivity method described below, this is either the maximum or average of the IR and PI scores, and directly funnels into the absolute spillover.

As noted, we calculated IR and PI scores using contractors' responses to influence questions with a 0-to-10 response scale. In this scale, 0 equals 0.0 and 10 equals 1.0; interim ratings (1 to 9) vary by sensitivity method. We then calculated Absolute SO for each respondent by measure type, multiplying their non-program sales by the SO Influence score. After summing Absolute SO across all respondents, we divided it by the sum of program sales across all respondents who were asked about the measure. The result is the NPSO.

Figure 7: Non-Participant Spillover Algorithm (Participating Contractor Survey)



* Depending on the sensitivity analysis method, we apply either the average or maximum values from SO5b and SO5c for the PI score and IR and PI scores for the SO influence score.
IR, PI, and Influence scores range from 0 to 1. Ratings of 0 (no influence) are equal to 0 and ratings of 10 (a great deal of influence) are equal to 1; ratings between vary by sensitivity method.

3.5 PARTICIPANT SPILLOVER

After receiving a program rebate, customers might install additional energy-efficient measures. If these measures do not receive any type of rebate and customers' decisions to install them are influenced by their experiences with the program, some programs claim the savings, which are referred to as Participant Spillover (PSO). There are two types of PSO: *like* and *unlike*. Like PSO refers to situations in which customers install additional measures of the same type as those that received a rebate through the program. Unlike PSO refers to situations in which customers install different types of energy-efficient measures than those supported by the program (e.g., installing an energy-efficient clothes washer after receiving a rebate for installing an energy-efficient HPWH).

For this study, the evaluation team followed the approach outlined in the Illinois 2017 TRM[13] to account for like and unlike retrospective PSO among participants. This approach had two steps: (1) summing the savings[14] associated with SO-eligible measures and (2) dividing that by the sum of savings associated with the installed measures in the survey sample. Table 14 presents PSO results. We found some PSO. The PSO rate among CAC participants (0.10) was relatively high, largely due to one respondent who reported that the program influenced them to make several upgrades, including air and duct sealing and installations of insulation and ENERGY STAR appliances.

Table 14: Participant Spillover Results

Program Measures	n[1]	Program Savings (kWh)[2]	Spillover Savings (kWh)	Spillover Rate
Ductless MSHP	65	26,620	528	**0.02**
Heat pump water heater	79	132,320	711	**0.01**
Central air conditioning	66	14,313	1,386	**0.10**
Central heat pump	35	31,640	733	**0.02**
Warm air furnace	61	173,632	4,050	**0.02**
Boiler	60	262,410	1,876	**0.01**

[1] One ductless MSHP participant discontinued after answering the FR series, but it did not affect precision.
[2] Program savings estimates are associated with all participants who answered spillover questions.

Figure 8 illustrates the key components involved in determining eligibility. After identifying unrebated measures that were potentially influenced by the program, we asked two influence questions. The first asked participants to rate the importance of the program's influence was on their decision to install the unrebated measure using a 0 to 10 scale, where 0 is *not at all important* and 10 is *very important*. The second asked them to rate how likely they would

[13] *Illinois Statewide Technical Reference Manual for Energy Efficiency*, Version 6.0, s.v. "4.1.2 Participant Spillover," February 8, 2017, http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_6/Final/IL-TRM_Version_6.0_dated_February_8_2017_Final_Volumes_1-4_Compiled.pdf
[14] Savings come from the MA TRM and secondary research. Where uncertain, we conservatively modified those savings with assumptions that non-program measures would likely not be as efficient as program measures and/or needed to speculate on home size or other key inputs.

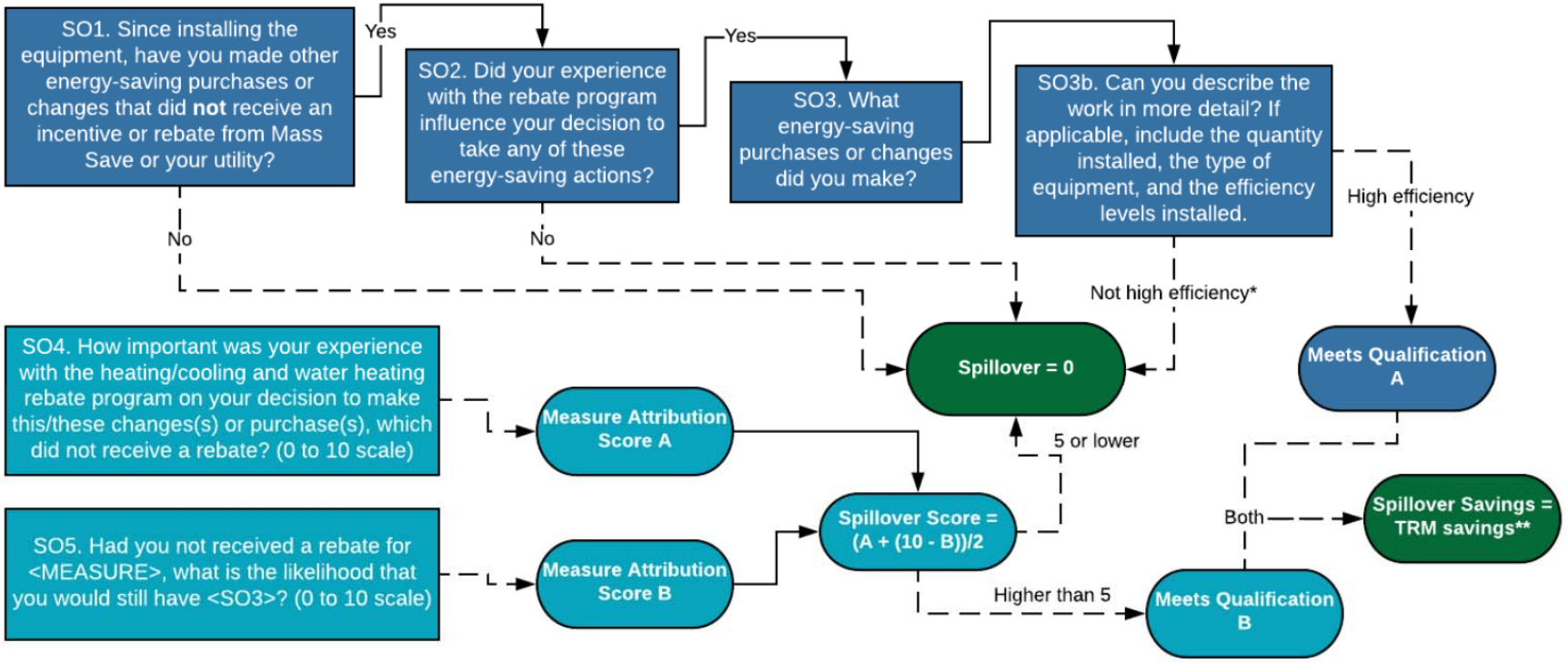
have been to install the unrebated measure (without their experience with the program) using a 0 to 10 scale, where 0 is *definitely would not have made the improvements* and 10 is *definitely would have made the improvements*.

For a measure to be SO-eligible, two qualifications (A and B) needed to be met:

- **Qualification A**. Non-rebated measures that either meet program specifications or are more efficient than federal standards (where applicable) meet Qualification A.
- **Qualification B**. The average of the participants' ratings for the program's importance and inverse likelihood ratings (on scales of 0 to 10) assigns the measure an SO Score. In line with the Illinois cut point, if the SO Score is higher than 5, then the measure meets Qualification B.

Appendix A.1.5 lists the reported spillover measures and their associated savings.

Figure 8: Participant Spillover Algorithm



* Efficiency specifications use TRM specifications for measures eligible for PA programs. For measures not offered by the PAs, we sought to determine if the measures were higher than federal standards. Customers were explicitly asked if appliances were ENERGY STAR-qualified.
** If Qualifications A and B are not *both* met, then spillover = 0. We used secondary sources to estimate savings for non-like measures if they were not available in the MA TRM. Spillover rates are equal to the sum of the saving associated with the spillover measures divided by the sum of the savings associated with respondents participating measures.

3.6 Market Share Predictions

Survey responses did not directly yield prospective NTG estimates. Instead, we asked Consensus Group members to assess prospective NTG, taking into consideration the retrospective NTG results presented above, as well as contractors' estimates of the percentages of their sales they expect to meet program requirements in three years under two different scenarios. The scenarios were (1) if the program were to continue, and (2) if the program were to end after 2017. Table 15 shows contractors' average estimates for both scenarios and the difference between the two. The differences between the scenarios varied by equipment type. Contractors predicted only a four-percentage point decrease in their CHP sales without the program (though the CHP sample size was small).

Table 15: Contractor Sales Projections of Energy-Efficient Units as Percentage of Total Sales Three Years from Now

Program Measures	n[1]	2016 Sales[2]		% of Respondents Expecting Change	Average Estimates		Difference
		Program	Total		Program Continues	Program Ends	
DMSHP[3]	45	463	983	54%	86%	72%	**14%**
HPWH	36	83	260	64%	70%	48%	**22%**
CAC	22	203	722	85%	82%	34%	**48%**
CHP	11	33	203	18%	63%	59%	**4%**
Furnace	38	307	899	80%	80%	49%	**31%**
Boiler	44	131	822	66%	75%	58%	**17%**

[1] Survey wording was adjusted for the new year on January 5 instead of January 1, 2018. (The wording was originally "at the end of this year" and it was updated to "the end of 2017.") Six contractors responded to the survey between January 1 and January 4, 2018; we omitted their responses. Note that CHP sample size decreased to n=11 for this question series, widening absolute sampling error to +/-25%.
[2] We weighted responses by contractors' self-reported total 2016 sales, including program, non-program, and early and standard replacement.
[3] These questions asked about number of indoor ductless MSHP heads since the program structure used number of indoor heads as a unit of measurement starting in 2017. Before 2017, it focused on number of outdoor heads, so retrospective NTG questions asked about outdoor heads.

3.7 Consensus Group Results

In Table 16, we show three NTG options that we presented to the Consensus Group for their consideration. These NTG options correspond to the three adjusted FR options described in Section 3.3. For all measures except CHPs, the Consensus Group decided to use NTG Option 3 results for both retrospective and prospective NTG. For CHPs, the Consensus Group decided to use a modified version of NTG Option 3 results. Below, we explain this in more detail and the rationale for these decisions.

Table 16: Net-to-Gross Options Considered by Consensus Group

Free-Ridership Approach						
Participant FR	Adjustment	Program Measures	FR	NPSO	PSO	NTGR[1]
NTG Option 1						
Average *Maximum* and *Means Methods*	**Average of *Selected Equipment* and *Top Rating Methods***	Ductless MSHP	0.39	0.15	0.02	**0.79**
		Heat pump water heater	0.16	0.04	0.01	**0.89**
		Central air conditioning	0.43	0.05	0.10	**0.72**
		Central heat pump	0.46	0.04	0.02	**0.61**
		Warm air furnace	0.33	0.16	0.02	**0.85**
		Boiler	0.24	0.14	0.01	**0.90**
NTG Option 2						
Average *Maximum* and *Means Methods*	**Average of *Selected or Recommended Equipment* and *High Rating Methods***	Ductless MSHP	0.45	0.15	0.02	**0.72**
		Heat pump water heater	0.23	0.04	0.01	**0.81**
		Central air conditioning	0.53	0.05	0.10	**0.62**
		Central heat pump	0.54	0.04	0.02	**0.53**
		Warm air furnace	0.46	0.16	0.02	**0.72**
		Boiler	0.38	0.14	0.01	**0.77**
NTG Option 3						
***Maximum Method* only**	**Average of *Selected or Recommended Equipment* and *High Rating Methods***	Ductless MSHP	0.41	0.15	0.02	**0.77**
		Heat pump water heater	0.21	0.04	0.01	**0.83**
		Central air conditioning	0.48	0.05	0.10	**0.67**
		Central heat pump[2]	0.49	0.04	0.02	**0.58**
		Warm air furnace	0.42	0.16	0.02	**0.76**
		Boiler	0.35	0.14	0.01	**0.79**

[1] Values may not sum due to rounding.
[2] The Consensus Group recommended Option 3 estimates for all measures except CHPs.

After reviewing the options and results described in the table, as well as additional information that we provided – including a summary of current equipment standards and specifications, results from other studies, and contractors' observations about program market effects – Consensus Group members independently developed retrospective and prospective NTG estimates by equipment type. We consolidated and anonymized the estimates then sent them back to Group members. The Group then met to discuss their recommendations and the rationales behind them. In addition to agreeing on the FR adjustment methods (described in Section 3.3), two other themes and decisions emerged from this meeting:

Central heat pumps need special consideration. Given that the CHP sampling error was particularly large, the Consensus Group hesitated to accept Option 3 without further adjustment. One of the three parties represented in the group proposed to average the NTG Option 3 values for CHP (0.58) with CAC (0.67) NTG, which would result in a CHP NTGR of 0.63. The rationale for this adjustment was that CAC NTG has previously been used to approximate CHP NTG. The other two parties expressed concern about taking this approach without information about NTG precision. NTG precision had not been calculated at the time of the discussion, so the group agreed to use an average of their three separate CHP NTG estimates (0.58, 0.58, and 0.63), or 0.60, as a placeholder. Section □ shows the final

precision results and describes how the NTGRs meet a precision threshold defined by the PAs.

The Consensus Group agreed to use the 2016 retrospective NTG estimates for 2019, 2020, and 2021 for a variety of reasons:

- Contractor responses do not indicate consistent projections of future program trends. When asked to predict sales with and without the program, their forecasts varied widely by equipment type and were inconsistent with current estimates.
- There are no concrete plans to change the design of the programs, and the reliably stable market for these equipment types does not indicate a need to adjust NTG estimates during this period.
- The programs' requirements already exceed federal standards and both ENERGY STAR and CEE specifications. There are no imminent changes planned to federal standards or to specifications, and it seems unlikely that changes to standards for these equipment types will be proposed under the current federal administration.

3.8 Net-to-Gross Precision

To accept a study's estimated NTGRs, the Massachusetts PAs have provided the general guidance that estimates should meet 10% absolute precision *or* 25% relative precision at the 90% confidence level. Table 17 shows the absolute and relative precision of the Option 3 NTGRs. Appendix A.1.1 details these calculations. All measures meet the relative precision requisite (less than 25%) for Methods E and F.

Table 17: Net-to-Gross Precision for Option 3

Measure	Method	FR		Net of FR		NPSO		PSO		SO		NTGR[1]				Precision	
		Estimate	Standard Error	Estimate	Standard Error	Estimate	Standard Error	Estimate	Standard Error	Estimate	Standard Error	Midpoint	Standard Error	Confidence Interval (90%)		Absolute	Relative
														Lower	Upper		
DMSHP	E	0.36	0.03	0.64	0.03							0.81	0.08	0.68	0.94	0.13	16%
	F	0.45	0.02	0.55	0.02	**0.15**	0.07	**0.02**	0.02	**0.17**	0.07	0.72	0.08	0.60	0.84	0.12	17%
	Avg.	**0.41**	0.03	**0.59**	0.03							**0.77**	0.08	**0.64**	**0.89**	**0.13**	**16%**
HPWH	E	0.19	0.03	0.81	0.03							0.85	0.04	0.78	0.93	0.07	8%
	F	0.23	0.03	0.77	0.03	**0.04**	0.03	**0.01**	0.00	**0.04**	0.03	0.81	0.04	0.74	0.88	0.07	9%
	Avg.	**0.21**	0.03	**0.79**	0.03							**0.83**	0.04	**0.76**	**0.90**	**0.07**	**9%**
CAC	E	0.43	0.03	0.57	0.03							0.71	0.08	0.59	0.84	0.12	17%
	F	0.53	0.03	0.47	0.03	**0.05**	0.04	**0.10**	0.06	**0.15**	0.07	0.62	0.07	0.50	0.73	0.12	19%
	Avg.	**0.48**	0.03	**0.52**	0.03							**0.66**	0.07	**0.54**	**0.79**	**0.12**	**18%**
CHP	E	0.46	0.05	0.54	0.05							0.61	0.07	0.50	0.72	0.11	18%
	F	0.52	0.05	0.48	0.05	**0.04**	0.04	**0.02**	0.02	**0.07**	0.04	0.55	0.06	0.44	0.65	0.10	19%
	Avg.	**0.49**	0.05	**0.51**	0.05							**0.58**	0.06	**0.47**	**0.68**	**0.11**	**18%**
Furnace	E	0.40	0.03	0.60	0.03							0.78	0.07	0.66	0.90	0.12	15%
	F	0.44	0.03	0.56	0.03	**0.16**	0.06	**0.02**	0.01	**0.18**	0.06	0.74	0.07	0.62	0.85	0.11	15%
	Avg.	**0.42**	0.03	**0.58**	0.03							**0.76**	0.07	**0.64**	**0.87**	**0.12**	**15%**
Boiler	E	0.34	0.04	0.66	0.04							0.80	0.07	0.69	0.92	0.12	15%
	F	0.37	0.04	0.63	0.04	**0.14**	0.06	**0.01**	0.00	**0.14**	0.06	0.78	0.07	0.66	0.89	0.12	15%
	Avg.	**0.35**	0.04	**0.65**	0.04							**0.79**	0.07	**0.67**	**0.91**	**0.12**	**15%**

Blue signifies that overall precision meets PA requirements (0.10 for absolute precision and 25% for relative precision).

[1] The NTGR's SE is the square root of the sum of net-of-FR SE squared and the SO SE squared. Confidence intervals are the midpoints +/- 1.645 times SE.

4 Section 4 Market Effects Results

The logic models presented in Section 1.3 illustrated key market outcomes that the programs seek to achieve. Table 18 shows the indicators we used to assess progress toward the expected outcomes and how we measured these through questions in the contractor survey.[15] For each equipment type, we first asked contractors if they had observed changes in the market in the previous three years. We then asked those who said yes to rate the programs' level of influence on the changes using a 0 to 10 scale, where 0 is *not at all influential* and 10 is *very influential*.

Table 18: Market Effects Progress Indicators

Expected Outcome or Market Effect	Market Effects Progress Indicator	Survey Question *Over the past three years, have you observed an increase, decrease, or no change in the following?*
Increased stocking and supply of energy-efficient equipment	Rate at which distributors have the models of high-efficiency equipment that contractors need in stock	*How often distributors have the models of high-efficiency residential [MEASURE] that you need in stock?*
Reduced cost barriers	Cost contractors pay for high-efficiency equipment	*The cost that YOU, as the contractor, pay for high-efficiency residential [MEASURE]?*
Increased demand for energy-efficient equipment	Frequency with which customers ask for high-efficiency equipment	*The frequency with which customers ask for high-efficiency residential [MEASURE]?*

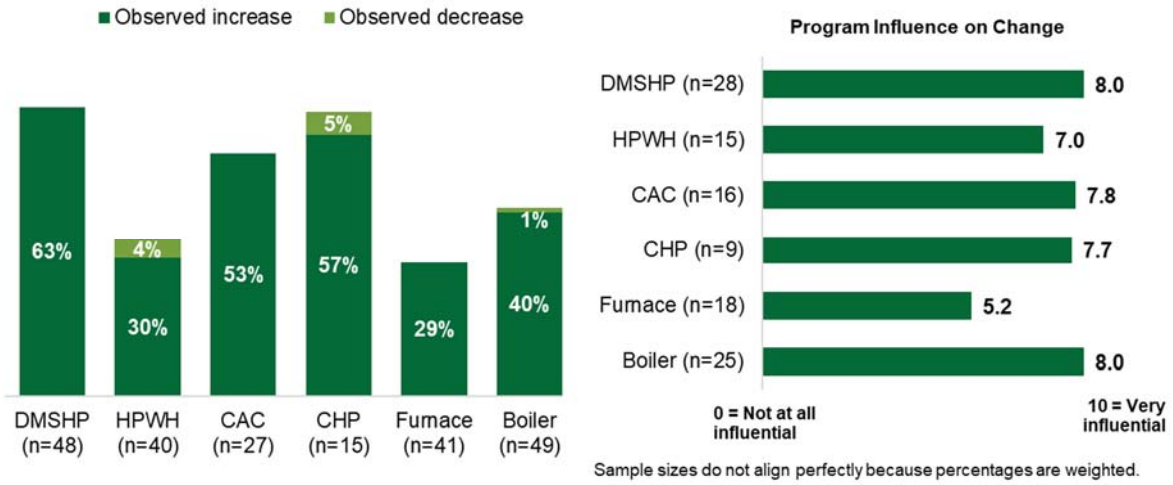
Figure 9, Figure 10, and Figure 11 show the percentages of contractors who observed changes in the indicators over the previous three years, as well as their assessments of the programs' influence on those changes.

