

# Evidence for Market Effects from Support for Ductless Mini-split Heat Pump Integrated Controls (MA19X09-B-INTCTRME)

Final Report

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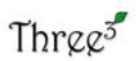
SUBMITTED TO:

Massachusetts Energy Efficiency Program Administrators

SUBMITTED BY:

NMR Group, Inc.

DNV GL, Inc.





# Evidence for Market Effects from Support for Ductless Mini-split Heat Pump Integrated Controls

The lack of an easy way for customers to use ductless mini-split heat pumps (DMSHPs) in combination with fossil fuel heating equipment is a barrier to the adoption and use of cold-climate DMSHPs for heating. In 2018 the PAs began working with manufacturers and distributors to adapt, develop, and promote integrated controls for use with DMSHPs. This study assesses the evidence for the PAs' support of DMSHP integrated controls having made a substantial impact on the market for these controls and for cold-climate DMSHPs.

The study found that the PAs are partly responsible for launching the Massachusetts market for DMSHP integrated controls for use in homes heated primarily by delivered fuels and accelerating the development of this market in both Massachusetts and the Northeast region. However, the market is not yet established.

The study lays out how the market effects from the PAs' support of this market could be quantified through a market-focused approach to measuring net-to-gross (NTG) using the structured expert judgment method.



The integrated controls market in MA is at the beginning of the early adopters stage of the innovation adoption curve.

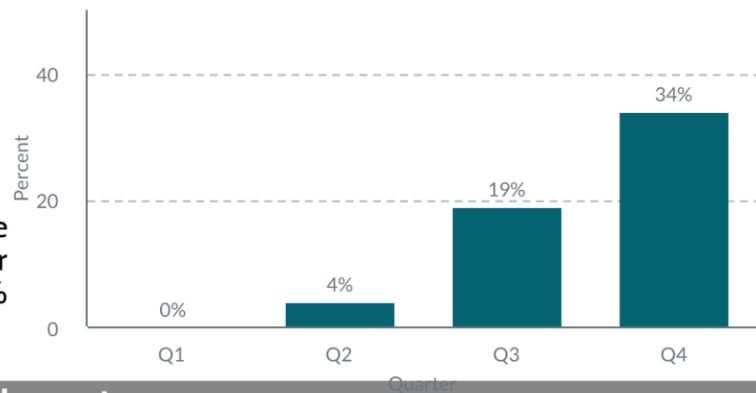


There could be additional savings from market effects due to the PAs' activities in accelerating the market for integrated controls.



Preliminary 2019 data suggest that MA market share of DMSHPs with integrated controls destined for homes heated by delivered fuels increased from 0% in Q1 to 34% in Q4 and averaged 13% for the year.

2019 MA Market Share of DMSHPs Sold with Integrated Controls



## Key Considerations



Make minor revisions and additions to the logic model and market effects indicators.



Consider narrowing the market transformation goal to residences only, or alternatively, expanding the rebates to small businesses.



Consider conducting research to estimate baselines for some or all of the market effects indicators and to assess consumers' awareness, understanding, and use of integrated controls.



When PAs conclude that sufficient time has passed that the magnitude of accrued market effects might well be large enough to warrant the cost of measurement, consider quantifying market effects from the PAs' efforts to establish and accelerate the Massachusetts market for DMSHP controls. If a NTG ratio is needed before this, consider using one of two simpler NTG estimation approaches suggested in the report.



Consider providing financial support to defray the cost of callbacks for contractors to help eliminate this barrier to the installation of integrated controls, publicizing successful case studies to contractors, and working closely with a few large contractors who are receptive to DMSHP integrated controls.

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## Acronyms

Acronyms	Definitions
<b>AHRI</b>	Air-Conditioning, Heating, and Refrigeration Institute
<b>ASHP</b>	Air Source Heat Pump
<b>ASHRAE</b>	American Society of Heating, Refrigeration, and Air Conditioner Engineers
<b>CEE</b>	Consortium for Energy Efficiency
<b>DMSHP</b>	Ductless Mini-Split Heat Pump
<b>HARDI</b>	Heating, Air-Conditioning, & Refrigeration Distributors International
<b>HSPF</b>	Heating Seasonal Performance Factor
<b>HVAC</b>	Heating, Ventilation and Air Conditioning
<b>IC</b>	Integrated Control
<b>KPI</b>	Key Performance Indicator
<b>CEC</b>	Massachusetts Clean Energy Center
<b>NTG</b>	Net-to-Gross
<b>NTGR</b>	Net-to-Gross Ratio
<b>NYSERDA</b>	New York State Energy Research & Development Authority
<b>NGO</b>	Non-Governmental Organization
<b>NEEP</b>	Northeast Energy Efficiency Partnerships
<b>NEEA</b>	Northwest Energy Efficiency Alliance
<b>OEM</b>	Original Equipment Manufacturer
<b>PA</b>	Program Administrator
<b>SEER</b>	Seasonal Energy Efficiency Ratio