Stocking and supply of high-efficiency equipment. As Figure 9 shows, the majorities of DMSHP (63%), CHP (57%), and CAC (53%) contractors had observed increases in the frequency with which distributors stock the high-efficiency models they need. Contractors attributed much of this change to the programs (with influence rated between 7.0 and 8.0 for all of the equipment types except furnaces, for which the programs' influence has been more modest, at 5.2 on the same scale).

[15] We did not factor market effects results into NTGRs.

Figure 9: Changes in Frequency That Distributors Have Needed High-Efficiency Models in Stock

(Reported by Contractors)

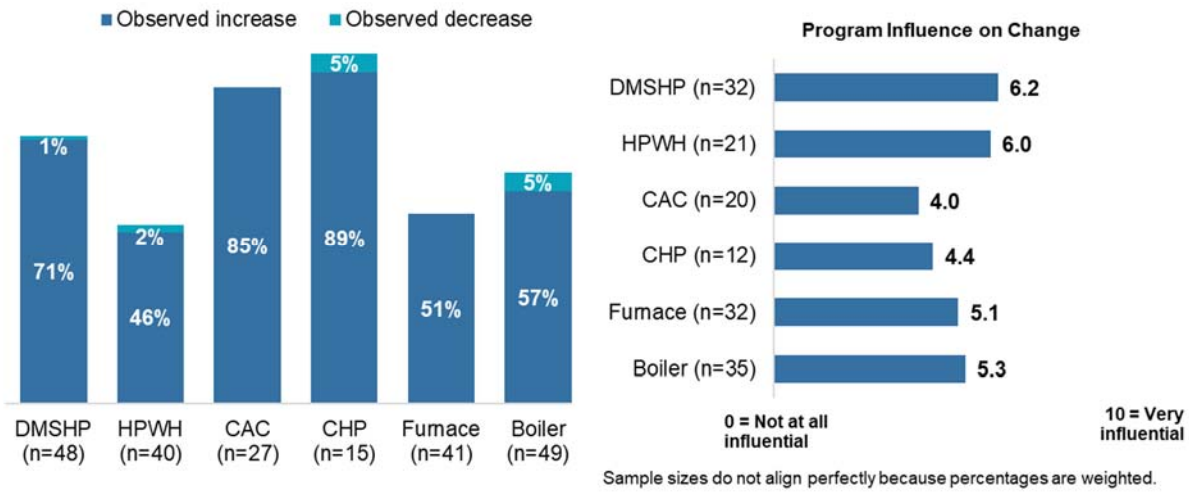


Cost barriers. The logic models predict that, over time, program activities will result in reduced costs for high-efficiency equipment relative to standard-efficiency equipment. For all measures, either the majority of contractors (51% to 89%, depending on the measure) or nearly one-half (46%) of contractors reported having incurred increased costs for purchasing high-efficiency models (Figure 10). This finding suggests that assessing whether contractors perceived prices of high-efficiency equipment as changing at faster, slower, or the same rates as standard-efficiency equipment will be useful for measuring market effects going forward.

The programs' effects on equipment costs were not as pronounced as on other market effects discussed in this section, providing anecdotal evidence that the programs played a modest role in affecting changes in cost. Contractors reported that the programs had a somewhat greater effect on the costs of DMSHPs and HPWHs compared to other equipment. Given that DMSHPs are a newer type of technology, and HPWHs are relatively rare in Massachusetts, it seems logical to expect that the programs would have a greater effect on cost than for equipment that is more commonly installed in Massachusetts homes.

Figure 10: Changes in Costs Contractors Pay for High-Efficiency Measures

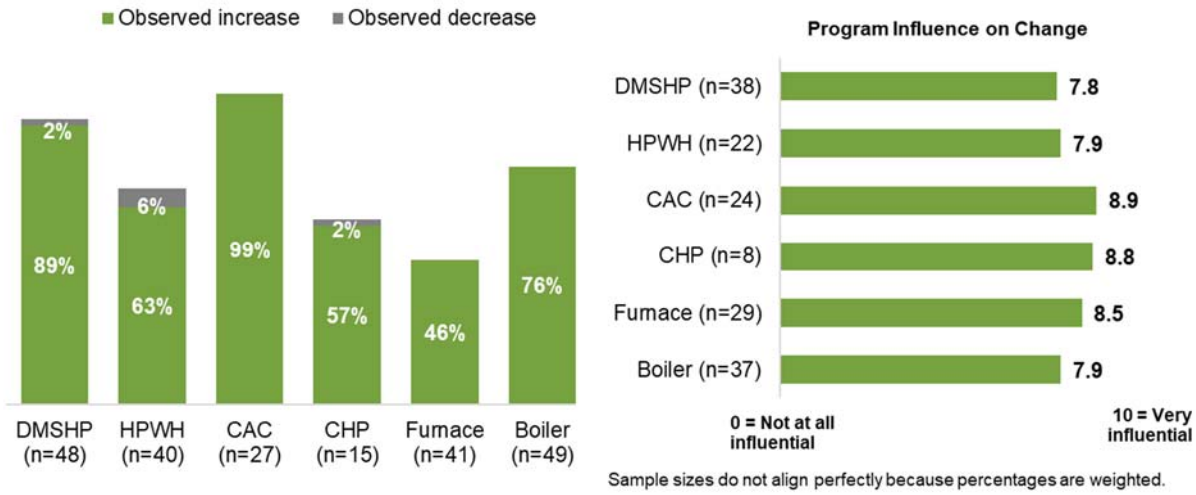
(Reported by Contractors)



Demand for energy-efficient equipment. For all but one measure, the majority of contractors (57% or more) observed increases in customer demand for high-efficiency models in the previous three years (Figure 11). Contractors reported seeing the strongest increases in demand for CAC (99%), DMSHPs (89%), and boilers (76%). With attribution ratings for all equipment types ranging from nearly 8 to nearly 9 on a scale of 0 to 10, contractors attribute much of this change in demand to the programs.

Figure 11: Changes in Frequency at Which Customers Ask for High-Efficiency Measures

(Reported by Contractors)



The savings associated with program influence on changes in stocking practices are somewhat reflected in NPSO savings (especially in the case of replace on failure). Changes in these indicators over time could corroborate a market share analysis, which could quantify market effects.

5 Section 5 Contractor Influence, Equipment Replacement, and Fuel Switching

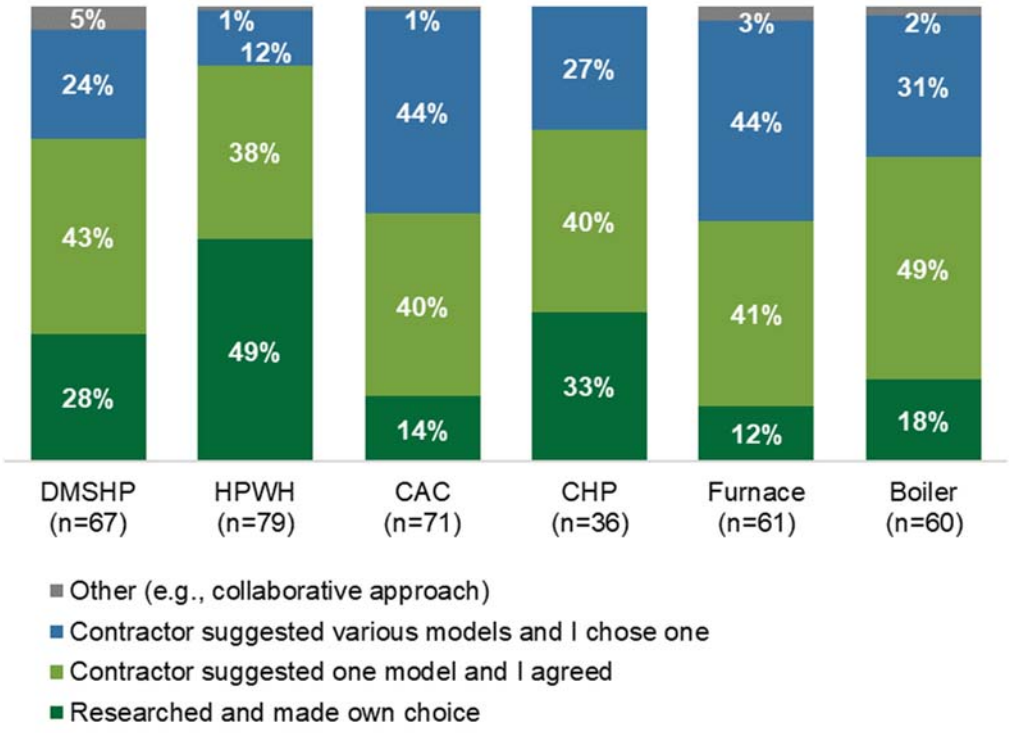
Research results also offer insights into the influence of contractor recommendations on customer decision-making, lost opportunities for early equipment replacement rebates, and fuel switching.

5.1 Contractor Influence

Participant survey results indicate that contractors' recommendations have considerable influence on customer decisions about the models of equipment they choose to install. For each measure type, between more than one-third (38%) and nearly one-half (49%) of respondents reported that their contractors suggested just *one* model, which the customer then agreed to have installed (Figure 12). With the exception of HPWHs, two-thirds or more of customers reported that the contractor either suggested one model or various models, and the customer agreed to install one of the models. Contractor recommendations appear to be less influential when it comes to heat pump systems, whether for domestic hot water or for heating and cooling purposes. These systems in and of themselves are often indicative of increased energy efficiency. Nearly one-half of participants who installed HPWHs (49%), one-third of participants who installed CHPs (33%), and more than one-quarter of participants who installed DMSHPs (28%) reported researching and selecting the equipment themselves. It may be the case that if participants selected heat pump measures, they were looking to improve their home's energy efficiency and had, therefore, already conducted some background research before engaging their contractor.

Figure 12. How Participants Selected Equipment Models

(Reported by Participants)

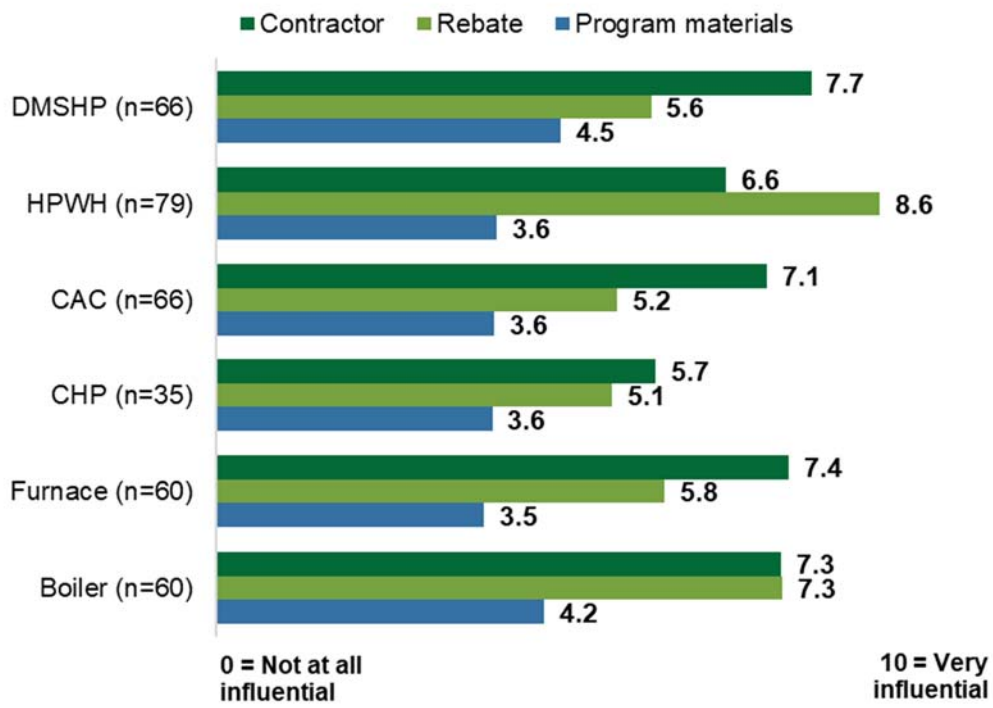


As Figure 13 shows, on average, participants rated the influence of their contractors' suggestions on their decision making for nearly all measures as high as or higher than the influence of program rebates or program materials.[16] Again, HPWHs were an exception: for this equipment type, participants rated the influence of the program rebate considerably higher than the influence of their contractor (8.6 versus 6.6, on average).

[16] Program materials were worded as "Mass Save or utility marketing materials (advertising, mailers)."

Figure 13: Influence of Contractor Compared to Program Rebate and Materials

(Average Ratings among Participants)



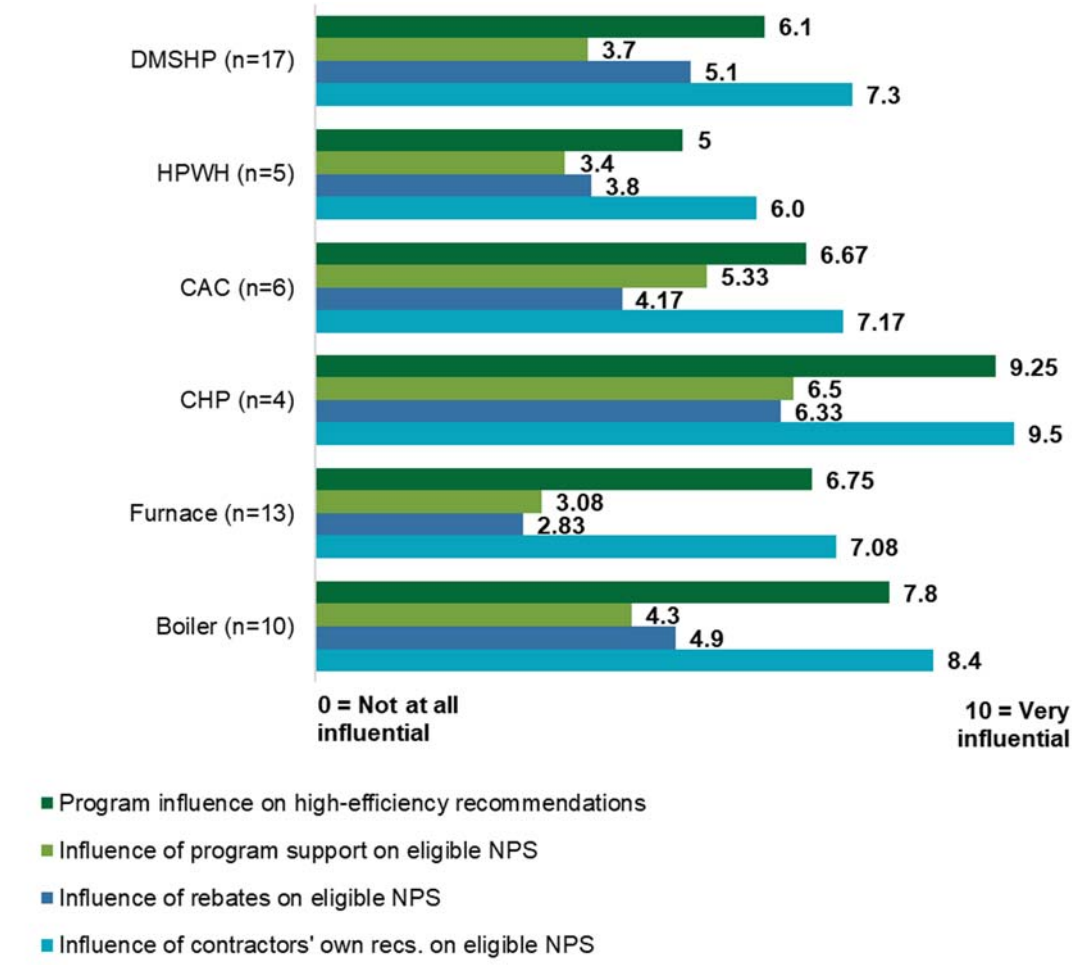
As discussed in Section 3.4, some contractors reported having installed program-eligible equipment that did not receive program rebates. We asked these contractors spillover questions to assess their perceptions of the influence of the following factors on their sales of high-efficiency equipment outside the program:

- Their recommendations to customers;
- Mass Save Standard rebates offered but not received; and
- Other support offered through the program, such as marketing, advertising, education, training, or seminars.

We also asked them about the influence of the Mass Save Standard rebates on the frequency with which they recommended high-efficiency measures to their customers who did not receive rebates. Their ratings were on a scale of 0 to 10, where 0 is *no influence* and 10 is *a great deal of influence*. Figure 14 compares the average ratings for each of these questions by equipment type. The results indicate that contractors felt their own recommendations had the most influence on customer installations of qualifying non-program equipment (ranging by equipment type from 5.0 to 9.25 on the scale), and that the programs strongly influenced their recommendations (ranging by equipment type from 6.0 to 9.5 on the scale). The results suggest that the programs have substantial indirect influence on what appears to be the strongest driver in the selection of qualifying equipment outside the program. (Since the number of contractors asked this question for each equipment type was quite small, ranging from four to 17, these results should be generalized with caution.)

Figure 14: Contractor Perceptions of Influential Factors on Non-Program Sales

(Average Ratings among Contractors)



Note: Sample sizes are small because few contractors reported program-eligible NPS; results are unweighted.

5.2 Equipment Replacement and Fuel Switching

Mass Save offers higher rebates for replacing older (but functioning), inefficient heating and cooling equipment.[17] Prior to receiving an Early Replacement rebate, the homeowner must receive an HEA through HES or receive an AC Check, where energy specialists/contractors verify that the equipment to be replaced qualifies by meeting all of the following criteria:

- Is functioning
- Meets the minimum age (specific to equipment type)[18]
- Has a remaining working life of at least two years

[17] https://www.masssave.com/en/saving/residential-rebates/early-heating-and-cooling/

[18] Replaced equipment must be 12 years or older, except in the case of boilers, where the replaced boiler must be 30 years or older.

- Is the same fuel and measure type as the rebated equipment

The program offers Early Replacement rebates for four of the six measures that we studied: CACs, CHPs, furnaces, and boilers. Though the participant survey respondents did not receive Early Replacement rebates for the measures in question, it is possible that they would have qualified for one had they elected to go through the verification process before installation, so we asked about their replaced equipment to identify these cases.[19] Because results are based on customer self-reports and the equipment replaced has already been removed such that the customer could not verify its age, readers should interpret customers' answers to these questions with caution.

The Team adapted the approach to identifying early replacement equipment outlined in Cadmus's 2012 study to the data collected for this study. The Cadmus 2012 study categorized installations into four types: *new installation*, *replace on failure*, *early replacement*, and *in-between replacement*:

- **New installation**. The study considered a measure to be a *new installation* if it did not replace anything. For example, if a participant had not had a CAC before installing one through the program, then the program-supported CAC was considered a *new installation*.
- **Replace on failure**. The analysis considered a measure to be *replace on failure* in a few scenarios. First, if a measure replaced existing heating or cooling equipment that was not working or needed major repairs, then they considered it a *replace on failure*. If respondents projected that their replaced measures would have lasted one year or less, then it was a *replace on failure*, too. The 2012 study also considered systems that had been repaired twice in the year before they were replaced as *replace on failure.* (Since the current study did not ask about number of repairs, the Team could not categorize installations as replace on failure.)
- **Early replacement**. If replaced equipment had been working or needed only minor repairs and respondents estimated it would have last four or more years, then the analysis considered them *early replacement*.
- **In-between replacement**. If respondents estimated that replaced equipment would have likely lasted two to three years, then the study considered them *in-between replacement*.

If a system was deemed *early* or *in-between replacement* based on those conditions, then the 2012 study asked about the importance of the system's lifetime on the decision to replace it and adjusted categorizations as needed.[20] The current study did not ask this question.