## Executive Summary

### OBJECTIVES

Evaluation research has found that residential customers with ductless mini-split heat pumps (DMSHP) often do not use them as their primary heating systems, largely because of the complexity of determining when a fossil - fuel heating system becomes the more cost - effective heating method. (For the purposes of this report, “DMSHP” refers to inverter-driven mini- and multi-split heat pump systems, regardless of configuration. It does not refer to traditional, non-inverter air source heat pump [ASHP] systems that condition space through a central distribution system.) The lack of an easy way for customers to use DMSHPs in combination with fossil fuel heating equipment is a barrier to the adoption and use of cold-climate DMSHPs for heating. In 2018, the Massachusetts energy-efficiency Program Administrators (Berkshire Gas, Blackstone Gas, Cape Light Compact, Columbia Gas of Massachusetts, Eversource, Liberty Utilities, National Grid, and Unitil) developed a specification for integrated controls for use with DMSHPs to address this barrier and reached out to manufacturers to encourage them to produce equipment to meet it. In January 2019, the PAs began offering generous rebates for customers heating with delivered fuels who install DMSHPs with qualified integrated controls. The goal of these efforts is to foster more widespread adoption and use of cold-climate DMSHPs for heating by filling a hypothesized gap in the market: namely, that customers could not otherwise be expected to stage their heating systems for optimal efficiency, comfort, and cost savings.

The objective of this study is to assess the evidence for or against the PAs’ support of DMSHP integrated controls having made a substantial, lasting impact on the Massachusetts market for these controls and for cold-climate DMSHPs, and to provide a qualitative – not quantitative – assessment of the degree of market effects, if any.

### KEY FINDINGS & CONSIDERATIONS BY RESEARCH QUESTION

The key findings and considerations below are organized by the research questions that this study addressed.

#### Validity of Program Theory

Research Question: *Is the underlying theory about the status of the market for residential and small commercial DMSHPs correct?*

The historical tracing validates the underlying program theory. The lack of an easy way for customers to optimize using DMSHPs efficiently in combination with fossil fuel heating equipment is a major barrier to more widespread adoption and use of cold-climate DMSHPs for heating. The evidence also validates the program logic. All the activities, barriers, target audiences, and changes in behavior displayed in the logic model were substantiated by the market actor interviews.

The NMR team found a program outcome, “Increased use of cold-climate heat pumps for heating,” missing from the logic model.

### Considerations

- In the logic model, consider connecting “Offer incentives for integrated controls for heat pumps” to “Integrated controls are not offered in the Massachusetts market, but they are needed to displace oil/propane with heat pumps”.
- Consider adding “Lack of contractor confidence in integrated controls” to the barriers in the logic model.
- Consider adding “Increased use of heat pumps for heating” to the outcomes in the logic model. Also consider assessing the in-service rate for rebated integrated controls. Some interviewees expressed skepticism that end-users were using the integrated controls for heating as intended.
- Consider making the following changes to the market effects indicators listed in [Section 3.3](#):
  - 1. Percentage of homes and small businesses with cold-climate DMSHPs: It is not possible to identify cold-climate heat pumps with Heating, Air-conditioning, & Refrigeration Distributors International (HARDI) sales data. It is likely that cold climate will be identifiable only through baseline study site visits and program tracking data. It is also the only indicator that specifies cold-climate DMSHPs. Consider the possibility of tracking the percentage of homes and businesses with DMSHPs, not cold-climate DMSHPs specifically.
  - Consider rewording “4. Percentage of DMSHPs installed that have integrated controls (with and without program incentives)” to “4. Percentage of DMSHPs sold or installed that have integrated controls (with and without program incentives) (i.e., market share).”
  - It may be difficult to track sales of integrated controls on their own. Consider rewording “5. Change in sales of integrated controls (inside and outside the Mass Save program)” to “5. Change in sales of DMSHPs with integrated controls (inside and outside the Mass Save program).”
- Consider adding “Rate of adoption by the target market of DMSHPs with integrated controls” as a market progress indicator.
- Consider narrowing the market transformation goal to residences only, or alternatively, expanding the rebates to small businesses.
- Consider conducting a study to estimate baselines for some or all of the market effects indicators described in [Section 3.3](#) with the revisions suggested here. Also, consider assessing consumers’ awareness, understanding, and use of integrated controls. These could be done together, as separate studies, or added to data collection efforts undertaken for other residential studies.



## Market Status

Research Question: What is the state of the Massachusetts market for integrated controls?