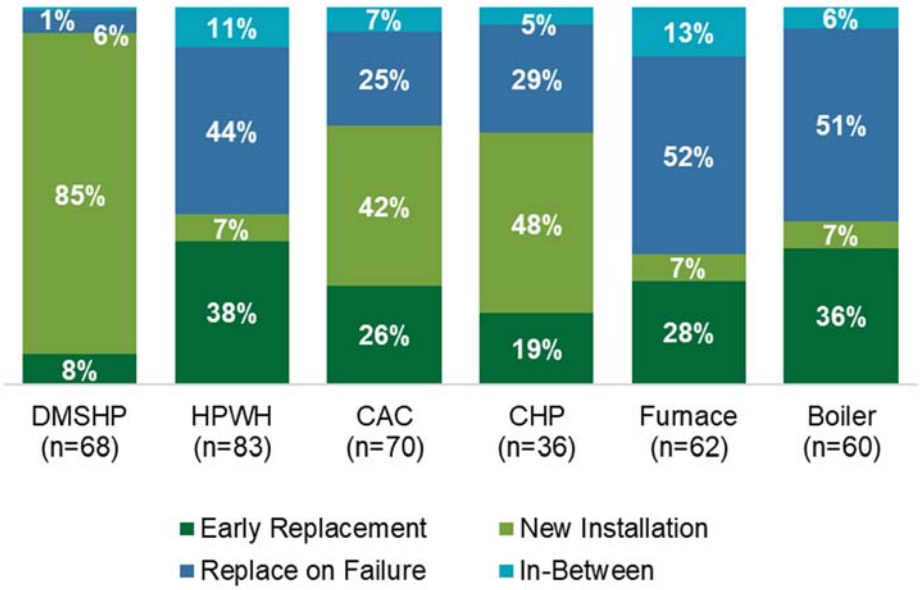
Figure 15 illustrates the distribution of installation types in the current study based on the 2012 study's criteria. Note that Mass Save's Early Replacement rebate criteria are different from the 2012 study's criteria. Unlike the 2012 study's criteria, Mass Save's Early

[19] As noted, the RES36 study examined the early replacement program in greater detail.
[20] The survey asked, "How important of a reason for you was the fact that your system might be reaching the end of life and might fail in the near future on your decision to replace?" If it was "very" important, then Cadmus recategorized the measure as *replace on failure* and if it was "somewhat" important, then they considered it an *in-between replacement*.

Replacement rebate requires that (1) program measures must replace like measures (e.g., gas furnace replacing a gas furnace), (2) replaced equipment must be of a certain age, (3) replaced equipment is expected to last at least two more years, not at least four more years, and (4) the participant's importance rating of the expected lifetime of the replaced equipment is not a factor. If the team were to implement Mass Save's criteria for the four relevant measures strictly, different proportions would have been eligible for Early Replacement rebates compared to the results below. Larger shares of furnaces (33% vs. 28%) and CHPs (26% vs. 19%) would have qualified and smaller shares of CACs (11% vs. 26%) and boilers (4% vs. 36%) would have qualified.

Figure 15: Installation Types

(Based on Participant Self-Reports)



Currently, Mass Save does not directly support fuel conversions (although National Grid does subsidize conversions from fuel oil to natural gas). The contractor survey included a small battery of fuel switching questions. Eighty-five percent of contractors (n=143) reported that their company assists customers in switching from either propane or oil to natural gas or electricity for heating equipment. They estimated that their companies complete between one and 50 fuel switching projects a year, with a median of 6.0 and mean of 9.6 projects annually.

Based on participants' responses, 23% of boiler installations and 7% of furnace installations were part of oil-to-gas conversions. Two percent of DMSHP installations were part of oil-to-electric conversions, and 1% were part of gas-to-electric conversions. No CHP installations were part of fuel conversions (Figure 16).

Figure 16: Fuel Switching
(Based on Participant Self-Reports)

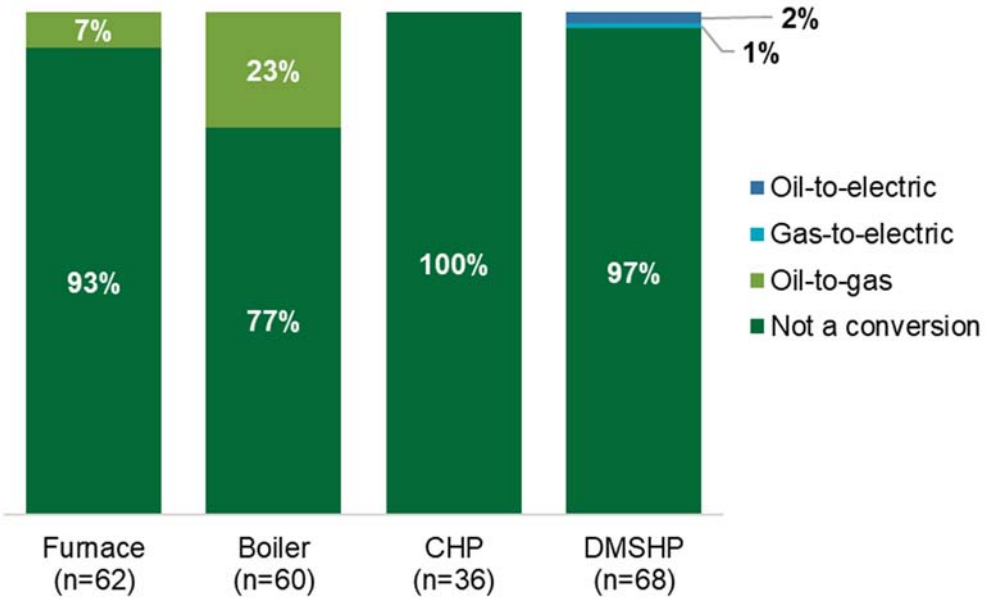


Table 19 compares fuel switching by installation type.

Table 19: Fuel Switching by Installation Type

Installation Type	Fuel Conversion	Furnace (n=62)	Boiler (n=60)	DMSHP (n=68)
Early Replacement	**Yes**	**-**	**13%**	**2%**
	No	28%	23%	6%
Replace on Failure	**Yes**	**6%**	**10%**	**1%**
	No	46%	41%	5%
In-Between	**Yes**	**1%**	**-**	**-**
	No	12%	6%	1%
New Installation	(No)	7%	7%	85%
Total	**All**	**100%**	**100%**	**100%**

Appendix A.1.6 reports participants' other responses about equipment replacement.

6 Section 6 Results, Recommendations, and Considerations

In this section, we summarize the key results from the study and offer recommendations and considerations to improve program outcomes.

6.1 Net-to-Gross Ratios

Using primary data collection and a Consensus Group approach, this study estimated NTGRs for DMSHPs, HPWHs, CACs, CHPs, furnaces, and boilers that are incented with Standard rebates.

Results

Compared to the 2016-2018 ratios, the 2019-2021 NTGRs developed via this study are higher for DMSHPs and boilers, and lower for HPWHs, CAC, CHPs, and (to a lesser extent) furnaces.

Recommendation

The team recommends using the NTGRs shown in Table 20 for measures incented with Standard rebates in program years 2019-2021.

Table 20: Recommended Net-to-Gross Ratios
(2019-2021)

Program Measures	NTG
Ductless MSHP	0.77
Heat pump water heater	0.83
Central air conditioning	0.67
Central heat pump	0.60
Warm air furnace	0.76
Boiler	0.79

Considerations

Consider how changes in NTGRs may affect the PAs' benefit/cost ratio models and decisions about continuing to support each of the measures at the current efficiency specification and rebate levels.

6.2 Market Effects

In accordance with the logic models presented in Section 1.3, this study measured three market effects indictors to provide anecdotal evidence of progress toward market transformation and set baselines for comparison with future studies. It also assessed the degree to which the progress measured could be attributed to the programs. The outcomes and related indicators are as follows:

- Outcome: Increased stocking and supply of energy-efficient equipment. Indicator: The rate at which distributors have the models of high-efficiency equipment that contractors need in stock, as perceived by contractors.
- Outcome: Reduced cost barriers. Indicator: The cost contractors pay for high-efficiency equipment, as perceived by contractors.
- Outcome: Increased demand for energy-efficient equipment. Indicator: Frequency with which customers ask for high-efficiency equipment, as perceived by contractors.

Results

Stocking and supply of high-efficiency equipment. The logic models predict that the program efforts would result in increased stocking and supply of energy-efficient equipment. Contractors offered anecdotal evidence that, to some degree, the programs' intended effects on stocking are occurring – particularly for equipment supported by the electric program. The majorities of contractors who installed DMSHP (63%), CHP (57%), and CAC (53%) equipment observed increases in the frequency with which distributors stock the high-efficiency models they need. They attributed much of this change to the programs, saying that they had considerable influence on these outcomes (with influence rated between 7.0 and 8.0 on a 0-10 scale for all equipment types except furnaces, for which their influence has been more modest, at 5.2 on the same scale).

Cost barriers. The logic models predict that, over time, program activities will result in reduced costs for high-efficiency equipment relative to standard-efficiency equipment. For nearly all measures, the majority of contractors reported having incurred increased costs for purchasing high-efficiency models. To limit respondent fatigue, survey questions did not ask contractors to compare changes in costs between high-efficiency and standard equipment.

The results of the attribution questions for equipment costs provide anecdotal evidence that the programs played a modest role in affecting changes in cost.

Demand for energy-efficient equipment. This indicator offers evidence that customer demand for high-efficiency HVAC equipment is increasing, and that contractors attribute much of this change to the programs.

Recommendation

Measure the same market indicators in future studies of the programs' activities, and compare the results to track progress over time. Future measurements of the indicator of reduced cost barriers should allow for a comparison between changes in costs of high-efficiency and standard equipment to assess whether contractors perceived prices of high-efficiency equipment as changing at faster, slower, or the same rates as standard efficiency equipment. To claim savings from market effects, market share data must be available for analysis. Changes in the indicators assessed in this report could corroborate findings from market share data analysis.

Consideration

The evaluation team has previously attempted to obtain Massachusetts HVAC market share data from manufacturers on behalf of the PAs, and is currently attempting to obtain Massachusetts unit sales data from distributors. The team has encountered considerable

difficultly obtaining meaningful state-level data from HVAC industry players. There remain two ready sources of HVAC market share data that the PAs previously examined and may wish to consider using in the future: the national ENERGY STAR® shipment data and HARDI HVAC data from D&R International. The PAs have previously chosen not to rely on either data source because the data were not sufficiently representative of Massachusetts. Since the completion of this evaluation, D&R International has informed the evaluation team that they have successfully brought on board a distributor with many Massachusetts outlets. D&R estimates that the data they now have in hand for Massachusetts represents slightly over 35% of the state's market for furnaces, CAC, and ASHP equipment. This is more than double the previous representation, and the data go back several years.

Another approach the PAs may want to consider in the future is to leverage national ENERGY STAR shipment data. This would involve asking manufacturers to estimate the Massachusetts market share of ENERGY STAR-qualified HVAC equipment in relation to the national data, with some consideration of attribution. While this would be less expensive than purchasing D&R data, and likely less expensive than the approach taken in this evaluation, it would not be as precise as either. ENERGY STAR also does not equate directly with Mass Save program capacity and efficiency requirements.

6.3 CONTRACTOR INFLUENCE

Both customers and contractors have important roles to play in advancing equipment markets to the next level of efficiency. It benefits contractors to be conservative in recommending or choosing equipment for their customers, since returning to fix problems with equipment can spell the difference between profit and loss on a job. Innovator and early-adopter customers can help move contractors when technology is newer and less proven. When technology is more mainstream, contractors can help late-majority and late-adopter customers move forward.

Results

Participant survey results indicate that contractors' recommendations have considerable influence on customer decisions about the models of equipment they choose to install. Contractor recommendations appear to be less influential when it comes to equipment that is generally high-efficiency (i.e., heat pump technology): nearly one-half of participants who installed HPWHs (49%), one-third of participants who installed CHPs (33%), and more than one-quarter of participants who installed DMSHPs (28%) reported researching and selecting the equipment themselves. The results indicate that contractors felt their own recommendations had the most influence on customer installations of qualifying non-program equipment, and that the programs strongly influenced their recommendations. The results suggest that the programs have substantial indirect influence on what appears to be the strongest driver in the selection of qualifying equipment outside the program. (Since the number of contractors asked this question for each equipment type was quite small, ranging from four to 17, these results should be generalized with caution.)

Recommendation

While the market effects indicator results show that customer demand for high-efficiency equipment has increased over the last three years, and participant survey results indicate that contractors' recommendations have considerable influence on customer decisions about the models of equipment they choose to install, for certain equipment types, customers are important drivers of decision-making. Given this, the programs should continue to target both customers and contractors.

6.4 Results and Considerations

Results

The team conducted a large amount of work to clean program data to develop a contractor survey sample for evaluation purposes. This suggests a need for a better system of tracking contractor contact information (such as consistently using unique company and contact identification numbers).

Considerations

Improve contractor contact information tracking (e.g., develop contractor IDs, require email addresses)to better prepare for future evaluation efforts.

In the future, consider using in-depth interviews rather than programmed surveys with contractors to estimate market shares and program influence. The complexity involved in these questions requires abstract consistency checks that are difficult to implement through a programmed survey with no trained expert guiding respondents to correctly interpret the questions.

Appendix A Additional Details

This appendix offers additional details that were referenced in the body of the report. These include FR standard error calculation details; descriptions of the NTG sensitivity analyses; NTG consistency checks and revisions; HES participation cross-tabulation; benchmarking of the NTG results; and background on HVAC equipment standards.

A.1 Net-to-Gross Analysis

A.1.1 Net-to-Gross Precision

To accept a study's estimated NTGRs, the Massachusetts PAs have provided the general guidance that estimates should meet 10% absolute precision *or* 25% relative precision at the 90% confidence level. Because the NTGR is a sum of two components (FR and SO), the same formula used to calculate the standard error (SE) associated with the combined SO components can be used to calculate the SE of the NTGR.

NTGR – Standard Error Formula

$$SE\langle NTGR\rangle = \sqrt{SE\langle FR\rangle^2 + SE\langle SO\rangle^2 + 2Cov\langle FR, SO\rangle}$$

We assume that $Cov\langle FR, SO\rangle = 0$, so that:

$$SE\langle NTGR\rangle = \sqrt{SE\langle FR\rangle^2 + SE\langle SO\rangle^2}$$

We describe these inputs in more detail below.

A.1.1.1 Free-Ridership Standard Error Formulae

As described earlier, the Consensus Group preferred the Option 3 FR adjustment method. Option 3 is the average result of two adjustment methods: the first (Method E), which left alone, averaged, or replaced a participant's FR with that of the contractor depending on the extent of the contractor's involvement in the selection process, and the second (Method F), which replaced a participant's FR if the participant rated highly the influence of their contractor. We estimated precision for each method.

Since FR was a product of two independent samples (participants and contractors), we blend the Uniform Methods Project's (UMP's)[21] algorithms for calculating precision, using formulae for calculating standard error (SE) of either a sum or a product. The formulae below use data from four elements: (1) count and FR rates among participants whose FR was unadjusted, (2) count and FR rates among participants whose FR was averaged with that of contractors, (3) proportion of participants whose FR was replaced with that of the contractor, and (4) FR

[21] National Renewable Energy Laboratory. "The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures." Chapter 11: Sample Design Cross-Cutting Protocol. September 2017.

rates among contractors. **Error! Reference source not found.** defines the parameters in these two formulae. Below we provide more details on the derivation of this relationship.

Free-Ridership Method E – Standard Error Formula

$$SE(FR^{\sim}) = \sqrt{f_c'^2 SE^2(FR_c) + FR_c{}^2 SE^2(f_c) + \left(SE(f_c)SE(FR_c)\right)^2 + \left(1 - f_c'\right)^2 SE^2\left(FR_p\right) + FR_{poa}{}^2 SE^2(f_c) + \left(SE(f_c)SE\left(FR_p\right)\right)^2 - 2SE^2(f_c)FR_c FR_{poa}}$$

Free-Ridership Method F – Standard Error Formula

$$SE(FR) = \sqrt{f_c{}^2 SE^2(FR_c) + FR_c{}^2 SE^2(f_c) + \left(SE(f_c)SE(FR_c)\right)^2 + (1 - f_c)^2 SE^2\left(FR_p\right) + FR_p{}^2 SE^2(f_c) + \left(SE(f_c)SE\left(FR_p\right)\right)^2 - 2SE^2(f_c)FR_c FR_p}$$

Table 21: Free-Ridership – Standard Error Formulae Parameters

Parameter	Description
f_c	Proportion of participants whose FR was replaced by that of contractors
f_a	Proportion of participants whose FR was averaged with that of contractors
FR_c	Average FR among contractors
FR_p	Average FR among customers whose FR was not adjusted
f_c'	Proportion of participants whose FR was averaged with that of contractors divided by two and added to the proportion of participants whose FR was replaced by that of contractors: (f_a / 2) + f_c
FR_{PoA}	Sum of unadjusted FR divided by count of respondents
$FR^{\sim}$	((1 – f_c') * FR_{POA}) + (f_c' * FR_c)

Starting with Method F, in which there is no averaging for individual customers, FR is calculated as:

$$FR = f_o FR_p + f_c FR_c = (1 - f_c)FR_p + f_c FR_c$$

Where FR_p is the FR rate based on customer survey responses, FR_c is the FR rate based solely from the contractor survey, f_o is the fraction of observations based on the participants' own response, and f_c is the fraction of observations based on the contractor survey.

The SE of this is derived from the equation presented in the UMP Sample Design, Section 7.4 for the SE of a sum.

$$SE(FR) = \sqrt{SE^2(f_c FR_c) + SE^2\left((1 - f_c)FR_p\right) + 2Cov\left(f_c FR_c, (1 - f_c)FR_p\right)}$$

or

$$SE^2(FR) = SE^2(f_c FR_c) + SE^2\left((1-f_c)FR_p\right) + 2Cov\left(f_c FR_c, (1-f_c)FR_p\right)$$

Since FR_c and FR_p come from different samples and are independent. Similarly, FR_c and f_c are independent. As a simplifying approximation, we also assume that f_c (or $(1-f_c)$) is independent of FR_p. That is, there is no relationship between what fraction of customers in the sample are in the group that uses the participants' FR information directly and the average FR value found in the sample for that group. This is a reasonable assumption because we might over- or under-sample the self-reportable group relative to the population, but that would not swing the expected FR value for that group one way or the other.

Therefore:

$$Cov\left(f_c FR_c, (1-f_c)FR_p\right) = -Var(f_c)FR_c FR_p = -SE^2(f_c)FR_c FR_p$$

To calculate $SE^2(f_c FR_c)$ and $SE^2\left((1-f_c)FR_p\right)$, we apply the formula for the product of two independent quantities from the UMP, Section 7.5.

$$SE(f_c FR_c) = \sqrt{{f_c}^2 SE^2(FR_c) + {FR_c}^2 SE^2(f_c) + \left(SE(f_c)SE(FR_c)\right)^2}$$

or

$$SE(f_c FR_c)^2 = {f_c}^2 SE^2(FR_c) + {FR_c}^2 SE^2(f_c) + \left(SE(f_c)SE(FR_c)\right)^2$$

and

$$SE\left((1-f_c)FR_c\right)^2 = (1-f_c)^2 SE^2\left(FR_p\right) + {FR_p}^2 SE^2(1-f_c) + \left(SE(1-f_c)SE\left(FR_p\right)\right)^2$$

thus

$$SE(FR) = \sqrt{\begin{array}{c}{f_c}^2 SE^2(FR_c) + {FR_c}^2 SE^2(f_c) + \left(SE(f_c)SE(FR_c)\right)^2 + (1-f_c)^2 SE^2\left(FR_p\right) + \\ {FR_p}^2 SE^2(1-f_c) + \left(SE(1-f_c)SE\left(FR_p\right)\right)^2 - 2SE^2(f_c)FR_c FR_p\end{array}}$$

And since $SE(1-f_c) = SE(f_c)$

$$SE(FR) = \sqrt{\begin{array}{c}{f_c}^2 SE^2(FR_c) + {FR_c}^2 SE^2(f_c) + \left(SE(f_c)SE(FR_c)\right)^2 + (1-f_c)^2 SE^2\left(FR_p\right) + \\ {FR_p}^2 SE^2(f_c) + \left(SE(f_c)SE\left(FR_p\right)\right)^2 - 2SE^2(f_c)FR_c FR_p\end{array}}$$

The equation shown directly above is what is used to calculate the SE for Method F, when only participant or contractor FR values are used. In the more complicated case of Method E, in which participant, contractor, or an average FR value are used, there is not a

straightforward analytic solution. As an approximation, the FR is calculated in the same way using an average of the values included, and then calculating the SE of that. An approximate FR value is used as a substitute in the SE formula. The formula for actual FR in Method E is given by:

$$FR = f_o FR_o + \frac{f_a}{2} FR_a + \left(\frac{f_a}{2} + f_c\right) FR_c$$

To calculate the SE, the same equation above is used while substituting an approximate FR given by:

$$\tilde{FR} = (1 - f_c')FR_{poa} + f_c' FR_c$$

where

$$FR_{poa} = \left(\sum_j^{n_0+n_a} FR_{pj}\right) \Big/ (n_0 + n_a)$$

and

$$f_c' = \frac{f_a}{2} + f_c$$

So that f_c' is used in place of f_c and FR_{poa} is used in place of FR_o.

A.1.1.2 Spillover Standard Error Formulae

We calculated NPSO and PSO precision separately. As described in Section 3.4, for each equipment type, NPSO is the ratio of the sum of non-program sales times each contractor's influence score divided by the sum of all program sales. The confidence intervals associated with these estimates are calculated using the formula presented in the UMP to calculate the SE for a ratio estimator.

Non-Participant Spillover Formula

$$NPSO = \frac{\sum_i^n (NonProgramSales_i * InfluenceScore_i)}{\sum_i^n ProgramSales_i}$$

Where *n* is the number of contractors, *i*.

Non-Participant Spillover – Standard Error Formula

$$SE = \frac{1}{\sqrt{n}} \sqrt{\sum_i^n \frac{([NonProgramSales_i * InfluenceScore_i] - [NPSO * ProgramSales_i])^2}{\left(\frac{\sum_i^n ProgramSales_i}{n}\right)^2 * (n-1)}}$$

The PSO estimation method described in Section 3.5 and its SE formula mirror those of the NPSO. The central estimate for each equipment type is calculated as a ratio of all spillover savings divided by program savings.

Non-Participant Spillover Formula

$$PSO = \frac{\sum_i^n SpilloverSavings_i}{\sum_i^n ProgramSavings_i}$$

Participant Spillover – Standard Error Formula

$$SE = \frac{1}{\sqrt{n}} \sqrt{\sum_i^n \frac{\left(\sum_i^n SpilloverSavings_i - [PSO * ProgramSavings_i]\right)^2}{\left(\frac{\sum_i^n ProgramSavings_i}{n}\right)^2 * (n-1)}}$$

An overall spillover value is generated by summing the NPSO and PSO for each equipment type. Similarly, the confidence intervals associated with the overall spillover estimates are generated using the formula for the SE of an estimated sum from the UMP's section 7.4, just as the SE for the overall NTGR is calculated by combining the SE of FR and SO.

Overall Spillover – Standard Error Formula

$$SE\langle SO \rangle = \sqrt{SE\langle NPSO \rangle^2 + SE\langle PSO \rangle^2 + 2Cov\langle NPSO, PSO \rangle}$$

We assume that $Cov\langle NPSO, PSO \rangle = 0$, so that:

$$SE\langle SO \rangle = \sqrt{SE\langle NPSO \rangle^2 + SE\langle PSO \rangle^2}$$

Where $SE\langle SO \rangle$ is the SE of the SO estimate, $SE\langle NPSO \rangle$ is the SE of NPSO, $SE\langle PSO \rangle$ is the SE of the PSO estimate, and $Cov\langle NPSO, PSO \rangle$ is the covariance of NPSO and PSO. For this calculation, we again make the simplifying assumption that $Cov\langle NPSO, PSO \rangle = 0$, which is warranted since the two estimates are drawn from separate samples (contractors and participants, respectively).

A.1.2 Sensitivity Analyses

We conducted sensitivity analyses for participant FR and contractor NPSO.

A.1.2.1 Participant Sensitivity Analysis

We used a modified version of Cadmus's four sensitivity testing methods to examine participant FR (Table 22). Methods 1 and 3 – the "Maximum" methods – applied the maximum likelihood and influence scores into the efficiency credit, and Methods 2 and 4 – the "Means"

methods – applied the *mean* scores.[22] Methods 1 and 2 use increments of 0%, 50%, and 100% when establishing the timing credit, but Methods 3 and 4 more leniently assigned 66% instead of 50% for the partial timing score. The differences with adjusting the timing credit had close to no influence. As a result, we set aside the results of Methods 3 and 4.

The industry has slowly moved towards using a maximum versus mean scoring approach. However, we observed instances where the program rebate has nearly no influence, but program marketing materials have high influence. In these instances, awarding a very large efficiency credit could mean assigning someone *no* FR. These scenarios led us to continue considering the Means Method in our analysis. Nonetheless, the Consensus Group chose to move forward with the Maximum Method alone.

Table 22: Participant Free-Ridership – Sensitivity Analysis Methods

Input	Method 1	Method 2	Method 3	Method 4
Influence scores/rating	Maximum	Average	Maximum	Average
Timing credit for units that would have been replaced within 6-12 months	50%	50%	66%	66%

A.1.2.2 Contractor Sensitivity Analysis

For contractor NPSO, we toggled maximums and averages and then created thresholds for assigning IR and PI scores. The first two methods divide ratings by ten (e.g., 1 = 0.10 and 9 = 0.90) to calculate incrementally increasing scores. For the last two methods, any rating below 6 equals 0.0, and ratings of 6 to 9 incrementally increase by fifths (e.g., 6 = 0.20 and 9 = 0.80). We recommended applying the average value across methods.

[22] As noted, we began allowing HES participants into our sample mid-fielding. We asked those participants about HES technician's level of influence as well, but those responses are not incorporated into our algorithm.

Table 23: Contractor Non-Participant Spillover – Sensitivity Analysis Methods

Input	Method 1	Method 2	Method 3	Method 4
Spillover Influence Score	Maximum	Average	Maximum	Average
IR and PI Scoring				
Cutoff points	**None**	**None**	**High**	**High**
0	-	-	-	-
1	0.1	0.1	-	-
2	0.2	0.2	-	-
3	0.3	0.3	-	-
4	0.4	0.4	-	-
5	0.5	0.5	-	-
6	0.6	0.6	0.20	0.20
7	0.7	0.7	0.40	0.40
8	0.8	0.8	0.60	0.60
9	0.9	0.9	0.80	0.80
10	1.0	1.0	1.0	1.0

A.1.3 Consistency Checks and Revisions

Nearly all responses required careful examination after applying the standard algorithm. In a number of cases, we manually revised scores/ratios to account for inconsistencies.

A.1.3.1 Participant Consistency Checks and Revisions

We asked participants who gave conflicting likelihood and influence scores in the FR module why they gave the scores they did. Table 24 lists some FR revisions we made based on open-end responses to consistency checks.

Table 24: Participant Respondent-Level Free-Ridership Revisions

Raw Inputs[1]					FR	
Rebate Influence Rating (0-10)	Likelihood Rating (0-10)	Timing Credit (0-100%)	Quantity Credit (0-100%)	How did the rebate impact your decision to install the measure?	Orig.	Rev.
10	10	0%	n/a	"It was such a small amount for the rebate, I still would have done it"	**0.35**	**1.00**
10	10	0%	n/a	"The rebate sealed the deal. It was important to which model we purchased"	**0.25**	**0.10**
10	10	100%	n/a	"It was money back on a system that I had to purchase"	**0.00**	**0.80**
8	8	0%	0%	"The rebate was influential in terms of *which* furnace to install. Ours was going to need to be replaced, but the rebate allowed us to purchase a more efficient and slightly more expensive furnace."	**0.38**	**0.20**

[1] Ratings for contractors and program materials were also factored in but did not trigger open-end questions.

Table 25 lists a few participant-reported non-program measures that participants claimed were influenced by the program in the SO module, but that their open-end responses indicate were already rebated or the program had no influence on them.

Table 25: Customer Respondent-Level Participant Spillover Exclusions

Ratings		How did the rebate influence your decision to install the non-rebated measure?
Program Importance	Likelihood to Install	
10	4	"In my case it had no effect on it; [the insulation] was done years before the heat pump."
10	8	"The rebate for the thermostat was through Eversource. I would not have gotten the smart thermostat without the Eversource rebate, as it is way too expensive.
10	5	"The rebate on the boiler did not influence the insulation decision. A potential rebate for the insulation itself did."

A.1.3.2 Contractor Consistency Checks and Revisions

Table 26 lists some FR revisions we made based on contractors' open-end responses to consistency checks. We excluded contractors whose responses indicated that they did not understand we were asking about high-efficiency models (versus *any* models).

Table 26: Contractor Respondent-Level Free-Ridership Revisions

Percentage Installed in Absence of Program	Why do you give that response?	FR	
		Original	Revised
60%	"A lot of people do it because of rebates, and the rebates make the installation cost a better value."	0.60	0.25
25%	"They would not have been high-efficiency."	0.20	0.00
100%	"[The customer] needed to have it replaced anyway."	1.00	Exclude
70%	"Most units I install are cracked heat-exchangers or failing equipment that needs to be replaced."	0.70	Exclude

While contractors were asked to estimate non-program sales that would have qualified for the program but did not go through the program, open-end responses revealed cases where those sales would not have been program-eligible anyhow, so we changed their reported non-program sales to zero for the NPSO analysis. Table 27 lists typical responses that warranted this treatment. We also judiciously normalized reported non-program sales on a case-by-case basis where the basic math did not add up.

Table 27: Contractor Respondent-Level Non-Participant Spillover Revisions

Spillover Comment	Non-program Sales	
	Original	Revised
"They were installed in a [geographical] area that the rebates do not cover."	4	0
"I wasn't sure if SEER 14 was high enough."	3	0
"[They] were not high-efficiency."	2	0

A.1.4 Free-Ridership by HES Participation

We compared HES and non-HES participant FR to determine if weighting was necessary to fully represent the HES population. At the measure-level, HES sample sizes were often too small and would have had excessive weight on results if we weighted them back to the full population. Therefore, we looked holistically at the results across measures to assess the overall differences between the two populations. Considering the averages between the Maximum and Means Methods, we found a 0.05 difference between HES (0.26) and non-HES (0.32) participant FR. Given that this was not a statistically significant difference at a 95% confidence level, we set aside the concern and did not weight results by HES participation.

Table 28: Unadjusted Participant Free-Ridership Results by HES Participation

Program Measures	Non-HES		HES	
	n	FR	n	FR
Ductless MSHP	43	0.43	23	0.27
Heat pump water heater	77	0.14	2	0.10
Central air conditioning	54	0.44	12	0.23
Central heat pump	28	0.43	7	0.42
Warm air furnace	45	0.31	16	0.26
Boiler	42	0.22	18	0.21
Weighted average	**289**	**0.31**	**79**	**0.26**

A.1.5 Participant Spillover Savings

Table 29 shows the measures that qualified towards PSO. Respondents also confirmed installing energy-efficient lighting, but we excluded those responses from the analysis because they may have been incented upstream.

Table 29: Participant Spillover Measure-Level Savings

Spillover-Eligible Measures	n	Annual Estimated Savings (kWh)
Smart thermostat	5	3,473
Insulation	3	2,034
Appliances	6	1,442
HVAC equipment	1	1,286
Ductwork and air sealing	2	1048

A.1.6 Massachusetts Clean Energy Center Rebates

The MassCEC, an economic development agency in the Commonwealth, offers rebates to customers of Eversource, National Grid, Unitil, and some municipal electric utilities for installing air-source heat pumps (ASHPs). A homeowner can receive MassCEC rebates of up to $2,500 for installing ASHPs.[23]

While we did not incorporate outside rebates and incentives into our analysis, we did ask survey respondents if they received rebates or incentives from sources besides Mass Save. For those that did, we directed them to focus only on the Mass Save rebate when answering our survey questions.

One-fifth of DMSHP respondents (21%) confirmed receiving MassCEC rebates for their DMSHPs, and one CHP respondent received a MassCEC rebate for their CHP. Because the MassCEC rebates are so sizeable, the value of the Mass Save rebate could be called into question when participants receive both. However, the average FR rate among MassCEC DMSHP rebate recipients was lower than that of DMSHP recipients who did not receive the MassCEC rebate (0.34 versus 0.42). The evaluation team speculates that FR may be lower for two reasons: (1) participants' pursuit of two rebates may indicate a greater need for financial support, making all financial support vital; and/or (2) respondents disregarded the prompt and could not isolate the importance of the Mass Save rebate from that of the MassCEC rebate.

A.2 Equipment Replacement

To understand if participants may have been eligible for Early Replacement rebates, we asked them about the nature of their installations. These tables show the topline results.

Table 30: Participant Survey – Heating Equipment Installations

	Ductless MSHP (n=68)	Central Heat Pump (n=36)	Furnace (n=62)	Boiler (n=60)
ER1. Was the new measure in stalled to do one of the following?				
Replace	15%	56%	92%	95%
Supplement	49%	11%	8%	5%
Neither	37%	33%	-	-
ER2. What type of [heating] equipment did it replace?				
Boiler	1%	-	2%	80%
Furnace	1%	-	87%	25%
Central heat pump	1%	47%	-	-
Other	3%	-	3%	5%
ER3. What type of fuel did your old heating system that you replaced use?				
Oil	1%	-	8%	23%
Natural Gas	1%	-	81%	70%
Electricity	4%	47%	2%	2%
Other	-	-	2%	-

[23] See http://www.masscec.com/air-source-heat-pumps for more details.

ER4. What best describes the condition of your old heating system that you replaced?				
Working - no need of repair	-	17%	16%	23%
Working - need minor repair	1%	6%	23%	23%
Working - need major repair	4%	17%	39%	30%
Not working	1%	8%	15%	18%
ER5. Was your old system repairable or was it beyond repair?				
Repairable	-	3%	2%	2%
Beyond repair	1%	6%	13%	17%
ER6. How old do you think your old heating system was?				
11 years or less	1%	-	10%	13%
12 to 19 years	4%	25%	27%	22%
20 to 29 years	-	8%	37%	32%
30 years or older	1%	14%	16%	23%
Don't know	-	-	2%	5%
ER7. How long do you think your old system would have lasted?				
1 year or less	1%	14%	24%	30%
2 to 3 years	3%	19%	32%	15%
4 to 5 years	1%	6%	15%	8%
More than 5 years	6%	3%	8%	25%

Table 31: Participant Survey – Cooling Equipment Installations

	Ductless MSHP (n=68)	Central Heat Pump (n=36)	CAC (n=70)
ER1. Was the new measure installed to do one of the following?			
Replace	15%	56%	59%
Supplement	49%	8%	9%
Neither	37%	33%	33%
ER2. What type of [cooling] equipment did it replace?			
CAC	4%	11%	56%
Central heat pump	1%	47%	-
Other	7%	-	3%
ER8. What best describes the condition of your old cooling system that you replaced?			
Working - no need of repair	6%	19%	23%
Working - need minor repair	1%	6%	13%
Working - need major repair	4%	19%	17%
Not working	1%	11%	6%
ER9. Was your old system repairable or was it beyond repair?			
Repairable	-	-	1%
Beyond repair	1%	11%	4%
ER10. How old do you think your old cooling system was?			
11 years or less	6%	8%	7%

12 to 19 years	4%	22%	13%
20 to 29 years	1%	11%	34%
30 years or older	1%	14%	4%
ER11. How long do you think your old system would have lasted?			
1 year or less	4%	19%	20%
2 to 3 years	3%	14%	20%
4 to 5 years	1%	8%	10%
More than 5 years	3%	3%	4%

Table 32: Participant Survey – Heat Pump Water Heater Installations

	(n=83)
EW0. Did the new heat pump water heater replace an existing water heater?	
Yes	93%
No	7%
EW1. What type of fuel did your old water heater use?	
Oil	13%
Natural Gas	1%
Electricity	75%
Propane	4%
EW1A. What best describes the condition of your old water heater?	
Working w/ no need of repair	35%
Working with need of minor repair	22%
Working with need of major repair	23%
Not working	13%
EW2. Was your old water heater repairable or was it beyond repair?	
Repairable	-
Beyond repair	13%
EW3. How old do you think your old water heater was?	
6 years or less	5%
7 to 11 years	33%
12 to 19 years	35%
20 to 29 years	14%
30 years or older	4%
Don't know	2%
EW4. How long do you think your old water heater would have lasted?	
1 year or less	31%
2 to 3 years	29%
4 to 5 years	8%
More than 5 years	11%

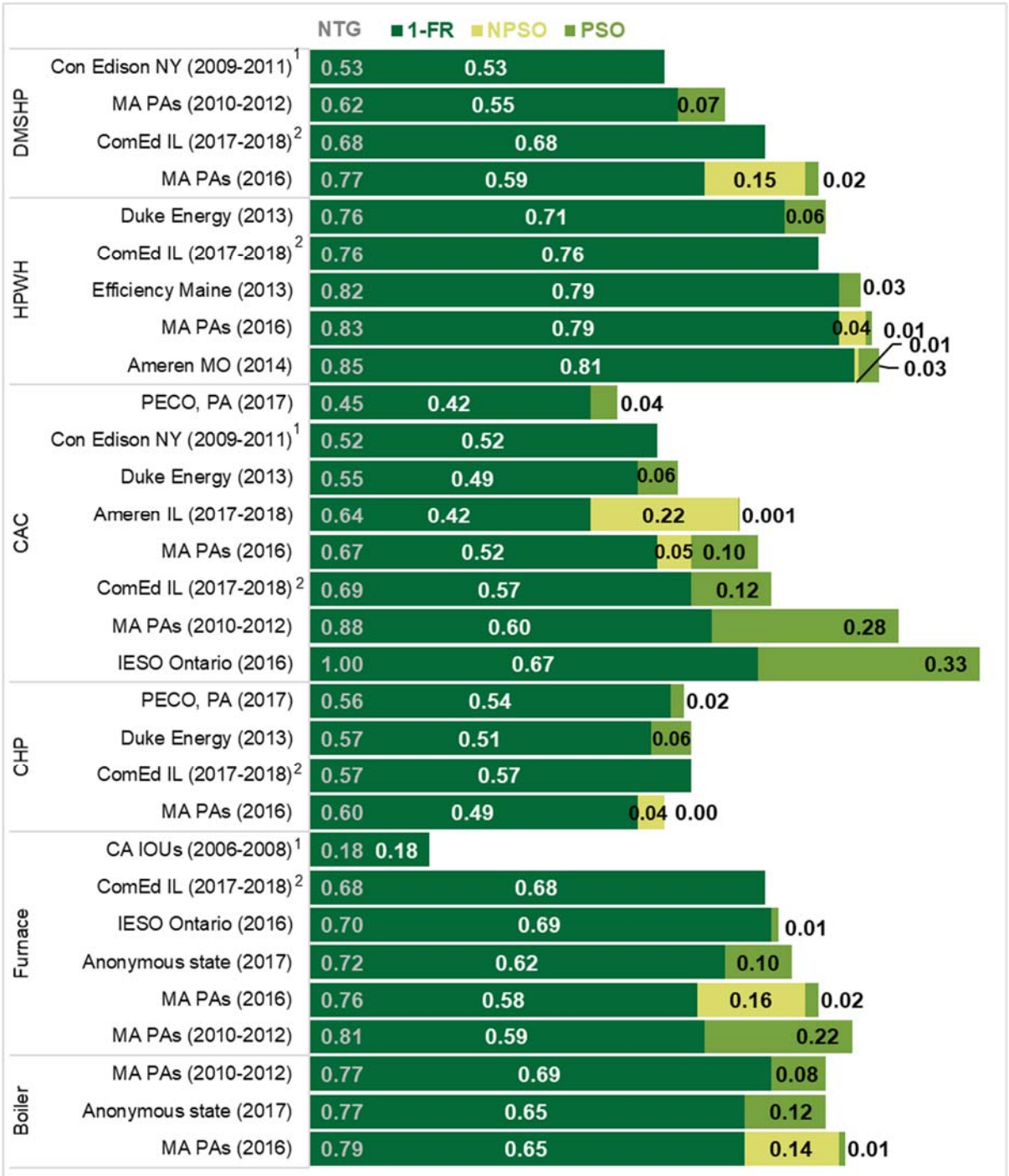
A.3 PRICE SENSITIVITY

Participants (six respondents representing seven measures) who were unaware they received a rebate but confirmed installing measures answered questions about price sensitivity. While the number of respondents who answered is too small to generalize to the population, their responses provide some insight into price sensitivity. Four respondents who installed one measure each speculated that they would have purchased the measure without the rebate if the price were increased by the rebate amount (presented in Section 1.2). These respondents explained that this was because they either were not worried about price or were intent on upgrading to more energy-efficient equipment. Two respondents who installed either one or two measures speculated that they would not have purchased the equipment if the price were increased by the rebate amount. Their reasoning was that they were disappointed with their equipment in retrospect, or had replaced functioning equipment and thus were more price sensitive.

A.4 BENCHMARKING

Figure 17 compares TXC34 NTG recommendations with those from several other jurisdictions. Efficiency levels of equipment covered by programs in these other jurisdictions are generally comparable to that of Mass Save. However, the Consensus Group agreed that other programs may differ substantially in terms of incentive levels and delivery methods. Moreover, NTG estimation methods could differ dramatically. Therefore, they determined that comparing TXC34 results against these was not valuable.

Figure 17: TXC34 NTG Estimates Compared to Other Jurisdictions



[1] The PSO estimate is zero, which is not shown on the graph.
[2] The ComEd IL study only assessed NTG components for CACs. NTG estimates for other equipment were derived from secondary sources.