As the rebates are for customers heating with delivered fuels who install DMSHPs with qualified integrated controls, the target market is Massachusetts homes heated with delivered fuels that could potentially use DMSHPs for heating and benefit from an integrated control. The team developed a rough estimate of the rate of adoption of DMSHPs with integrated controls by the target market. In 2019, this rate was 0.4%. (A detailed explanation of this and other market size calculations referenced here can be found in [Section 5.1.](#))

The target market is Massachusetts homes heated with delivered fuels that could potentially use DMSHPs for heating and benefit from an integrated control (i.e., existing single- and multifamily oil- and propane-heated homes of up to nine units per structure and without ducts.)

There are substantial opportunities for progress in this market. The team’s rough estimate of the remaining number of Massachusetts homes heated with delivered fuel that could potentially use DMSHPs for heating and benefit from an integrated control was about 338,000 as of January 2020.

A market for DMSHP integrated controls for use in homes heated primarily by delivered fuels did not exist in Massachusetts or elsewhere at the beginning of 2019, but preliminary evidence indicates that this market grew rapidly in Massachusetts over the course of 2019. The team calculated a preliminary estimate of the 2019 Massachusetts share of all Massachusetts residential DMSHP systems that included integrated controls for use in homes heated primarily by delivered fuels, or “DMSHP integrated controls delivered fuels market share.” The data suggest that the market share of DMSHP systems with integrated controls destined for homes heated by delivered fuels increased from 0% in Q1 to 34% in Q4, and averaged 13% for the year. This estimate should be recalculated with final rebate data when these data become available.

Despite the rapid growth in 2019 of DMSHP integrated controls for use in Massachusetts homes heated primarily by delivered fuels, insights from the market actor interviews indicate that this market is still at the beginning of the early adopters stage of the innovation adoption curve – it is nearly totally dependent on rebates from the PAs.

## Attribution

Research Question: *To what degree are the PAs responsible for establishing or accelerating the development of integrated controls on the market in Massachusetts?*

The study assessed evidence for and against three causal hypotheses.  $H_1$  is the causal hypothesis based on the program theory underlying the heat pump integrated controls intervention:

$H_1$ : The PAs were entirely or largely responsible for establishing or accelerating the development of the market for DMSHP integrated controls in MA.

The alternative causal hypotheses are as follows:

H<sub>2</sub>: The PAs were partly responsible for establishing or accelerating the development of the market for DMSHP integrated controls in MA. Other organization(s), market forces, or both were also partly responsible.

H<sub>3</sub>: Other organization(s), market forces, or both were entirely or largely responsible for establishing or accelerating the development of the market for DMSHP integrated controls in MA.

The evidence most closely supports Hypothesis 2.

- The PAs are partly responsible for launching the Massachusetts market, but it is not yet established.
- The PAs are partly responsible for accelerating the development of the Massachusetts market for DMSHP integrated controls for use in homes heated primarily by delivered fuels.
- The PAs are also partly responsible for accelerating the development of the market for DMSHP integrated controls for use in homes heated primarily by delivered fuels in the Northeast region.

### Future Market Effects Tracking & Quantification

Research Question: *What market effects indicators would be appropriate for measuring the market effects expected from the PAs' efforts to establish this market, as well as the effects of support from Mass Save on the market? For which indicators is it realistic to expect to gather data?*

The market progress indicators proposed by the PAs are currently appropriate and measurable. The study identifies the outcome associated with each indicator and appropriate sources of indicator data.

### Considerations

- If PAs act on the consideration above to add “Lack of contractor confidence in integrated controls” to the barriers in the logic model, they should add a “corresponding market progress indicator.”
- Consider developing a plan to operationalize and collect market progress indicator data.

Research Question: *How can future evaluations quantify market effects from these efforts? What are the steps and timelines?*

The evidence from this study suggests that there could be additional savings from market effects due to the PAs' early activities helping to launch and accelerate the Massachusetts market for DMSHP integrated controls for use in homes heated primarily by delivered fuels and from their ongoing support for this product. In [Section 5.2](#), the NMR team lays out how an evaluator could quantify these market effects through a market-focused approach to measuring net-to-gross (NTG) using the structured expert judgment method. As with all of the four methods for quantifying market effects and the energy savings associated with them described in the [Action Plan for Measuring Market Effects](#), this approach requires estimates of the following:

- *The market-level gross savings from the energy-efficiency measure.* For this measure, this is the incremental gross savings from integrated controls used with DMSHPs in homes with delivered fuel-fired heating equipment (i.e., it is the difference between gross savings from using integrated controls with DMSHP systems in homes with fuel-fired heating equipment and gross savings from DMSHP systems *without* integrated controls in homes with fuel-fired heating equipment).
- *The within-program level of adoption of the measure.* This would be obtained via a Delphi panel consisting of upstream suppliers (manufacturers and distributors), PAs who have supported integrated controls or conducted studies, and industry experts.
- *The naturally occurring (counterfactual) level of adoption.* This would also be obtained via the Delphi panel. Current policy in Massachusetts calls for a prospective NTG estimate to be applied to future program years, which also requires developing estimates of *future* with-program and naturally occurring sales (but not gross savings, which can be updated annually). In turn, this requires an estimate of the total size of the target market.

The evaluator would develop a prospective NTG estimate for DMSHP integrated controls for use in homes heated primarily by delivered fuels, as follows:

- A. Gross program sales (number of PA rebates provided for integrated controls)
- B. Market-level sales of integrated controls assuming continued support (from the Delphi panel)
- C. Market-level sales of integrated controls assuming the PAs had never intervened in the market (from the Delphi panel)
- D.  $NTGR = (B - C) / A$

PAs will need to develop NTG ratios in 2021 for the 2022-2024 cycle. While the PAs could use the approach described above to measure NTG with market effects in time for the next planning cycle, it would be costly for the relatively small magnitude of market effects likely to have accrued so early on. Given this, PAs may wish to consider taking a simpler approach to measuring NTG in the 2022-2024 cycle, and towards the end of the cycle, assess the appropriateness of measuring NTG at the market level for the 2025-2027 cycle. We offer two simpler NTG estimate options for the PAs to consider for the 2022-2024 cycle:

1. Assume that program-supported sales of integrated controls will constitute the vast majority of market-level sales, and that market-level sales would be close to zero without the program. Taking this approach, the NTG ratio would be 1.0.
2. Use a negotiated NTG ratio.

### Considerations

- When PAs conclude that sufficient time has passed so that the magnitude of accrued market effects might be large enough to warrant the cost of measurement, consider quantifying market effects from the PAs' efforts to establish and accelerate the Massachusetts market for DMSHP controls. If a NTG ratio is needed before this, consider using one of the two simpler NTG estimation approaches suggested here.

### Implications for Fuel Optimization

Research Question: *What are the implications of integrated DMSHP controls for switching from delivered fuels to electric heating? From natural gas to electric heating?*

The availability of integrated controls for DMSHPs is likely to encourage fuel switching among residential customers. A majority of market actors (57%) believe that the availability of integrated controls for DMSHPs would affect the adoption of DMSHPs in homes that heat with oil or propane.

The availability of integrated controls for DMSHPs is less likely to encourage fuel switching among small business customers than among residential customers. Just one-fifth (19%) of market actors believe small businesses that heat with oil or propane would increase their adoption of DMSHPs because of the availability of integrated controls. Their rationale for the difference between their answers for residential and small business customers was that there is no integrated control rebate for small businesses, small businesses are too busy to worry about their heating systems, and DMSHPs are not appropriate for certain types of small businesses.

Due to low gas prices and the absence of rebates for integrated controls, customers who heat with gas are less likely than customers who heat with delivered fuels to switch to heating primarily with DMSHPs. Only one-quarter (24%) of market actors expect that the availability of integrated controls would affect the adoption of DMSHPs in homes that heat with gas, and only 9% expect that they would affect the adoption of DMSHPs among small businesses that heat with gas. However, it is worth examining in future research whether the availability of the PAs' rebates for DMSHP integrated controls in homes heated primarily with delivered fuels increases awareness of and experience with integrated controls among installers and customers, thus contributing to increased installation of DMSHPs with integrated controls in homes heated with natural gas.



Also, DMSHPs are better able to serve as the primary heating source in homes with tighter envelopes. Therefore, customers will experience the benefits of DMSHP heating more fully if their homes are weatherized. Integrated controls installations represent an opportunity to cross-sell PA incentives for building shell improvements, achieving further energy savings.

Two of the manufacturers we interviewed foresee comprehensive integration of energy-consuming devices, including heating equipment, with whole-home integrated controls that may be offered by Google and Amazon, among others. This may result in new program opportunities. PAs should expect to adapt support for integrated controls to the home automation market over time.

### Considerations

- Consider cross-selling building shell improvements to DMSHP integrated controls customers.
- Keep apprised of developments in smart home technology.
- Assess the effects of the PAs' integrated controls efforts on the adoption of DMSHPs with integrated controls in homes heated by natural gas.

### Additional Implications

In addition to encouraging contractors to promote and install DMSHP integrated controls by providing training and education, the PAs could encourage wider adoption by helping overcome contractor apprehension about the effectiveness and reliability of the technology by providing support to defray the cost of callbacks. Below are this and other considerations that could help contractors promote this technology.

### Considerations

- Consider providing financial support to defray the cost of callbacks for contractors to help eliminate this barrier to the installation of integrated controls. Just as a warranty eases a customer's mind, knowing that some degree of financial support is available in the event of callbacks can serve as an insurance policy that installers would not be fully on the hook for the cost of handling customer complaints, thus helping them overcome concerns about the technology. If PAs choose to pursue this path, it should be done with the support and financial contribution of manufacturers.
- Publicize successful case studies to contractors.
- Work closely with a few large contractors who are receptive to DMSHP integrated controls.