A.5 HVAC EQUIPMENT STANDARDS

For additional context on the equipment offered through the Mass Save program, we compared the equipment requirements for the Mass Save program to federal standards,[24] ENERGY STAR specifications,[25] and Consortium for Energy Efficiency (CEE) tiers[26] (see Figure 18 and Table 33). In general, we found that equipment offered through the Mass Save program exceeds federal standards and, in most instances, meets or exceeds ENERGY STAR and CEE specifications. In addition to examining current standards and specifications, we investigated the extent to which future changes to efficiency standards may impact the HVAC market. *Our research revealed that there are no imminent changes related to these equipment types.* Below, we summarize our findings related to current standards and specifications for the equipment covered in this study.

- **Central air conditioning:** The program supports CAC systems that meet the minimum requirement of 16 SEER, 13 EER, which is higher than minimum federal requirements and ENERGY STAR specifications for single package units and split systems, and meets the CEE Tier 2 threshold for both types of equipment.
- **Central heat pumps:** The program provides rebates for two minimum levels of efficiency: 16 SEER, 8.5 HSFP and 18 SEER, 9.6 HSPF. These requirements are higher than both the minimum federal standards and ENERGY STAR specifications. The program's 16 SEER central heat pumps exceed the CEE Tier 2 level for single package units and CEE Tier 1 level for split systems. The 18 SEER equipment exceeds the CEE specifications for single package and split systems.
- **Mini-split heat pumps:** The PAs offer rebates for two minimum levels of efficiency: 18 SEER, 9 HSPF and 20 SEER, 11 HSPF. Both of these are more efficient that the federal standard and ENERGY STAR specifications for single package units and split systems. The program's 18 SEER DMSHP surpass the CEE Tier 2 specification for single package units and CEE Tier 2 standard for split systems. The 20 SEER equipment exceeds the CEE specification for single package and split systems.
- **Heat pump water heaters:** The program supports two levels of efficiency: ≤ 55 gallons with an EF ≥ 2.3 and > 55 gallons with an EF ≥ 3.0. Massachusetts' program requirements are higher than federal standards and ENERGY STAR specifications. CEE does not have a specification for heat pump water heaters.
- **Furnaces:** The program offers rebates for two minimum efficiency levels: 95% AFUE and 97% AFUE, which are higher than the federal standard and CEE Tier 0. ENERGY STAR has a minimum specification of 95% AFUE, and CEE has a minimum specification of 95% AFUE for Tier 1 and 97% for Tier 2.

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[24] US Department of Energy: Office of Energy Efficiency & Renewable Energy – *CFR 430.32 13.0.* https://www.gpo.gov/fdsys/pkg/CFR-2013-title10-vol3/pdf/CFR-2013-title10-vol3-part430-subpartC.pdf.
[25] ENERGY STAR specifications listed by equipment type at: https://www.energystar.gov/products/heating_cooling and https://www.energystar.gov/products/water_heaters/heat_pump_water_heaters.
[26] CEE specifications are available at: https://library.cee1.org/system/files/library/9570/CEE_ResHVAC_CAC_ASHP_Specifications_1January2015.pdf and https://library.cee1.org/system/files/library/12048/CEE_ResHVAC_FurnaceBoilerSpecifications_1August2015.pdf.

- **Boilers:** The program promotes boilers with a minimum efficiency of 90% and 95% AFUE, which is more efficient than the federal standard and CEE Tiers 0 and 1. The ENERGY STAR minimum specification is 90%, and the CEE Tier 2 minimum is 95% AFUE.

Figure 18: Comparison of Equipment Standards

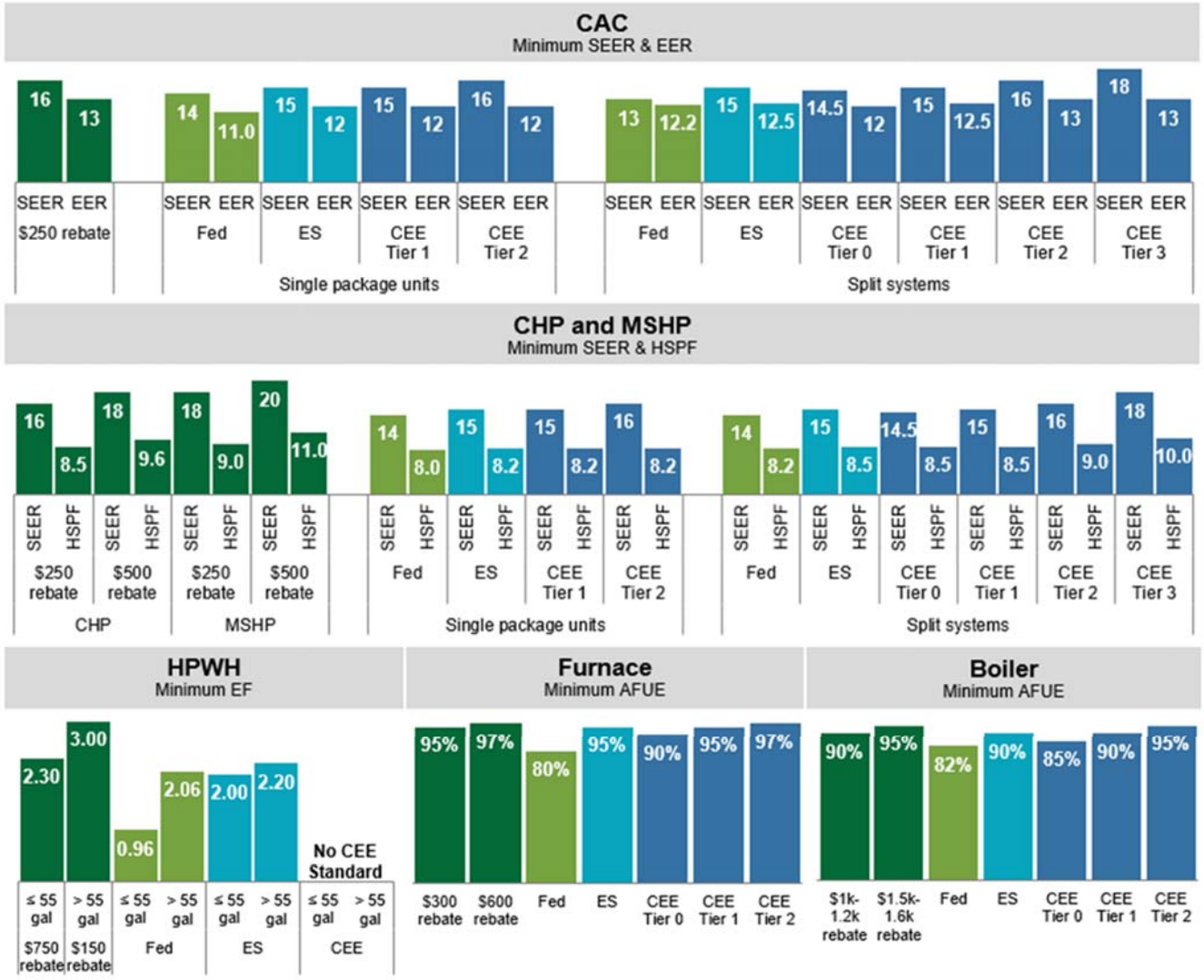


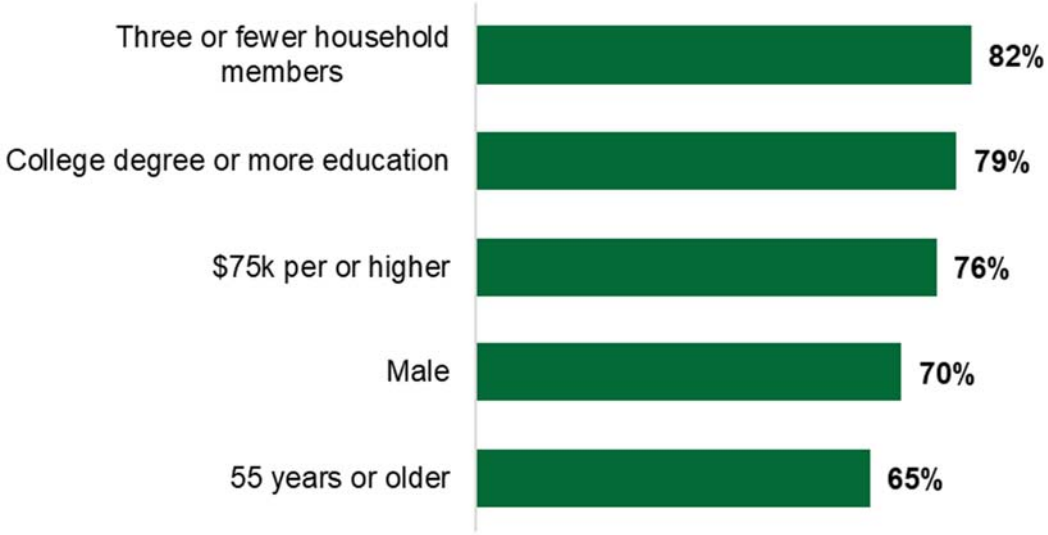
Table 33: Comparison of HVAC Equipment Standards

Program Equipment	MA Program Requirement	Federal Requirement	ENERY STAR Requirement	CEE Requirement
Electric Equipment				
Central air conditioning	SEER ≥ 16, EER ≥ 13	*Single package units:* SEER ≥ 14, EER ≥ 11.0 *Split systems:* SEER ≥ 13, EER ≥ 12.2 (1/1/15)	*Single package units:* SEER ≥ 15, EER ≥ 12.0 *Split systems:* SEER ≥ 15, EER ≥ 12.5 (9/15/15 [v5.0])	*Single package units:* Tier 1: SEER ≥ 15, EER ≥ 12 Tier 2: SEER ≥ 16, EER ≥ 12 *Split systems:* Tier 0: SEER ≥ 14.5, EER ≥ 12 Tier 1: SEER ≥ 15, EER ≥ 12.5 Tier 2: SEER ≥ 16, EER ≥ 13 Tier 3: SEER ≥ 18, EER ≥ 13 (1/1/15) (3/1/14 [Tier 3 split CAC])
Central heat pump	SEER ≥ 16, HSPF ≥ 8.5	*Single package units:* SEER ≥ 14, HSPF ≥ 8.0 *Split systems:* SEER ≥ 14, HSPF ≥ 8.2 (1/1/15)	*Single package units:* SEER ≥ 15, HSPF ≥ 8.2 *Split systems:* SEER ≥ 15, HSPF ≥ 8.5 (9/15/15 [v5.0])	*Single package units:* Tier 1: SEER ≥ 15, HSPF ≥ 8.2 Tier 2: SEER ≥ 16, HSPF ≥ 9.2 *Split systems:* Tier 0: SEER ≥ HSPF ≥ 8.5 Tier 1: SEER ≥ 15, HSPF ≥ 8.5 Tier 2: SEER ≥ 16, HSPF ≥ 9.0 Tier 3: SEER ≥ 18, HSPF ≥ 10.0 (1/1/15)
	SEER ≥ 18, HSPF ≥ 9.6			
Ductless MSHP	SEER ≥18, HSPF ≥9			
	SEER ≥20, HSPF ≥11			
Heat pump water heater	≤ 55 gallons: EF ≥ 2.3	≤ 55 gallons: EF ≥ 0.960 > 55 gallons: EF ≥ 2.057 (4/16/15)	≤ 55 gallons: EF ≥ 2.0 > 55 gallons: EF ≥ 2.20 (4/16/15 [v3.2])	No standard
	> 55 gallons: EF ≥ 3.0			
Gas Equipment				
Furnace	≥ 95% AFUE	≥ 80% AFUE (11/19/15)	≥ 95% AFUE, ECM, 2% air leakage (2/1/13 [v4.1])	Tier 1: ≥ 90% AFUE Tier 2: ≥ 95% AFUE Tier 3: ≥ 97% AFUE (6/1/15)
	≥ 97% AFUE			
Boiler	≥ 90% AFUE	≥ 82% AFUE (1/1/12 – 1/15/21)	≥ 90% AFUE (10/1/14 [v3.0])	Tier 0: ≥ 85% AFUE Tier 1: ≥ 90% AFUE Tier 2: ≥ 95% AFUE (6/1/15)
	≥ 95% AFUE			

A.6 PARTICIPANT DEMOGRAPHICS

As illustrated in Figure 19, survey respondents were most often 45 years or older (85%), in relatively small households (2.5 on average), educated (80%), in moderate to high-income households (76%), and male (71%). These demographics may not necessarily represent the average participant; rather, they may represent the type of participant who wished to complete the survey.

Figure 19: Participant Survey Demographics



[1] Average household size = 2.5 members
Percentage bases exclude refusals so sample sizes vary (n=317 or fewer).

B Appendix B Survey Instruments

B.1 Participant Survey

B.1.1 Sample Variable List

Variable	Format	Notes	Type
PA	String	Eversource, National Grid, etc.	Read-in
PA_CONTACT	String	Contact name at PA	Read-in
MEASURE1	Numeric	First sampled measure 1 – Central heat pump 2 – Central air conditioning system 3 – Heat pump water heater 4 – Mini-split heat pump 5 – Boiler 6 - Furnace	Skips and read-in
MEASURE2	Numeric	Second sampled measure 0 – No second measure 2 – Central air conditioning system 3 – Heat pump water heater 4 – Mini-split heat pump 5 – Boiler 6 - Furnace	Skips and read-in
MEASURE3	Numeric	Third sampled measure 4 – Mini-split heat pump 5 – Boiler 6 - Furnace	Skips and read-in
MEASURE4	Numeric	Fourth sampled measure 4 – Mini-split heat pump	Skips and read-in
QUANTITY1	Numeric	Quantity of first sampled measure	Skips and read-in
QUANTITY2	Numeric	Quantity of second sampled measure	Skips and read-in
REBATE1	Numeric	Rebate amount for first sampled measure	Read-in
REBATE2	Numeric	Rebate amount for second sampled measure	Read-in

[BLUE] = Instructions for programmer

[Green] = Read-in variable

INTRO Thank you for your willingness to complete the survey!

As mentioned in the email or letter you received, we are conducting this survey on behalf of [PA] as part of the group of utilities who sponsor the Mass Save® energy-efficiency program. We would like to learn about your experience participating in the Mass Save® rebate program for new high-efficiency heating, water heating, or cooling equipment. Your feedback is important and will help ensure that the Sponsors of Mass

Save® continue to benefit customers like you throughout the state. This survey will last approximately 10 minutes and your responses are entirely confidential.

If you would like to verify the legitimacy of this research, you can contact [PA_CONTACT]. If you have questions about this survey you can reach our study manager, Nicole Rosenberg, at (617) 284-6230 extension 9 or nrosenberg@nmrgroupinc.com.

Please use the survey's navigational buttons to move between questions. Do not use your browser's "Back" and "Forward" buttons.

B.1.2 Screening

S1. In the last two years, have you received a home energy assessment from Mass Save or your utility company? An energy specialist would have visited your home and provided you with recommendations to improve your home's energy efficiency. They may also have installed free energy saving equipment. (Select one)

1. Yes
2. No
98. Don't know

S1A. [IF S1 = 1] Over the course of this survey, we ask you to think about equipment you appear to have installed and received a rebate for **before or after** the audit—**not** during the audit.

[ASK FOR MEASURE1 THROUGH MEASURE4 – START ROSTER]

S2. Our records show that in 2016 or 2017 you or your HVAC contractor received a rebate from Mass Save® or your utility for a high-efficiency [MEASURE]. Is that correct? (Select one)

1. Yes
2. No
98. Don't know

S3. [ASK IF S2=2 OR 98] In 2016 or 2017, did you install [MEASURE]? (Select one)

1. Yes
2. No
98. Don't know

[END ROSTER]

TERM1. [IF S2R1, S3R1, S2R2, S3R2 all <>1] Thank you for your willingness to complete this survey. Unfortunately, we are only conducting this survey with participants who are able to confirm installing the equipment. [TERMINATE]

S4. Are you the person in your household who is most familiar with the decision making that went into purchasing the equipment? (Select one)

1. Yes
2. No

S4A. [IF S4 = 2, READ] Is the person most familiar with the decision making that went into purchasing the equipment available to complete this survey at this time? If so, we will return to the first question. (Select one)

1. Yes, that person is available [SKIP TO INTRO]
2. No, that person is not available

S4B. [IF S4A = 2, READ] What is that person's email address? We will invite them to respond to this survey instead.

1. [OPEN END]
2. Would rather not provide/Don't know

S4C. [IF S4B = 2, READ] Would you be willing to forward them the link we provided to you to complete this survey?

1. Yes
2. No

TERM3. [IF S4B=2 AND S4C=2] Thank you for your time. Have a good day. [TERMINATE]

TERM2. [IF S4A OR S4B = 2] On behalf of the Sponsors of Mass Save, we thank you for your willingness to complete this survey. Have a great day. PRESS NEXT TO RESTART SURVEY

AWARE. [IF (S2R1=2 OR S2R1=98) AND (S2R2=2 OR S2R2=98), COMPUTE AWARE=0; ELSE AWARE=1]

[IF AWARE=0, SKIP TO ER1]

[ASK FOR MEASURE1 AND MEASURE2 – START ROSTER]

S5. [SKIP IF INSTALL=1] Our records show that you installed [QUANTITY] [MEASURE](s) that received a rebate from Mass Save® or your utility. Is that correct? (Select one)

1. Yes
2. No

S6. [ASK IF S5 = 2] How many [MEASURE]s did you install? [OPEN END NUMERIC]

[IF S5=2, COMPUTE QUANTITY=S5]

[END ROSTER]

B.1.3 Introduction

IN1. How did you learn about the Mass Save® or utility rebates for high-efficiency heating, water heating, and cooling equipment? (Select all that apply) [ALLOW MULTIPLE RESPONSES]

1. Mass Save® television, radio, or print advertisements
2. [PA] advertising (bill inserts, mailers)
3. Word of mouth (friend, neighbor, or coworker)
4. The contractor who installed the equipment
5. The retailer who sold you the equipment
6. Other [SPECIFY]
7. Don't recall

IN2. Other than the rebate(s) you received from Mass Save® or your utility, which of the following rebates or incentives did you receive for your new heating, water heating, or cooling equipment? (Please select all that apply) [ALLOW MULTIPLE RESPONSES]

1. No other rebates received
2. Tax credits
3. Massachusetts Clean Energy Center (CEC) Rebates
4. Other rebates or incentives [SPECIFY]

IN2A. [IF IN2 = 2, 3, or 4, READ] For the remainder of this survey, when we refer to "the rebate," we are referring ONLY to the rebate you or your contractor received from Mass Save® or your utility company for your new high-efficiency heating, water heating, or cooling equipment. [CONTINUE]

B.1.4 Early Replacement – Heating and Cooling

[ASK FOR MEASURE1 AND MEASURE2 – START ROSTER]

[IF MEASURE=3 (Heat Pump Water Heater), SKIP TO NEXT MODULE/MEASURE]

ER1. Was the new [MEASURE] installed to do one of the following? (Select one)

1. Replace existing equipment
2. Supplement a primary heating or cooling system
3. Serve as the primary equipment to heat or cool my home [SKIP TO NEXT MODULE/MEASURE]

ER2. [ASK IF ER1 = 1] What type of equipment did it replace? (Select all that apply) [ALLOW MULTIPLE RESPONSES]

[HIDE CATEGORY 4, 5, AND 6 IF MEASURE = 5 OR 6 (Boiler or Furnace); HIDE CATEGORIES 1 - 3 IF MEASURE = 2 (Central AC)]

1. Boiler
2. Furnace
3. Another type of heating system
4. Central air conditioning system
5. Central heat pump
6. Another type of cooling system (e.g., window or room A/C units)

ER2S. [ASK IF ER1 = 2] What equipment is **primarily** used to condition the space? (Select all that apply) [ALLOW MULTIPLE RESPONSES]

[HIDE CATEGORIES 4, 5, 6 IF MEASURE = 5 OR 6 (Boiler or Furnace); HIDE CATEGORIES 1, 2 3 IF MEASURE = 2 (Central AC)]

1. Boiler
2. Furnace
3. Another type of heating system
4. Central air conditioning system
5. Central heat pump
6. Another type of cooling system (e.g., window or room A/C units)

[END ROSTER]

HEAT [IF ER2R1 or ER2R2 = 1, 2, 3, OR 5, COMPUTE HEAT = 1; ELSE HEAT=0]

COOL [IF ER2R1 or ER2R2 = 4, 5, OR 6, COMPUTE COOL = 1; ELSE COOL=0]