A rigorous impact evaluation of savings from integrated controls for DMSHPs working in conjunction with delivered-fuel-fired heating equipment has yet to be conducted, but is currently being planned by the PAs. Energy savings from DMSHP with integrated controls can be affected by a variety of factors, including (but not limited to) the proper installation and use of the DMSHPs and integrated controls.

- The planned impact evaluation should include an estimate of the incremental gross savings from integrated controls used with DMSHPs in homes with delivered fuel-fired heating equipment.

## RESEARCH METHODOLOGY

This study uses the evaluation approach of historical tracing to assess the validity of the predefined theory of how and why the initiative should work, or the program logic. Historical tracing involves carefully reconstructing events leading to the outcome of interest to develop a weight of evidence conclusion regarding the influence or role of a program on the outcome.

The primary source of data for historical tracing was structured in-depth interviews with three groups: one interview with program administrator (PA) staff; one interview with program implementation staff; 19 interviews with market actors (manufacturers, distributors, and installers of DMSHPs, integrated controls, or both); and five interviews with selected energy-efficiency organizations familiar with or involved in the events leading to establishing the market for integrated controls or that are running or planning to run programs that support the controls. The NMR team also relied on secondary data, including the implementation contractor's (CLEAResult's) documentation of outreach activities with market actors and reports on integrated controls pilot studies conducted by interviewees.

## KEY LIMITATIONS & SOURCES OF UNCERTAINTY

The subset of manufacturers, distributors, and installers interviewed for this study may not accurately represent the perspectives of all the manufacturers, distributors, and installers to whom the PAs reached out or who are the target of PA outreach. Manufacturers, distributors, and installers with whom the PAs had connected through their outreach were disproportionately more likely to respond to the NMR team's requests for interviews, compared to those whom the PAs had not interacted with, introducing some possible bias into the results. However, based on market share estimates from interviews with market actors, the NMR team estimates that the manufacturers interviewed account for at least 90% of US DMSHP sales.

## Section 1 Introduction

### 1.1 BACKGROUND

Massachusetts energy-efficiency Program Administrators (Berkshire Gas, Blackstone Gas, Cape Light Compact, Columbia Gas of Massachusetts, Eversource, Liberty Utilities, National Grid, and Unitil) have made a commitment to promoting cold-climate air-source heat pumps to enable energy optimization and reduce greenhouse gas emissions. This support encourages customers with oil and propane heat to displace fossil fuels with cold-climate ductless mini-split heat pumps (DMSHP).

Evaluation has determined that residential customers with DMSHPs often do not use them as their primary heating systems.<sup>1</sup> (For the purposes of this report, “DMSHP” refers to inverter-driven mini- and multi-split heat pump systems, regardless of configuration. It does not refer to traditional, non-inverter air source heat pump (ASHP) systems that condition space through a central distribution system.) While the percentage of Mass Save program participants using mini-splits for heating has risen over time, a 2017 evaluation survey found that only 38% of respondents reported using their DMSHP system for all or most of the heat in their space.<sup>2,3</sup> To achieve the optimal use of DMSHPs and backup heating systems, it is necessary to understand the crossover temperature when a fossil-fuel heating system becomes the more cost-effective heating method, and set DMSHP and backup heating system thermostats differently depending on whether temperatures are above or below the crossover point. This process is confusing for customers, especially when they must also consider comfort given the distribution and range of systems. The program administrators (PAs) concluded that a product that could automatically switch between a DMSHP and an oil or propane heating system depending on the temperature – an *integrated control* – could increase the use of DMSHPs for heating. Finding no integrated control product readily available on the market, the PAs developed a specification for integrated controls, reached out to manufacturers to encourage them to produce equipment to meet it, and publicized and began offering generous rebates for customers heating with delivered fuels who install DMSHPs with qualified integrated controls. PA support for heat pump integrated controls is considered neither a program nor an initiative; therefore, this report refers to PA support for heat pump integrated controls as an intervention.

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<sup>1</sup> Ductless Mini-Split Heat Pump Impact Evaluation <http://ma-eeac.org/wordpress/wp-content/uploads/Ductless-Mini-Split-Heat-Pump-Impact-Evaluation.pdf>

<sup>2</sup> Quick Hit Study: Ductless Mini-Split Heat Pump Survey [http://ma-eeac.org/wordpress/wp-content/uploads/RES-29\\_Final-Memo\\_18.03.30.pdf](http://ma-eeac.org/wordpress/wp-content/uploads/RES-29_Final-Memo_18.03.30.pdf)

<sup>3</sup> Ductless Mini-Split Heat Pump Customer Survey Results <http://ma-eeac.org/wordpress/wp-content/uploads/Ductless-Min-SplitHeat-Pump-Customer-Survey-Results1.pdf>

## 1.2 OBJECTIVES

The purpose of this study is to assess the evidence for or against the PAs' support of DMSHP integrated controls having made a substantial, lasting impact on the Massachusetts market for these controls and for cold-climate DMSHPs, and to provide a qualitative – not quantitative – assessment of the degree of market effects, if any. To these ends, the study seeks to complete the following tasks:

- Confirm and refine, or disconfirm, the underlying theory about the status of the market for residential and small commercial DMSHPs (i.e., that lack of an easy way for customers to use DMSHPs efficiently in conjunction with fossil fuel heating equipment is a major barrier to the spread of DMSHPs for combined heating, and that making integrated controls available will address this need and help accelerate the adoption and proper use of DMSHPs)
- Qualitatively assess the status of the Massachusetts market for controls that integrate heating from DMSHPs and existing oil or propane heating systems
- Gather evidence documenting the PAs' role, if any, in bringing this market barrier and opportunity to the attention of manufacturers and facilitating the development of the market
- Develop a preliminary assessment of attribution (i.e., the degree to which the PAs played a role, if any, in establishing a market for controls that integrate heating from DMSHPs and existing oil or propane heating systems, optimizing how they work together to maximize both efficient heating and comfort)

If the study finds evidence that some portion of any market effects could be attributed to PA efforts, additional objectives are as follows:

- Based on the evidence and secondary data, develop a qualitative estimate of the likely degree of market effects that the PAs could hope to claim in the future, and over what period
- Sketch out a high-level approach to quantifying the market effects over time

## 1.3 RESEARCH QUESTIONS

Table 1 shows the research questions relevant to this study. Quantifying market effects is not the purpose of this study; rather, the purpose is to assess what evidence there may be of substantial, lasting market effects due to PA efforts in this market in Massachusetts. Because of this, this study addresses certain of these research questions only in a qualitative or preliminary fashion. Should this study show evidence of substantial, lasting market effects due to PA efforts, quantifying the market effects would require these questions to be revisited either quantitatively or more thoroughly in a future study. Such a study would also need to address the question in Table 1 below, “What is the baseline for each of the market effects indicators?” This question is key to measuring market effects but is not part this study.



**Table 1: Research Questions**

Research Question	To be Addressed in:			
	This Study	Details	Future Study	Details
<b>Validity of Program Theory</b>				
Is the underlying theory about the status of the market for residential and small commercial DMSHPs correct?	●			
<b>Market Status</b>				
What is the state of the Massachusetts market for integrated controls?	●	Qualitative	●	Quantitative
<b>Attribution</b>				
To what degree are the PAs responsible for establishing or accelerating the appearance of integrated controls on the market in Massachusetts?	●	Preliminary Qualitative & order of magnitude	●	Quantitative
<b>Future Market Effects Tracking &amp; Quantification</b>				
What market effects indicators would be appropriate for measuring the market effects expected from the PAs' efforts to establish this market, as well as the effects of support from Mass Save on the market? For which indicators is it realistic to expect to gather data?	●			
How can future evaluations quantify market effects from these efforts? What are the steps and timelines?	●	High level whether & how to quantify market effects, general steps involved	●	More detailed quantification approach & suggested timeline
What is the baseline for each of the market effects indicators?			●	
<b>Implications for Fuel Optimization</b>				
What are the likely effects of integrated DMSHP controls on switching from delivered fuels to electric heating with DMSHPs? From natural gas to electric heating with DMSHPs?	●		●	

## Section 2 Research Methodology

### 2.1 EVALUATION APPROACH

This study uses the evaluation approach of *historical tracing* to assess the validity of the theory of change, a.k.a. *program theory*, underlying the design of the heat pump integrated controls intervention. As a theory-based evaluation approach, historical tracing assesses a program according to the program team’s predefined theory of how and why the program should work, or the *program logic* – that is, “the chain of events from intervention to changes in the amount of efficient products produced/consumed and the resulting energy savings.” Historical tracing involves carefully reconstructing events leading to the outcome of interest to develop a *weight of evidence* conclusion regarding the influence or role of a program on the outcome. This approach requires developing alternative causal hypotheses to the program theory and logic model, gathering evidence (typically in the form of narratives of events supplied by individuals with different points of view and interests in the outcome and other market information that may be available), assessing this evidence for consistency with the program theory and logic model versus the alternative causal hypotheses, and identifying and weighting the relative contribution of factors or programs affecting the outcome.<sup>4</sup>

[Section 3](#) lays out the program theory and logic model for this intervention and presents alternative causal hypotheses. [Section 4](#) assesses the evidence for consistency with the program theory and logic model versus the alternative causal hypotheses and discusses the relative contribution of factors affecting the outcome. The remainder of this section describes the data the NMR team collected for this study and the sources of these data.