S_HEAT [IF ER2SR1 or ER2SR2 = 1, 2, 3, OR 5, COMPUTE S_HEAT = 1; ELSE S_HEAT=0]

S_COOL [IF ER2SR1 or ER2SR2 = 4, 5, OR 6, COMPUTE S_COOL = 1; ELSE S_COOL=0]

ER3. [ASK IF ER2R1 OR ER2R2 = 1, 2, OR 3] What type(s) of fuel did your old heating system that you replaced use? (Select all that apply) [ALLOW MULTIPLE RESPONSES]

1. Oil
2. Natural Gas
3. Electricity
4. Propane
5. Kerosene
6. Pellets
7. Wood
8. Solar
9. Other

ER4. [ASK IF HEAT = 1] Which of the following best describes the condition of your old **heating** system that you replaced? (Select one)

1. Working with no need of repair
2. Working with need of minor repair
3. Working with need of major repair
4. Not working at all

ER5. [ASK IF ER4 = 4] Was your old **heating** system repairable or was it beyond repair? (Select one)

1. Repairable
2. Beyond repair

ER6. [ASK IF HEAT = 1] How old do you think your old **heating** system was? (Select one)

1. 11 years or less
2. 12 to 19 years
3. 20 to 29 years
4. 30 years or older
98. Don't know

ER7. [SKIP IF ER5 = 2 OR HEAT = 0] How long do you think your old **heating** system would have lasted if you had not replaced it with the new equipment? (Select one)

1. 1 year or less
2. 2 to 3 years
3. 4 to 5 years
4. More than 5 years

ER8. [ASK IF COOL = 1] Which of the following best describes the condition of your old **cooling** system that you replaced? (Select one)

1. Working with no need of repair
2. Working with need of minor repair
3. Working with need of major repair
4. Not working at all

ER9. [ASK IF ER8 = 4] Was your old **cooling** system repairable or was it beyond repair? (Select one)

1. Repairable
2. Beyond repair

ER10. [ASK IF COOL = 1] How old do you think your old **cooling** system was? (Select one)

1. 11 years or less
2. 12 to 19 years
3. 20 to 29 years
4. 30 years or older
98. Don't know

ER11. [SKIP IF ER9 = 2 OR COOL = 0] How long do you think your old **cooling** system would have lasted if you had not replaced it with the new equipment? (Select one)

1. 1 year or less
2. 2 to 3 years
3. 4 to 5 years
4. More than 5 years

ER3S. [ASK IF ER2SR1 OR ER2SR2 = 1, 2, OR 3] What type(s) of fuel does your primary heating system use? (Select all that apply) [ALLOW MULTIPLE RESPONSES]

1. Oil
2. Natural Gas
3. Electricity
4. Propane
5. Kerosene
6. Pellets
7. Wood
8. Solar
9. Other

ER4S. [ASK IF S_HEAT = 1] Which of the following best describes the condition of your primary **heating** system? (Select one)

1. Working with no need of repair
2. Working with need of minor repair
3. Working with need of major repair
4. Not working at all

ER5S. [ASK IF S_HEAT = 1] How old do you think your primary **heating** system is? (Select one)

1. 11 years or less
2. 12 to 19 years
3. 20 to 29 years
4. 30 years or older
98. Don't know

ER6S. [ASK IF S_COOL = 1] Which of the following best describes the condition of your primary **cooling** system? (Select one)

1. Working with no need of repair
2. Working with need of minor repair
3. Working with need of major repair
4. Not working at all

ER7S. [ASK IF S_COOL = 1] How old do you think your primary **cooling** system is? (Select one)

1. 11 years or less
2. 12 to 19 years
3. 20 to 29 years
4. 30 years or older
98. Don't know

B.1.5 Early Replacement – Water Heater

[ASK IF MEASURE1 OR MEASURE2 = 3 (Heat Pump Water Heater)]

EW0. Did the new heat pump water heater you installed replace an existing water heater? (Select one)

1. Yes
2. No [SKIP TO FR1]

EW1. What type of fuel did your old water heater use?

1. Oil
2. Natural Gas
3. Electricity
4. Propane
5. Kerosene
6. Pellets
7. Wood
8. Solar
9. Other

EW1A. Which of the following best describes the condition of your old water heater? (Select one)

1. Working with no need of repair
2. Working with need of minor repair
3. Working with need of major repair
4. Not working at all

EW2. [ASK IF EW1A = 4] Was your old water heater repairable or was it beyond repair? (Select one)

1. Repairable
2. Beyond repair

EW3. How old do you think your old water heater was? (Select one)

1. 6 years or less
2. 7 to 11 years
2. 12 to 19 years
3. 20 to 29 years
4. 30 years or older
98. Don't know

EW4. [SKIP IF EW2 = 2] How long do you think your old water heater would have lasted if you had not replaced it with the new heat pump water heater? (Select one)

1. 1 year or less
2. 2 to 3 years
3. 4 to 5 years
4. More than 5 years

B.1.6 Free-Ridership

[IF AWARE = 0, SKIP TO C1]

[ASK FOR MEASURE1 AND MEASURE2 – START ROSTER]

[IF INSTALL=1, SKIP TO NEXT MODULE/MEASURE]

FR1. On a scale of 0 to 10, where 0 is "definitely would NOT have installed it" and 10 is "definitely WOULD have installed it," what is the likelihood that you would have installed the **same high-efficiency** [MEASURE] without the Mass Save® or utility rebate? (Select one) [ALLOW RESPONSES FROM 0 TO 10]

FR2. [ASK IF FR1 > 0] If you had not received the Mass Save® or utility rebate, would you have installed the **same high-efficiency** [MEASURE] at the *same* time, a *different* time, or *not at all*? (Select one)

1. Same time
2. Different time
3. Not at all

FR3. [ASK IF FR2 = 2] Without the rebate, **when** would you have installed the same high-efficiency [MEASURE]? (Select one)

1. At the same time
2. Sooner
3. Within 6 months
4. Six to 12 months later
5. More than 12 months later

FR4. [ASK IF QUANTITY > 1] Without the rebate, would you have installed the same number of high-efficiency [MEASURE]s that you did? (Select one)

1. Yes
2. No

FR5. [ASK IF FR4 = 2] Without the rebate, how many high-efficiency [MEASURE]s would you have installed? (Record whole number) [OPEN END NUMERIC]

FR6. On a scale of 0 to 10, where 0 is "not at all influential" and 10 is "very influential," how influential were the following on your decision to install the high-efficiency [MEASURE]? (Select one for each) [FOR EACH, ALLOW RESPONSES FROM 0 TO 10; INCLUDE 96 "Not applicable" OPTION FOR b AND c]

a. The Mass Save® or utility rebate
b. Salesperson or contractor recommendations [IF S1 = 1]. Only think of the company who installed [MEASURE], not the auditor you interacted with during your home energy assessment.
c. Mass Save® or utility marketing materials (advertising, mailers)

FR7. [ASK IF ((FR6a < 3 or FR6c < 3) AND FR1 < 3) OR ((FR6a > 7 or (FR6c > 7 and FR6c<>96)) AND FR1 > 7); **ELSE SKIP TO NEXT MODULE/MEASURE**] Some of your answers (shown below) appear inconsistent with respect to the rebate's importance in your decision to install the [MEASURE]. Do you want to change your responses to one or both questions? Enter your final answers below.

		Your response	Revised response [ALLOW 0 TO 10 RESPONSES]
FR7a2	On a scale of 0 to 10, where 0 is "definitely would NOT have installed it" and 10 is "definitely WOULD have installed it" **without the Mass Save® or utility rebate**, what is the likelihood that you would have still installed the same high-efficiency [MEASURE]?	[FR1]	
FR7b2	On a scale of 0 to 10, where 0 is "not at all influential" and 10 is "very influential," how influential was the Mass Save® or utility rebate on your decision to install the high-efficiency [MEASURE]?	[FR6a]	

FR8. [READ IF FR7b < 3 AND FR7a < 3] You say that, without the Mass Save® or utility rebate, you would have been unlikely to install the [MEASURE], but at the same time you say that the rebate was not influential in your decision to install it.

[READ IF FR7b > 7 AND FR7a > 7] You say that, without the Mass Save® or utility rebate, you would have been likely to install the [MEASURE], but at the same time you say that the rebate was influential in your decision to install it.

[READ FOR ALL] Could you explain how the rebate played into your decision? [OPEN END]

[END ROSTER]

B.1.7 Contractor Influence

[ASK FOR MEASURE1 AND MEASURE2 – START ROSTER]

C1. Before speaking with your contractor, had you already been considering high-efficiency options for the [MEASURE]? By "high-efficiency," we mean [MEASURE]s that use considerably less energy than the typical, standard efficiency [MEASURE]s that are available. (Select one)

1. Yes
2. No
98. Don't remember

C2. Which of the following *best* describes how you ultimately selected the new [MEASURE]? (Select one) [ALLOW ONE RESPONSE; RANDOMLY ROTATE 1 THROUGH 3]

1. I did some research on [MEASURE]s and made my own choice
2. My contractor suggested one [MEASURE] model, and I agreed
3. My contractor suggested various [MEASURE] models, and I chose one
4. Something else [SPECIFY]

[IF AWARE = 1, SKIP TO NEXT MODULE/MEASURE]

C3. [ASK IF C2 = 3] About how many [MEASURE] models did the contractor offer you? [OPEN END NUMERIC]

C4. Did your [MEASURE] contractor emphasize the benefits of high-efficiency equipment?

1. Yes
2. No

C5. On a scale of 0 to 10, where 0 is "not at all influential" and 10 is "very influential," how influential was the following on your decision to install the high-efficiency [MEASURE] that you did? (Select one for each) [FOR EACH, ALLOW RESPONSES FROM 0 TO 10; INCLUDE 96 "Not applicable"]

a. Materials, such as brochures, that you received from the contractor
b. Salesperson or contractor's recommendations

C6. How did the contractor influence your purchase decision? [OPEN END]

[END ROSTER]

B.1.8 Price Sensitivity

[IF AWARE = 1, SKIP TO SO1]

[ASK FOR MEASURE1 AND MEASURE2 – START ROSTER]

PR1. **Approximately** how much did the [MEASURE](s) cost in dollars, including installation?

[OPEN END NUMERIC]

98. Don't know

PR2. Would you have purchased the exact same high-efficiency [MEASURE] if the price was $[REBATE] higher? If you installed more than one [MEASURE], assume this price increase is for each one you installed.

1. Yes
2. No

PR3. Why do you say that? [OPEN END]

[END ROSTER]

B.1.9 Spillover

[IF AWARE = 0, SKIP TO D1]

SO1. Since installing the equipment, have you made other energy-saving purchases or changes that did **not** receive an incentive or rebate from Mass Save® or your utility? (Select one)

1. Yes
2. No [SKIP TO FR6d]

SO2. Did your experience with the Mass Save® or utility rebate program influence your decision to take any of these energy-saving actions? (Select one)

1. Yes
2. No [SKIP TO FR6d]

SO3. What energy-saving purchases or changes did you make? (Select all that apply) [ALLOW MULTIPLE RESPONSES]

1. Energy-efficient light bulbs
2. Energy-efficient appliance(s) [SPECIFY]
3. Attic, wall, or basement insulation
4. Duct sealing or duct insulation
5. Air sealing of leaks
6 Smart thermostat
7. Other purchases or changes [OPEN END]

SO3a. [ASK IF SO3 = 2] Were any of the appliances ENERGY STAR-labeled? (Select one)

1. Yes
2. No
3. Don't know

[ASK FOR EACH MEASURE SELECTED IN SO3 – START ROSTER]

SO3b. [ASK IF SO3 = 3, 4, 5, 7] Can you describe the [SO3] work in more detail? If applicable, include the quantity installed, the type of equipment, and the efficiency levels installed? [OPEN END]

SO4. On a scale of 0 to 10, where 0 is "not at all important" and 10 is "very important," how important was your experience with the Mass Save® or utility rebate program on your decision to [INSERT TEXT BELOW], which did not receive a rebate?

[ALLOW RESPONSES FROM 0 TO 10]

[IF SO3 = 1] purchase energy-efficient light bulbs
[IF SO3 = 2] purchase energy-efficient appliance(s)
[IF SO3 = 3] install attic, wall, or basement insulation
[IF SO3 = 4] install duct sealing or duct insulation
[IF SO3 = 5] seal air leaks
[IF SO3 = 6] purchase a smart thermostat
[IF SO3 = 7] purchase/install [SO3 OPEN END RESPONSE]

SO5. On a scale of 0 to 10, where 0 is "definitely would NOT have made the improvements" and 10 is "definitely WOULD have made the improvements," had you *not* received a rebate for the [MEASURE1] [IF MEASURE2>0, SHOW: "and MEASURE2"], what is the likelihood that you would still have [INSERT TEXT BELOW]?

[ALLOW RESPONSES FROM 0 TO 10]

[IF SO3 = 1] purchased energy-efficient light bulbs
[IF SO3 = 2] purchased energy-efficient appliance(s)
[IF SO3 = 3] installed attic, wall, or basement insulation
[IF SO3 = 4] installed duct sealing or duct insulation
[IF SO3 = 5] sealed air leaks
[IF SO3 = 6] purchased a smart thermostat
[IF SO3 = 7] purchased/installed [SO3 OPEN END RESPONSE]

SO6. [ASK IF ANY SO4 > 7 OR SO5 < 3] How did the rebate(s) for the [MEASURE1] [IF APPLICABLE: "and MEASURE2]"] influence your decision to [INSERT TEXT BELOW]?

[ALLOW OPEN ENDED RESPONSES]

[IF SO3 = 1] Purchase energy-efficient light bulbs
[IF SO3 = 2] Purchase energy-efficient appliance(s)
[IF SO3 = 3] Installed attic, wall, or basement insulation
[IF SO3 = 4] Installed duct sealing or duct insulation
[IF SO3 = 5] Sealed air leaks
[IF SO3 = 6] Purchase a Smart thermostat
[IF SO3 = 7] Purchase/install [SO3 OPEN END RESPONSE]

FR6d. [ASK IF S1 = 1] Shifting gears, think back to the home energy assessment you received. On a scale of 0 to 10, where 0 is "not at all influential" and 10 is "very influential," how influential was the auditor who performed your home energy assessment on your decision to install the high-efficiency [MEASURE]? [ALLOW RESPONSES FROM 0 TO 10; and INCLUDE 96 "Not applicable"]

[END ROSTER]

B.1.10 Demographics

TEXT1. You're nearly done. We have some questions for statistical purposes about you and your household. Your responses are strictly confidential.

D1. Including yourself, how many people live in your home most of the year?

[OPEN END NUMERIC]
98. Would rather not answer

D2. What is the highest level of education that you have completed? (Select one)

1. Less than high school
2. High school graduate
3. Technical or trade school graduate
4. Some college
5. College graduate
6. Some graduate school
7. Graduate degree
98. Would rather not answer

D3. Which of the following category best describes your age? (Select one)

1. 18 to 24
2. 25 to 34
3. 35 to 44
4. 45 to 54
5. 55 to 64
6. 65 or over
98. Would rather not answer

D4. What category best describes your total household income in 2016, before taxes? (Select one)

1. Less than $35,000
2. $35,000 to $49,999
3. $50,000 to $74,999
4. $75,000 to $99,999
5. $100,000 to $149,999
6. $150,000 to $199,999
7. $200,000 or more
98. Would rather not answer

➢ D5. Which of the following best describes you? (Select one)

1. Male
2. Female
3. Other
98. Would rather not answer

Those are all the questions we have. On behalf of the utilities that sponsor the Mass Save® rebate program, thank you for completing our survey.

B.2 CONTRACTOR SURVEY

[BLUE] = Instructions for programmer

[Green] = Read-in variable

B.2.1 Introduction

Thank you for agreeing to take part in this survey!

As mentioned in the email you received, we are conducting this survey on behalf of the utilities and energy efficiency service providers that sponsor Mass Save®. We would like to learn about your experiences with the Mass Save rebate program for high-efficiency heating, water heating, and cooling equipment. Your feedback will help make sure that the Sponsors of Mass Save continue to benefit customers and contractors such as yourself. If you are eligible for the survey and complete it, we will send you a $50 Amazon gift card or check or donate $50 to one of these charities: Hurricane Relief Fund, Big Brothers Big Sisters of Massachusetts Bay, or the Berkshire Humane Society. Our questions should take less than 25 minutes of your time and your answers will be kept confidential.

[IF PHONE, SHOW "IF NEEDED:"] Questions about the legitimacy of this research? Contact Chris Chan, Eversource, at (781) 441-8544 or christopher.chan@eversource.com or study manager Nicole Rosenberg at (617) 284-6230 x9.

[IF WEB, LINK A POP UP TO FIRST MENTION OF MASS SAVE: "Mass Save® is a collaborative of Massachusetts' natural gas and electric utilities and energy efficiency service providers including Berkshire Gas, Blackstone Gas, Cape Light Compact JPE, Columbia Gas of Massachusetts, Eversource, Liberty Utilities, National Grid, and Unitil. They empower residents, businesses, and communities to make energy-efficient upgrades by offering a wide range of services, rebates, incentives, trainings, and information."]

[IF PHONE] IF SAYS JUST RESPONDED TO ANOTHER SURVEY: The sponsors of Mass Save are conducting two surveys. *This* survey is about how the Mass Save rebates affect the decisions that you and your customers make. The *other* survey is about the costs to purchase and install certain types of residential water heating and cooling equipment. We really appreciate your answering both surveys, and we hope you can take a little time today to answer these questions too.

B.2.2 Screening

S1. Let's first make sure that you are eligible to complete the survey. Does your company install residential heating, water heating, and cooling equipment in single-family homes in Massachusetts? [IF RESPONSE CATEGORIES ARE IN PARENTHESES, EXCLUDE FROM WEB SURVEY; DON'T KNOW/REFUSED SHOULD NEVER BE READ ALOUD ON PHONE]

1. Yes
2. No
98. Don't know
99. (Refused)

[IF S1 < > 1] Unfortunately, you are not eligible to complete this survey. Thank you for your time. [TERMINATE]

S1a. Are you familiar with your company's installation of high-efficiency heating, water heating, and cooling equipment for which customers received rebates from the Sponsors of Mass Save?

1. Yes
2. No
98. Don't know
99. (Refused)

[IF S1a < > 1, READ] Would you be able to refer us to a colleague who is familiar with your participation in these programs and can respond to this survey? [WILL WORK WITH SURVEY PROGRAMMERS ON BEST FOLLOW-UP APPROACH FOR EACH MODE TO OBTAIN CONTACT INFORMATION]

S1b. [WEB ONLY; SKIP AFTER REACHING P77 QUOTA (n=20)] Does your company install either of the following types of equipment in commercial or industrial buildings in Massachusetts?

a. Small commercial water heaters, including tankless or tank-style residential-style units

b. Large commercial water heaters, such as dedicated domestic hot water boilers and combined heating/DHW boilers

[FOR EACH]
1. Yes
2. No
98. Don't know
99. (Refused)

S1bb. [ASK IF S1b_a OR S1b_b = 1] Would you be willing to answer additional questions about your company's installations of commercial water heaters at the end of this survey, for an additional $30 gift card?

1. Yes
2. No
99. (Refused)

[COMPUTE P77 = 0; IF S1bb = 1, THEN P77 = 1]

S2_TEXT. The Sponsors of Mass Save offer two levels of rebates to encourage residential customers to replace less efficient heating and cooling equipment with high-efficiency equipment: **Early-Replacement** and **Standard**. Early Replacement rebates are offered for functioning furnaces, central air conditioning systems, and central heat pumps that are 12 or more years old, or functioning boilers that are 30 or more years old; and are expected to function and operate for the foreseeable future. Early Replacement rebates are about two and a half times as much as Standard rebates.

S2INTRO. [ASK IF STANDARD = 1 AND ER = 1] Our records indicate in 2016 your company installed equipment for which both Standard and Early Replacement rebates were claimed. To your knowledge, is that correct?

1. Yes, both Standard and Early Replacement rebates
2. No, just Standard rebates
3. No, just Early Replacement rebates
98. Don't know
99. (Refused)

S2INTROa. [ASK IF STANDARD = 1 AND ER = 0] Our records indicate in 2016 your company installed equipment for **Standard** rebates were claimed, but not for Early Replacement rebates. To your knowledge, is that correct?

1. Yes, just Standard rebates
2. No, just Early Replacement rebates
3. No, both Standard and Early Replacement rebates
98. Don't know
99. (Refused)

S2INTROb. [ASK IF STANDARD = 0 AND ER = 1] Our records indicate in 2016 your company installed equipment for which Early Replacement rebates were claimed, but not for Standard rebates. To your knowledge, is that correct?