### 2.2 DATA COLLECTION

The primary source of data for historical tracing was structured in-depth interviews with three groups:

- PA and implementation staff
- market actors, including manufacturers, distributors, and installers of DMSHPs, integrated controls, or both
- selected energy-efficiency organizations familiar with or involved in the events leading to establishing the market for integrated controls or that are running or planning to run programs that support the controls

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<sup>4</sup> Mitchell Rosenberg and Lynn Hoefgen, “Market Effects and Market Transformation: Their Role in Energy Efficiency Program Design and Evaluation,” *California Institute for Energy and Environment*, 2009, accessed November 25, 2019, [http://www.calmac.org/publications/Market\\_Effects\\_and\\_Market\\_Transformation\\_White\\_Paper.pdf](http://www.calmac.org/publications/Market_Effects_and_Market_Transformation_White_Paper.pdf).

The NMR team also relied on secondary data, including the implementation contractor's (CLEAResult's) documentation of outreach activities with market actors and reports on integrated controls pilot studies conducted by interviewees.

### 2.2.1 Market Actor Interviews

The NMR team set out to conduct interviews with up to ten heat pump manufacturers, four controls manufacturers, three distributors, and six installation contractors. The team targeted a mix of companies that the PAs previously identified as having been contacted by Mass Save or a Massachusetts PA representative between July of 2018 and February of 2019, as well as companies that were not contacted during this time frame. The team prioritized company representatives to interview based on factors which varied by interview group. These include the number of times Mass Save or a Massachusetts PA representative communicated with the organization about integrated controls, the organization's likely familiarity with integrated controls and/or DMSHPs, the likelihood of an organization representative agreeing to an interview, the size of the company by sales volume in dollars, and the availability of contact information for individual company representatives. Potential interviewees were offered \$100 for their cooperation.

Table 2 displays the number of companies in the sample frame and the number of completed interviews. The sample frame comprised companies the PAs had reached out to between July of 2018 and February of 2019 (55%), plus other companies in the industry the NMR team is aware of (45%). We compiled contact information from lists supplied by the PAs, attendees of the 2019 NEEP ASHP Market Transformation Workshop, our own industry contacts, and web searches. The sample frame column in Table 2 is limited to companies for which we obtained contact information. The NMR team completed no more than one interview per company; therefore, 19 companies are represented in the sample. Fifteen (79%) of the completed interviews were with companies the PAs had reached out to between July of 2018 and February of 2019, and four (21%) were with other companies. Based on market share estimates of the percentage of equipment sales represented by each manufacturer that PA staff and other market actors mentioned during the interviews, the NMR team estimates that the six heat pump manufacturers interviewed account for at least 90% of US DMSHP sales.

While the original sample plan specified separate targets for controls manufacturers and heat pump manufacturers, it became apparent over the course of the interviews that this delineation did not reflect the actual market. The companies characterized as controls manufacturers in the sample frame produced dual-fuel thermostats – a key component of integrated controls, but not necessarily a complete integrated controls package. In addition, some of the heat pump manufacturers in the sample frame also produced integrated controls. For purposes of simplicity, we have characterized the interviewed manufacturers as either heat pump or thermostat manufacturers based on their primary product. In addition, we have abbreviated “distributors and manufacturers’ representatives” to just “distributors.”

**Table 2: Market Actor Sample**

Market Actor Type	Sample Frame (N)	Completed Interviews (n)
Heat Pump Manufacturers	16	6
Thermostat Manufacturers	3	2
Distributors	25	5
Contractors	16	6
<b>Total</b>	<b>60</b>	<b>19</b>

Table 3 displays the products manufactured, distributed, and installed by the 19 interviewed market actors. All six heat pump manufacturers, five distributors, and six contractors sell DMSHPs; most also sell central heat pumps. All six heat pump manufacturers' DMSHPs are capable of being controlled as dual-fuel systems. Two of the six heat pump manufacturers also sell standalone controls packages for their own DMSHPs. The thermostat manufacturers sell dual-fuel thermostats that can be a component of integrated controls systems. Four of the six contractors interviewed installed integrated controls for DMSHPs at the time of the interviews. The two contractors who did not offer integrated controls were aware of them and were considering offering them in the future. Additional information on the products and configurations offered by the interviewees is provided in [Section 4.1](#).

**Table 3: Market Actors' Products**

Manufacture/ Distribute/Install	Heat Pump Manufacturers	Thermostat Manufacturers	Distributors	Contractors
<i>n</i>	6	2	5	6
DMSHPs	6	--	5	6
DMSHPs with integrated controls	6	--	3	4
Central heat pumps	4	--	3	6
Central heat pumps with integrated controls	3		2	4
Standalone controls packages for DMSHPs	2	2*	1	--
Standalone controls packages for central heat pumps	3	2*	2	1

\*Dual-fuel thermostat component of controls package.

Table 4 displays the number of market actors that Mass Save staff contacted between July of 2018 and October of 2019, and the interviewees' familiarity with the rebates and specification. Note that one of the heat pump manufacturers who was not contacted by Mass Save staff said he actively reached out to them instead.