1. Yes, just Early Replacement rebates
2. No, just Standard rebates
3. No, both Standard and Early Replacement rebates
98. Don't know
99. (Refused)

[IF S2INTRO, S2INTROa, OR S2INTROb = 98 OR 99, READ] Is there a colleague of yours who is familiar with your company's installation of rebated equipment who can respond to this survey? [WILL WORK WITH SURVEY PROGRAMMERS ON BEST FOLLOW-UP APPROACH FOR EACH MODE TO OBTAIN CONTACT INFORMATION]

[**COMPUTE V_STANDARD = STANDARD AND V_ER = ER**:
IF S2INTRO = 2, V_STANDARD = 1 AND V_ER = 0;
IF S2INTRO = 3, V_STANDARD = 0 AND V_ER = 1;
IF S2INTROa = 2, V_STANDARD = 0 AND V_ER = 1;
IF S2INTROa = 3, V_STANDARD = 1 AND V_ER = 1;
IF S2INTROb = 2, V_STANDARD = 1 AND V_ER = 0;
IF S2INTROb = 3, V_STANDARD = 1 AND V_ER = 1]

[IF V_STANDARD < > 1, SKIP TO S5]

S2. [IF V_ER = 1, INCLUDE "First, we will ask you to think about the types of residential equipment you installed that received **Standard** rebates through the Mass Save program."]

Our records show that in 2016 your company installed the following types of residential equipment for which you or your customers received **Standard** (not Early Replacement) rebates from Mass Save. Is that correct? If your company is a large retailer, only think of the installations that your store or location's installers perform. [SINGLE SCREEN]

a. [ASK IF S_MSHP = 1] Ductless mini-split heat pumps
b. [ASK IF S_HPWH = 1] Heat pump water heaters
c. [ASK IF S_CAC = 1] Central air conditioning systems
d. [ASK IF S_FURN = 1] Gas furnaces
e. [ASK IF S_BOIL = 1] Gas boilers
f. [ASK IF S_CHP = 1] Central heat pumps

[FOR EACH]
1. Yes
2. No
98. Don't know
99. (Refused)

[COMPUTE VERIFIED MEASURE VARIABLES, SERIES "VS_XX." STARTING VALUES FOR ALL THE VARIABLES IN THE VS_XX SERIES (VS_MSHP, VS_HPWH, VS_CAC, VS_FURN, VS_BOIL, VS_CHP) IS 0. RECODE VS_XX SERIES VARIABLES AS FOLLOWS:]

COMPUTE	EQUALS
VS_MSHP	0
VS_HPWH	0
VS_CAC	0
VS_FURN	0
VS_BOIL	0
VS_CHP	0

IF	THEN
S2a = 1	VS_MSHP = 1
S2b = 1	VS_HPWH = 1
S2c = 1	VS_CAC = 1
S2d = 1	VS_FURN = 1
S2e = 1	VS_BOIL = 1
S2f = 1	VS_CHP = 1

[IF ALL S2 < > 1 AND V_ER < > 1] Unfortunately, you are not eligible to complete this survey. Thank you for your time. [TERMINATE]

S3. Our records show that in 2016 your company installed the following quantities of residential equipment that received **Standard** rebates from Mass Save. Does this sound right? [SINGLE SCREEN]

a. [ASK IF VS_MSHP = 1] [SQTY_MSHP] Outdoor ductless mini-split heat pump systems
b. [ASK IF VS_HPWH = 1] [SQTY_HPWH] Heat pump water heaters
c. [ASK IF VS_CAC = 1] [SQTY_CAC] Central air conditioning systems
d. [ASK IF VS_FURN = 1] [SQTY_FURN] Gas furnaces
e. [ASK IF VS_BOIL = 1] [SQTY_BOIL] Gas boilers
f. [ASK IF VS_CHP = 1] [SQTY_CHP] Central heat pumps

[FOR EACH]
1. Yes
2. No
98. Don't know
99. (Refused)

S4. [ASK FOR EACH WHERE S3 > 1] About how many residential [MEASURE] that received **Standard** rebates from Mass Save did your company install in 2016?

[PHONE ONLY: "IF NEEDED:"] We'll need a rough estimate to continue the survey.

[OPEN END NUMERIC]
9998. Don't know
. (Refused)

[COMPUTE VERIFIED STANDARD QUANTITY VARIABLES, "VSQTY_X" SERIES. STARTING VALUES FOR ALL THE VARIABLES IN THE SERIES SHOULD EQUAL THE VALUES FOR THE SQTY_XX SERIES, AS SHOWN IN THE FIRST TABLE BELOW]

COMPUTE	EQUALS
VSQTY_MSHP	SQTY_MSHP
VSQTY_HPWH	SQTY_HPWH
VSQTY_CAC	SQTY_CAC
VSQTY_FURN	SQTY_FURN
VSQTY_BOIL	SQTY_BOIL
VSQTY_CHP	SQTY_CHP

IF	THEN
S3A < > 1	VSQTY_MSHP = S4A
S3B < > 1	VSQTY_HPWH = S4B
S3C < > 1	VSQTY_CAC = S4C
S3D < > 1	VSQTY_FURN = S4D
S3E < > 1	VSQTY_BOIL = S4E
S3F < > 1	VSQTY_CHP = S4F

IF	OR	THEN
S4A = 9998 or 9999	S2A < > 1	VSQTY_MSHP = 0
S4B = 9998 or 9999	S2B < > 1	VSQTY_HPWH = 0
S4C = 9998 or 9999	S2C < > 1	VSQTY_CAC = 0
S4D = 9998 or 9999	S2D < > 1	VSQTY_FURN = 0
S4E = 9998 or 9999	S2E < > 1	VSQTY_BOIL = 0
S4F = 9998 or 9999	S2F < > 1	VSQTY_CHP = 0

[COMPUTE **S_MEASURE_1 AND S_MEASURE_2 VARIABLES**:
RANDOMLY SELECT UP TO TWO MEASURES AND ASSIGN THEM WHERE THEY SATISFY THE REQUIREMENTS IN COLUMN 1 AND IN THE ORDER DEFINED IN COLUMN 3 IN THE TABLE BELOW] (as an example, a respondent installs central heat pumps, boilers, and furnaces only, we would assign s_measure_1 as *central heat pumps* and s_measure_2 as *furnaces*; we would not assign *boilers* to that respondent unless the other strata are full)

IF	S_MEASURE_1 OR S_MEASURE_2 =	PRIORITY
VSQTY_MSHP > 0	outdoor ductless mini-split heat pump systems	5
VSQTY_HPWH > 0	heat pump water heaters	4
VSQTY_CAC > 0	central air conditioning systems	2
VSQTY_FURN > 0	gas furnaces	3
VSQTY_BOIL > 0	gas boilers	6
VSQTY_CHP > 0	central heat pumps	1

[IF V_ER < > 1 AND ALL VSQTY_XX = 0, SKIP TO TERM4]

S5. [IF V_ER = 1, INCLUDE "Next, we'll ask you to think about the types of residential equipment you installed that received **Early Replacement** rebates through the Mass Save program [SINGLE SCREEN]."]

Our records show that in 2016 your company installed the following types of residential equipment for which you or your customers received **Early Replacement** rebates from Mass Save. Is that correct? If your company is a large retailer, only think of the installations that your store or location's installers perform.

a. [ASK IF ER_CAC = 1] Central air conditioning systems
b. [ASK IF ER_FURN = 1] Furnaces
c. [ASK IF ER_BOIL = 1] Boilers
d. [ASK IF ER_CHP = 1] Central heat pumps

[FOR EACH]
1. Yes
2. No
98. Don't know
99. (Refused)

[COMPUTE VERIFIED MEASURE VARIABLES, "VER_XX" SERIES]

COMPUTE	EQUALS
VER_CAC	0
VER_FURN	0
VER_BOIL	0
VER_CHP	0

IF	THEN
S5a = 1	VER_CAC = 1
S5b = 1	VER_FURN = 1
S5c = 1	VER_BOIL = 1
S5d = 1	VER_CHP = 1

[IF ALL S5 < > 1 AND V_STANDARD = 0] Unfortunately, you are not eligible to complete this survey. Thank you for your time. [TERMINATE]

9999. (Refused)

B.2.3 Standard Free-Ridership (TXC34)

[IF V_STANDARD = 0, SKIP MODULE]

FRINTRO. [READ IF V_ER = 1] For the next set of questions, we are going to ask you to think about your company's experiences with **Standard** rebates only. Later, we will ask you some questions about your company's experiences with Early Replacement rebates.

[CYCLE THROUGH MODULE FOR S_MEASURE_1 AND S_MEASURE_2; INPUT THE ASSOCIATED VSQTY_XX_1 AND VSQTY_XX_2 WITH CORRESPONDING MEASURE AS SHOWN IN TABLE]

IF MEASURE EQUALS	THEN
Outdoor ductless mini-split heat pump systems	VSQTY_XX = VSQTY_MSHP
Heat pump water heaters	VSQTY_XX = VSQTY_HPWH
Central air conditioning systems	VSQTY_XX = VSQTY_CAC
Gas furnaces	VSQTY_XX = VSQTY_FURN
Gas boilers	VSQTY_XX = VSQTY_BOIL
Central heat pumps	VSQTY_XX = VSQTY_CHP

FR1. If Mass Save had not offered rebates in 2016, about what percentage of the [VSQTY_XX] [MEASURE] that received **Standard** residential rebates would you have still installed that year? If you only installed 1, then enter 0 or 100.

[0 TO 100]
998. Don't know
999. (Refused)

FR2. [ASK IF FR1 < = 100] To confirm, you are estimating that in 2016, your company likely would still have installed [VSQTY_XX * (S_FR1 / 100)] [MEASURE] of the [VSQTY_XX] you installed if Mass Save had not offered the standard rebates. Is that **roughly** correct? [ROUND READ-IN CALCULATION TO NEAREST WHOLE NUMBER]

1. Yes
2. No
98. Don't know

S_FR3. [ASK IF S_FR2 > 1 OR FR1 > 100] Could you provide your best estimate of about how many of the [VSQTY_XX] [MEASURE] your company would still have installed in 2016 if Mass Save had not offered the Standard rebate?

[OPEN-END NUMERIC]
9998. (Don't know)

S_FR4. Why do you give that response?

(Don't know)

B.2.4 Early Replacement Free-Ridership (RES36)

[IF ER < > 1, SKIP MODULE]

ERFRINTRO. Next, I'd like you to think specifically about equipment you have installed that received an Early Replacement rebate. As a reminder, this would be equipment that was expected to work for at least two more years and met the program's age requirements.

[CYCLE THROUGH MODULE FOR ER_MEASURE_1 AND ER_MEASURE_2]

ER_FR1. About what percentage of your [ERQTY_XX] [MEASURE] that received **Early Replacement** residential rebates would you have installed in 2016 if the Mass Save rebates had not existed?

[0 TO 100(Don't know)

ER_FR2. [ASK IF ER_FR1 < = 100] To confirm, you are estimating that in 2016, your company likely would have installed [ERQTY_XX * (ER_FR1 / 100)] [MEASURE] of the [ERQTY_XX] that received residential **Early Replacement** rebates from Mass Save if the rebates had not existed. Is that **roughly** correct? [ROUND READ-IN CALCULATION TO NEAREST WHOLE NUMBER]

1. Yes
2. No

(Don't know)

ER_FR3. [ASK IF ER_FR2 = 2 OR ER_FR1 > 100] How many of the [ERQTY_XX] [MEASURE] that received **Early Replacement** rebates from Mass Save would you have installed in 2016 if the rebates had not existed?

[OPEN-END NUMERIC]
9998. (Don't know)
99999999. (Refused)

FR4. [SKIP IF FR3 = 9998 OR 9999] Why do you estimate that number would have still been installed in 2016 if Mass Save had not offered the Standard rebate

98. Don't know
9999. (Refused)

99. (Refused)

B.2.5 Standard Non-Participant Spillover (TXC34)

[IF V_STANDARD < > 1, SKIP MODULE]

[CYCLE THROUGH MODULE FOR S_MEASURE_1 AND S_MEASURE_2]

SO1. As a reminder, we consider equipment early replacement when they are expected to function and operate for the foreseeable future. Think of all your **standard replacement (not early replacement)** installations of residential [MEASURE], including standard-efficiency and high-efficiency and rebated and non-rebated units. About how many did your company install **in total** in 2016?

[OPEN END NUMERIC]
9998. Don't know
9999. (Refused)

The next questions ask about **high-efficiency** [MEASURE]. When they are standard replacements, we consider them high-efficiency if they [EFFICIENCY]. [PHONE ONLY: "PRONOUNCIATIONS: A-F-U-E, seer, E-C-M, H-S-P-F."]

MEASURE	**EFFICIENCY read-in**
Gas boilers	have an AFUE of 90% or higher
Gas furnaces	have an AFUE of 95% or higher with ECM
Heat pump water heaters	are 55 gallons or less with an energy factor of 2.3 or higher OR more than 55 gallons with an energy factor of 3.0 or higher
Central air conditioning systems	are SEER 16 or higher
Central heat pumps	are SEER 16 or higher and HSPF of 8.5 or higher
Outdoor ductless mini-split heat pump systems	are SEER 18 or higher and HSPF of 9 or higher

SO1a. About how many of the **standard replacement** installations of residential [MEASURE] in 2016 were high-efficiency, including rebated and non-rebated units?

[OPEN END NUMERIC]
9998. Don't know
9999. (Refused)

SO2. Did all the standard replacement high-efficiency [MEASURE] that your company installed in 2016 receive a **Mass Save** rebate of some kind?

[0 TO 100]

1. Yes
2. No
98. Don't know
99. (Refused)

999. (Refused)

[IF SO2 = 1, S_SO2a = 0]

SO2a. [SKIP IF SO2 = 1] About what percentage of the high-efficiency [MEASURE] that your company installed in 2016 did not receive a **Standard Rebate** even though they would have qualified for one?

[0 TO 100]
998. Don't know
999. (Refused)

SO3. [ASK IF SO1a AND SO2a < 9998] To confirm, that means about [(SO1a) * (SO2a / 100)] of the [SO1a] high-efficiency [MEASURE] your company installed in 2016 did not receive **a** Standard **rebate** even though they would have qualified for one. Is that **roughly** correct? [ROUND READ-IN CALCULATIONS TO NEAREST WHOLE NUMBER]

1. Yes
2. No
98. Don't know
99. (Refused)

99. (Refused)

SO3a. [ASK IF SO3 = 2 OR 98] About how many of the **standard replacement** installations of residential [MEASURE] in 2016 did not receive a Standard rebate even though they qualified?

[OPEN END NUMERIC]
9998. Don't know
9999. (Refused)

[IF NONE INSTALLED OUTSIDE PROGRAM ((SO3a = 0, 9998, OR 9999) OR (SO2 = 1 AND SO3 = 1)), SKIP TO NEXT MEASURE/MODULE]

SO4. Why do you think those high-efficiency [MEASURE] were installed without receiving a Standard rebate even though they were qualified for one?

[OPEN END]
98. Don't know
99. (Refused)

SO5. How much influence did each of the following have on your company's installations in 2016 of high-efficiency [MEASURE] that would have **qualified for but did not receive a Standard Rebate**. Please use a scale of 0 to 10, where 0 is no influence and 10 is a great deal of influence. [RANDOMIZE]

a. Your recommendations to customers

b. Incentives and rebates offered but not received through the program

c. Other support offered through the program, such as marketing, advertising, education, training, and seminars

[ALLOW 0 TO 10]
98. Don't know
99. (Refused)

SO6. Using a scale of 0 to 10, where 0 is no influence and 10 is a great deal of influence, how much influence did the Mass Save **Standard rebates** have on how frequently you recommended high-efficiency [MEASURE] to your customers in 2016?

[ALLOW 0 TO 10]
98. Don't know
99. (Refused)

99. (Refused)

B.2.6 Prospective NTG (TXC34)

[IF V_STANDARD < > 1, SKIP MODULE]

P1. [ASK IF MEASURE = VS_MSHP] In 2016, about how many residential ductless mini-split heat pump systems, as measured by the number of outdoor compressor/condenser units, did your firm install? This includes systems that were both standard-efficiency and high-efficiency.

[OPEN END NUMERIC]
9998. Don't know

P1T. [IF MEASURE = VS_MSHP, READ Beginning this year, the Mass Save program began offering its ductless mini-split heat pump rebates based on the number of **indoor** head units (evaporators), as opposed to previous years when the rebates were based on number of **outdoor** compressor/condenser units. For the following questions, please think of **indoor** head units only. [MEASURE READ-IN VALUE MUST CHANGE FROM "outdoor ductless mini-split heat pump systems" TO "**indoor** ductless mini-split heat pump systems" FOR THIS MODULE]

P2. In the coming years, various market factors in addition to Mass Save rebates could influence your company's installations of high-efficiency equipment. For example, upfront costs of equipment could increase or decrease, customer demand could increase or decrease, regulations could be imposed or removed, energy-efficiency specifications could be made more stringent or more lenient, model availability could change, and weather patterns could become less predictable.

If the Mass Save rebates stay the same, about what percentage of the total number of [MEASURE] your company installs do you think will be high-efficiency in three years from now?

998. Don't know
999. (Refused)

P3. Now I'd like you to imagine that the Mass Save rebates for [MEASURE] were to stop at the end of this year.

If this were to happen, about what percentage of the total number of residential [MEASURE] your company installs three years from now would be high-efficiency? [PHONE ONLY, IF NEEDED: There are no plans to stop the Mass Save rebates for [MEASURE].

[0 TO 100]

998. Don't know

[IF P2 OR P3 > = 998, SKIP TO NEXT MODULE]

P4. [ASK IF P2 < > P3] Your responses indicate that you expect that the continued existence of the Mass Save rebates will influence the number of your company's installations of high-efficiency residential [MEASURE] in the future. Why?

[OPEN END]
98. Don't know

P5. [ASK IF P2 = P3] Your responses indicate that you do **not** expect that the continued existence of the Mass Save rebates will influence the number of your company's installations of high-efficiency residential [MEASURE] in the future. Why not?

[OPEN END]
998. Don't know
999. (Refused)

B.2.7 Market Effects (TXC34)

[IF V_STANDARD < > 1, SKIP MODULE]

[CYCLE THROUGH MODULE FOR S_MEASURE_1 AND S_MEASURE_2]

[IF MEASURE = VS_MSHP, READ] Let's turn back to ductless mini-split heat pump systems, as measured by the number of outdoor compressor/condenser units. [MEASURE READ-IN VALUE MUST CHANGE BACK TO "**outdoor** ductless mini-split heat pump systems"]

ME1. Over the past three years, have you observed an increase, decrease, or no change in the following?

a. How often distributors have the models of high-efficiency residential [MEASURE] that you need in stock

b. The cost that YOU, as the contractor, pay for high-efficiency residential [MEASURE]

c. The frequency with which customers ask for high-efficiency residential [MEASURE]

[FOR EACH]
1. Increase
2. Decrease
3. No change
98. Don't know
99. (Refused)

ME2. [ASK WHERE ME1 = 1 OR 2] Using a scale from 0 to 10, where 0 is "not at all influential" and 10 is "very influential," how influential would you say the existence of the **Standard** Mass Save residential rebates has been on the change you observed in…

a. How often distributors have the models of high-efficiency residential [MEASURE] that you need in stock

b. The cost that YOU pay for high-efficiency residential [MEASURE]

c. The frequency with which customers ask for high-efficiency residential [MEASURE]

[FOR EACH]
[ALLOW 0 TO 10]
98. Don't know

B.2.8 Early Replacement Net-to-Gross Context (RES36)

[IF V_ER < > 1, SKIP MODULE]

Let's discuss your experiences with the Early Replacement rebates in 2016.

ER1. [ASK IF VER_FURN, VER_BOIL, OR VER_CHP = 1] Customers who receive an Early Replacement rebate for furnaces, boilers, or heat pumps must get a Mass Save Home Energy Assessment to verify eligibility. What percentage of customers who receive an Early Replacement rebate…

a. **First** receives a Home Energy Assessment, **then** contacts you to install their HVAC equipment?

b. Works with you **first**, and then you refer them to the Home Energy Assessment to verify eligibility?

[ALLOW 0 TO 100; WHOLE NUMBERS]
998. Don't know
999. (Refused)

ER2. Thinking about all of the HVAC equipment your company has installed that received Early Replacement rebates, how influential was the program, including the rebates and information provided, in your customers' decisions to replace their older HVAC equipment before it stopped functioning? Would you say the program was….

1. Very influential
2. Somewhat influential
3. Not very influential
4. Not at all influential
98. Don't know
99. (Refused)

ER3. Think about ALL of the customers you worked with who received an Early Replacement rebate for any equipment type. If the Early Replacement program had not existed, what percent of those customers would have likely still replaced their old functioning equipment at the same time without the rebate?

[FOR EACH ALLOW 0 TO 100; WHOLE NUMBERS]
998. Don't know
999. (Refused)

ER4. [SKIP IF ER3 > 100] You said that [ER3] percent of customers would have still replaced their old functioning equipment at the same time without the Early Retirement rebate. Does this vary by the type of equipment they are looking to replace? In other words, are there certain types of heating and cooling equipment that customers are more or less likely to replace before they fail?

1. Yes
2. No
98. Don't know
99. (Refused)

ER4a. [ASK IF ER4 = 1] How and why does this vary by equipment?

[OPEN END]
98. Don't know
99. (Refused)

ER4b. [ASK IF VER_FURN OR VER_BOIL = 1)] Does this vary based on whether the equipment uses gas, oil, propane, or another fuel type? In other words, are customers more or less likely to replace HVAC systems that use gas, oil, or propane before they fail?

1. Yes
2. No
98. Don't know
99. (Refused)

ER4c. [ASK IF ER4b = 1] How and why does this vary by fuel?

[OPEN END]
98. Don't know
99. (Refused)

ER5. In your own words, can you please describe the influence of the Early Replacement rebate on your customers' decisions to replace their old functioning HVAC equipment?

[OPEN END]
98. Don't know
99. (Refused)

ER6. We'd like to understand if there is any program-eligible equipment being installed without program rebates.

Since you began participating in the program, have you ever replaced any old, functioning equipment that you feel was eligible for the Early Replacement rebate, but did not receive one?

1. Yes
2. No
98. Don't know
99. (Refused)

ER7. [ASK IF ER6 = 1] Did any of these customers receive a Standard Program rebate instead?

1. Yes
2. No
98. Don't know
99. (Refused)

ER7A. [ASK IF ER7 = 1] What percent of customers would you say received a Standard rebate instead of an Early Replacement rebate even though they were eligible for an Early Replacement rebate?

[ALLOW 0 TO 100; WHOLE NUMBERS]
998. Don't know
999. (Refused)

ER8. [ASK IF ER6 = 1] About how many Early Replacement program-eligible projects did your company install that did not receive an Early Replacement rebate for each of the following equipment types? Include all installations, whether they received a Standard rebate or not. Your best guess is fine.

a. Furnaces
b. Boilers
c. Central air conditioners
d. Central heat pumps

[FOR EACH]
[OPEN-END NUMERIC]
998. Don't know
999. (Refused)

ER8. [ASK IF ER6 = 1] Why do you think these customers were eligible to receive an Early Replacement rebate, but did not get one?

[OPEN END]
998. Don't know
999. (Refused)

B.2.9 Fuel Types

F1. [SKIP IF V_ER < > 1] Our records indicate that your company installs equipment with the following fuel types. Does your company in fact install these? [SINGLE SCREEN]

a. [IF GAS_B = 1 AND VER_BOIL = 1] **Natural gas** hot water or steam boilers
b. [IF PROPANE_B = 1 AND VER_BOIL = 1] **Propane hot water or steam** boilers
c. [IF OIL_B = 1 AND VER_BOIL = 1] **Oil hot water or steam** boilers
d. [IF GAS_F = 1 AND VER_FURN = 1; SKIP IF VS_FURN = 1] **Natural gas** furnaces
e. [IF PROPANE_F = 1 AND VER_FURN = 1] **Propane** furnaces
f. [IF OIL_F = 1 AND VER_FURN = 1] **Oil** furnaces

[FOR EACH]
1. Yes
2. No
98. Don't know
99. (Refused)

F2. Are there instances when your company helps a customer switch from either propane or oil **to** natural gas or electricity for their heating equipment?

1. Yes
2. No
98. Don't know
99. (Refused)

F3. [IF F2 = 1] About how many fuel-switching projects does your company assist with per year?

[OPEN-END NUMERIC]
9998. Don't know
9999. (Refused)

B.2.10 Closing for TXC34 & RES36

C1. Would you prefer that we send you an Amazon gift card or donate to a charity in your name?

1. Amazon gift card
2. Check
3. Donate to a charity in my name
4. Donate to a charity anonymously
97. None of the above [SKIP TO C2 AND C3]

C2. [ASK IF C1 = 2] Which of the following non-profit charitable organizations would you like us to donate to?

1. Hurricane Relief Fund
2. Big Brothers Big Sisters of Massachusetts Bay
3. Berkshire Humane Society

C3. What is your name and address? [IF C1 = 2: "We will make the donation in your name where possible, or you may donate anonymously."]

[NAME AND ADDRESS FIELDS]

B.2.11 Commercial Water Heaters (P77) (WEB ONLY)

[SKIP MODULE AFTER REACHING 20 COMPLETES]

[ASK IF P77 = 1]

WH1. Earlier you said you would answer questions about commercial water heaters for an additional $30. About what percentage of your company's sales or installations of commercial gas water heaters are installed in existing buildings and what percentage are installed in new buildings? [SINGLE SCREEN]

a. Existing buildings
b. New buildings

[FOR EACH]
[ALLOW 0 TO 100]
998. Don't know

WH2. [SKIP IF WH1a = 0] About what percentage of your sales or installations of commercial gas water heaters in **existing** buildings in Massachusetts are replacing units which have failed and what percentage replaced units with some useful life remaining? [SINGLE SCREEN]

a. Replaced on failure

b. Replaced with some useful life remaining
[FOR EACH]
[ALLOW 0 TO 100]
998. Don't know

WH3. [ASK IF WH1 OR WH2 = 998] As you know, commercial gas water heaters can either **just heat water** or can provide **both heat and hot water**. They can also vary between **condensing** and **non-condensing** models.

Please estimate the percentages of your sales and installations of **all commercial gas water** heaters in Massachusetts over the past year across these categories. Your responses should sum to 100%. [SINGLE SCREEN; ALLOW 0 TO 100 FOR EACH; FORCE RESPONSES TO SUM TO 100]

Commercial Gas Water Heater Type	Efficiency
Dedicated hot water, no storage tank	a. Condensing
	b. Non-condensing
Dedicated, feeding storage tank	c. Condensing
	d. Non-condensing
Mixed heat and hot water	e. Condensing

WH4. [SKIP IF WH1a = 998 OR 0] As you know, commercial gas water heaters can either **just heat water** or can provide **both heat and hot water**. They can also vary between **condensing** and **non-condensing** models.

Please estimate the percentage of your sales and installations of commercial gas water heaters in **existing buildings** in Massachusetts over the past year which fall into the following equipment type and efficiency categories:

[REPLICATE WH3 RESPONSE CATEGORIES]

WH5. [SKIP IF WH1b = 998 OR 0] Please estimate the percentage of your sales and installations of commercial gas water heaters for **new construction** in Massachusetts over the past year which fall into the following equipment type and efficiency categories:

[REPLICATE WH3 RESPONSE CATEGORIES]

WH6. Some commercial gas water heaters are small enough to be installed in residences. You said, on average, the percentage of commercial water heater units replaced on failure was [WH2a] and the percentage replaced with useful life was [WH2b]. Would this percentage be different for smaller commercial water heaters?

1. Yes
2. No

WH7. [ASK IF WH6 = 1] Why would the percentages be different? [SINGLE RESPONSE]

1. Smaller water heaters have lower first costs
2. Smaller water heaters are more common in buildings that get retrofitted frequently
55. Other, specify [OPEN END]

WH8. [ASK IF WH6 = 1] How would these percentages be different?

[OPEN END]

B.2.12 Recruitment for RES19 & RES28 Surveys

RRS1. In a few weeks, the Mass Save sponsors will be conducting another survey of plumbers and contractors who have installed residential water heaters, boilers, furnaces, or ductless mini-split heat pumps in Massachusetts. This second survey will help the Mass Save sponsors better understand their purchase and installation costs under a wide range of scenarios, and will further support the rebate programs that encourage utility customers to upgrade their equipment. The sponsors will compensate survey participants with a $250 gift card. Are you interested in participating in this survey?

1. Yes, I am interested in participating in this survey when it becomes available
2. No, I am not interested in participating

[SKIP IF RRS1 = 2 OR RESPONSE CATEGORIES 1 THROUGH 4 ARE ALL INAPPLICABLE] RRS2. Please select the product(s) below for which you completed at least 10 installations since January 1, 2016. [MULTIPLE CHOICE]

1. [HIDE IF VSQTY_HPWH > 9] Residential water heaters
2. [HIDE IF VSQTY_BOIL > 9] Residential boilers
3. [HIDE IF VSQTY_FURN > 9] Residential furnaces
4. [HIDE IF VSQTY_MSHP > 9] Ductless mini-split heat pumps

97. None of the above

B.2.13 Final Closing

On behalf of the Sponsors of Mass Save, thank you very much for your time today.

B.3 CONSENSUS GROUP TOOL

Below are images from the TXC34 NTG Instrument along with the instructions that the evaluation team provided to the Consensus Group panelists.

Figure 20: Benchmarking NTG Estimates – Research Methods, Strengths, and Limitations

Program Administrator--Study	Research Methods	Strengths	Limitations	Notes
MA PAs--TXC34: Option 1 MA PAs--TXC34: Option 2 MA PAs--TXC34: Option 2	Self-reported counterfactual surveys: with participants (n = 332) and contractors (n = 167)	Combined NTG estimate based on results from program participants and contractors. Results incorporate estimates of both PSO and NPSO.	Self-reported data and potential for related biases. Sample sizes were small for some equipment types. Contractors represented small portions of	Contractor sample precision for most equipment types ranged between ±11% and 15% at 90% CI. CHP= ±20%
MA PAs--2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing (2013)	Self-reported counterfactual surveys: Surveys with distributors (n = 33), contractors (n = 240), and program participants (n = 759)	Sample includes distributors and contractors who represent a substantial segment of the market and are knowledgeable about market trends.	Self-reported data and potential for related biases. NPSO was not calculated.	The relative precision was not reported.
Other Northeast and Mid-Atlantic States				
Efficiency Maine--Appliance Rebate Program Evaluation (2014)	Self-reported counterfactual surveys: participant surveys (n = 382, n = 80 for HPWH)	FR calculated for each measure.	P SO is program-wide calculation, and participants had at most a year to install additional measures. NPSO was not calculated.	The relative precision was not reported.
Con Edison NY--Impact Evaluation of CECONY Residential HVAC Electric Program (2014)	Self-reported counterfactual surveys: participant surveys (n = 192)	Similar program and climate to MA. NTGR calculated from a series of structured and open-ended questions about the influence of the program.	No calculation of NPSO.	The relative precision of the NTGRs at a 90% CI was ±11% for CAC and ±13% for MSHP.
PECO, PA--Final Annual Report to the Pennsylvania Public Utility Commission: PECO (2017)	Self-reported counterfactual surveys: participant surveys (n = 75)	Self-report with program participants. FR includes equally weighted components for participant intention and program influence.	Self-reports relies only on program participants (no NPSO). Overall program HVAC estimate includes equipment that is not specified in the report.	Relative precision for overall HVAC NTG= ±5% at 85% and 90% CI.
Anonymous state--Residential HVAC Program (2018)	Self-reported counterfactual surveys: with participants (n = 244) and contractors (n = 95)	Combined NTG estimate based on results from program participants and contractors. Results incorporate estimates of both P SO and NPSO. Values align with State's current TRM values.	Self-report bias.	The relative precision of the furnace and boiler sampling design was <10% at a 90% CI.
Outside of Northeast				
Duke Energy--2013 EM&V Report for the Home Energy Improvement Program (2015)	Self-reported counterfactual surveys: participant surveys (n = 200)	FR questions covered scope, likelihood, and timing of installation.	P SO only calculated at program level, and program is a mix of equipment and non-equipment measures. No NPSO calculated.	The relative precision was not reported.
Ameren MO--Efficient Products Impact and Process Evaluation: Program Year 2014 (2015)	Self-reported counterfactual surveys: participant surveys - phone (n=71) and online (n=197)	Calculated both PSO and NPSO for installed equipment.		The relative precision of the HPWH sampling design was ±7.8% at a 90% CI.
Ameren MO--Heating and Cooling Program Impact and Process Evaluation (2017)	Self-reported counterfactual surveys: Online participant surveys: one immediate for FR (n = 1,044) and one 6 months later for SO (n = 610). Contractor interviews for NPSO (n = 10).	Self reported participant and contractor data. Study measured, FR, SO, and NPSO.		The relative precision of the weighted FR estimates at a 90% CI was ±2% for CHPs, ±8% for MSHP, and ±2% for CACs.
Ameren IL--Company PY10 Net-to-Gross Ratios for the Energy Efficiency Portfolio (2017)	FR: PY6 (2013-4) Participant customer surveys (n=204). SO: PY5 (2012-3) Participant customer surveys for PSO (n = 210), nonparticipant contractor survey (n=65) for nonparticipant spillover.	P SO and NPSO calculated.	Values are from 4 (FR) or 5 (SO) program years previous.	The relative precision was not reported.
ComEd IL--ComEd Programs NTG Approach for EPY10 (2017)	MSHP: see limitations CAC: FR = PY8 participant self-report survey; SO = PY7 SAG consensus value for CSR HPWH: see limitations CHP: see limitations Furnace: w/ furnace upgrade = Nicor 2017 Gas study; w/o furnace upgrade = default NTG value	CAC FR values were calculated based on a self-report survey. All other values were from secondary sources or from consensus.	NTGRs based on older data or other utility studies. MSHP NTG is based on average value from 2016 Focus On Energy DMSHP study. HPWH and CHP (air-source only) NTGRs are based on 2013 Duke Energy study. Furnace NTGRs are for ECM motors only.	The relative precision was not reported.
IESO Ontario--Volume I: Final PY2016 Evaluation of Consumer Programs (2017)	Self-reported counterfactual surveys: Customer surveys (PY2016) were used for SO, FR, and rebound and contractor surveys (PY2015) were used for CAI. 143 of 52k CAC customers and 141 of 78k furnace customers were surveyed. NTGR = 1 – Free Ridership + Spillover – Rebound	Use of counterfactual self-reported data from customers. Use of contractor adjustment influence (CAI) and rebound to further inform NTGR.	No calculation of NPSO.	The relative precision was not reported.
CA IOUs--Residential Retrofit High Impact Measure Evaluation Report (2010)	Self-reported counterfactual surveys: participants (n = 301) and distributors (n = 70)	Self-reported data from program participants and furnace distributors.	Did not estimate for NPSO. Wide discrepancy between reported FR from distributors (lower) and customers (high).	The relative precision of the furnace NTGR at a 90% CI was ±4.8%.

Figure 21: Benchmarking NTG Estimates – NTG Values

Program Administrator--Study	Electric Equipment																Gas Equipment								HVAC Category/Program			
	MSHP				HPWH				CAC				CHP				Furnace				Boiler							
	FR	NPSO	PSO	NTG	FR	NPSO	PSO	NTG	FR	NPSO	PSO	NTG	FR	NPSO	PSO	NTG	FR	NPSO	PSO	NTG	FR	NPSO	PSO	NTG	FR	NPSO	PSO	NTG
MA PAs--TXC34: Option 1	0.39	0.15	0.02	0.79	0.16	0.04	0.01	0.89	0.43	0.05	0.10	0.72	0.46	0.04	0.02	0.61	0.33	0.16	0.02	0.85	0.24	0.14	0.01	0.90				
MA PAs--TXC34: Option 2	0.45	0.15	0.02	0.72	0.23	0.04	0.01	0.81	0.53	0.05	0.10	0.62	0.54	0.04	0.02	0.53	0.46	0.16	0.02	0.72	0.37	0.14	0.01	0.77				
MA PAs--TXC34: Option 2	0.41	0.15	0.02	0.77	0.21	0.04	0.01	0.83	0.48	0.05	0.10	0.67	0.49	0.04	0.02	0.58	0.42	0.16	0.02	0.76	0.35	0.14	0.01	0.79				
MA PAs--2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing (2013)	0.45	--	0.07	0.62					0.4	--	0.28	0.88					0.4	--	0.22	0.81	0.3	--	0.08	0.8				
Other Northeast and Mid-Atlantic States																												
Efficiency Maine--Appliance Rebate Program Evaluation (2014)					0.21	--	0.033	0.82																				
Con Edison NY--Impact Evaluation of CECONY Residential HVAC Electric Program (2014)	0.47	--	0	0.53					0.48	--	0	0.52																
PECO, PA--Final Annual Report to the Pennsylvania Public Utility Commission: PECO (2017)									0.58	--	0.04	0.45	0.46	--	0.02	0.56									0.5	--	0.03	0.6
Anonymous state--Residential HVAC Program (2018)																	0.4	--	0.1	0.72	0.4	--	0.12	0.8				
Outside of Northeast																												
Duke Energy--2013 EM&V Report for the Home Energy Improvement Program (2015)					0.29	--	used program value	0.76	0.51	--	used program value	0.55	0.49	--	used program value	0.57									0.4	--	0.06	0.7
Ameren MO--Efficient Products Impact and Process Evaluation: Program Year 2014 (2015)					0.19	0.007	0.031	0.85																				
Ameren MO--Heating and Cooling Program Impact and Process Evaluation (2017)	0.12	0.004	0.02	0.92					0.161	0.004	0.003	0.85	0.03	0.004	0.001	0.98									0.1	0.004	0	0.9
Ameren IL--Company PY10 Net-to-Gross Ratios for the Energy Efficiency Portfolio (2017)									0.58 (ROB); 0.46 (ER)	0.22	0.001	0.641 (ROB); 0.761 (ER)																
ComEd IL--ComEd Programs NTG Approach for EPY10 (2017)	--	--	--	0.68	--	--	--	0.76	0.43	--	0.12	0.69	--	--	--	0.57	--	--	--	0.68 w/ upgrade; 0.80 w/o upgrade								
IESO Ontario--Volume I: Final PY2016 Evaluation of Consumer Programs (2017)									0.33	--	0.33	1.00					0.3	--	0.01	0.7					0.3	--	0.01	0.7
CA IOUs--Residential Retrofit High Impact Measure Evaluation Report (2010)																	0.8	--	0	0.18								

B.3.1 Steps 1 and 2: Contextualizing NTG Estimates

First, assess the importance of study results:

1. In the "NTG Estimates" tab, describe any additional strengths and limitations of each method in the yellow-shaded cells in the spreadsheet.
2. Next, rate the importance of the results from each method for the overall NTG estimate in the blue shaded cells.

Figure 22 shows the specific cells in the worksheet to fill out for these two steps.

Figure 22: Steps 1 and 2 of Deriving Your NTG Estimates

Program Administrator/State	Program Year	Study	STEP 1: Additional Strengths, Limitations (TO BE FILLED IN BY USER, OPTIONAL)	STEP 2: Please rate the importance of results from this method for the overall NTG estimate. (use drop-down menu)
MA PAs	2010-2012	2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing (2013)		no response recorded yet

B.3.2 Step 3: Retrospective Estimates

Next, in the tab labeled, "Your NTG estimates," add your *own 2016 NTG estimates for each equipment type in* the green-shaded cells in Columns B and C, and explain your reasoning. Please estimate NTG levels for the **2016 program** year only, *without* taking spillover from past program efforts into account.

Figure 23 shows the specific cells in the worksheet to fill out for this step.

Figure 23: Entering Your 2016 NTG Estimates and Rationales

Measure	Your 2016 NTG Estimate	Why do you recommend this NTG ratio?
Electric Equipment		
Mini-split heat pump		
Heat pump water heater		
Central air conditioning system		
Central heat pump		
Gas Equipment		
Warm air furnace		
Hot water boiler		

B.3.3 Step 4: Prospective Estimates

In the same, "NTG Estimates" tab, please fill out the grey cells with your prospective estimates for 2019-2021 and your rationale for these estimates. Please **do not** take spillover from pre-2016 programs into account.

Figure 24 shows the specific cells in the worksheet to fill out for this step.

Figure 24: Entering Your 2019-2021 NTG Estimates and Rationales

Measure	2019	Why do you recommend this NTG ratio?	2020	Why do you recommend this NTG ratio?	2021	Why do you recommend this NTG ratio?
Electric Equipment						
Mini-split heat pump						
Heat pump water heater						
Central air conditioning system						
Central heat pump						
Gas Equipment						
Warm air furnace						
Hot water boiler						

B.3.4 Step 5: Submitting your NTG Estimates

After you finish, please **save the Excel file** with your affiliation (e.g., PAs, EEAC, or evaluators) as part of the file name, and email it **by 12pm ET, February 20, 2018**. We will aim to compile and distribute responses by COB February 21, 2018, so you can review them before the NTG Consensus Group meeting schedule