**Table 4: Mass Save Outreach and Interviewee Familiarity with Intervention Elements**

Mass Save Outreach and Interviewee Familiarity	Heat Pump Manufacturers	Thermostat Manufacturers	Distributors	Contractors
<i>n</i>	6	2	5	6
Contacted Between July 2018 and October 2019	4	1	3	2
Familiar with Integrated Controls Rebate	6	2	5	6
Familiar with Integrated Controls Specification	4	2	4	n/a*

\*Contractors were not asked this question.

**2.2.2 Program Administrator and Non-governmental Organization Interviews**

The NMR team conducted interviews with five organizations to assess the extent of their (or their members’) activities around integrated controls for DMSHPs, the timing of these in relation to the PAs’ efforts, and any possible interaction with or leveraging of the PAs’ efforts.

**Table 5: Program Administrator and NGO Interviews**

Organization	Reason Interviewed
Northeast Energy Efficiency Partnerships (NEEP)	Known to be conducting research on or supporting DMSHP integrated controls
Northwest Energy Efficiency Alliance (NEEA)	Known to be conducting research on or supporting DMSHP integrated controls
Massachusetts Clean Energy Center (CEC)	Recently ended program providing residential rebates for DMSHPs to Massachusetts residents
New York State Energy Research & Development Authority (NYSERDA)	Identified by multiple interviewees as the only other program support for DMSHP integrated controls
Consortium for Energy Efficiency (CEE)	Identify PAs researching or supporting DMSHP integrated controls

**2.2.3 Secondary Research**

The NMR team reviewed the program theory, logic model, specification for integrated controls, and qualified product list. In addition, we examined a chronological summary of intervention activities conducted by CLEAResult between July of 2018 and February of 2019. We also reviewed reports and presentations pertaining to DMSHP integrated controls suggested by PA and non-governmental organization (NGO) interviewees. We used these materials to piece together the chain of events for the historical tracing.

## Section 3 Theory of Change

This section presents the program theory and logic model for the heat pump integrated controls intervention, as well as three causal hypotheses examined in this report: a causal hypothesis based on the program theory ( $H_1$ ), and two alternative causal hypotheses ( $H_2$  and  $H_3$ ).

In the Spring of 2019, PA program staff articulated the theory of change underlying the PAs' promotion of integrated controls, worked with PA evaluation staff to document the program logic in a logic model that visually summarizes the theory and the market effects expected from this promotion, and identified possible indicators of market effects. The program theory, logic model, and market effects indicators are presented here nearly verbatim from these documents.<sup>5</sup>

The goal of the integrated controls effort is to foster more widespread adoption and use of cold-climate DMSHPs for heating by filling a hypothesized gap in the market: namely, that customers could not automatically stage their heating systems for optimal efficiency, comfort, and cost savings. By coordinating with manufacturers and distributors to adapt, develop, and promote integrated controls for the Massachusetts market, PAs are facilitating adoption and use of cold-climate heat pumps to displace oil and propane heat. The PAs seek to transform the market so that installing integrated controls becomes standard practice for DMSHPs installed in homes and small businesses with oil and propane heating systems, and so that these customers heat their whole homes/small businesses (not just individual rooms) with the DMSHPs. Currently, the PAs offer support for DMSHP integrated controls to residential customers, but not to small business or other commercial or industrial customers.

### 3.1 PROGRAM THEORY

Massachusetts PAs are undertaking six steps to promote integrated controls.

- First, PAs identified the need in the market and encouraged manufacturers to adapt existing equipment and develop new equipment to meet the need for integrated controls. By offering incentives for these controls, PAs created a pool of likely customers, reducing uncertainty for manufacturers about bringing a new product or application of an existing product to market. PAs are continuing to coordinate with manufacturers as they promote the new products coming onto the market.
- Second, by establishing specifications for integrated controls, PAs are ensuring that integrated control products offered in the market meet the identified need.
- Third, PAs are developing training for Heating, Ventilation and Air Conditioning (HVAC) contractors to raise awareness of integrated controls. This training will be included as part of the HVAC check training, as well as more general training for HVAC contractors who do not participate in the HVAC check program. These training opportunities will promote

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<sup>5</sup> All information in this section was obtained via personal communication from Tracy Dyke-Redmond, Eversource, May 16, 2019.

integrated controls as a solution for fuel optimization and will direct HVAC contractors to manufacturer training for detailed instructions on installation and setup.

- Fourth, PAs are developing marketing efforts to raise awareness about integrated controls, how they are designed to make DMSHPs work seamlessly with backup heating systems, and the benefits for customers of heating their whole homes with DMSHPs.
- Fifth, PAs are developing customer education materials to help customers understand how integrated controls can help them use their DMSHPs for heating, and how to stage their heating systems with integrated controls.
- Sixth, PAs are offering significant incentives (\$1,600 per ton) for qualified cold-climate air-source heat pumps with integrated controls.<sup>6</sup> These incentives are designed to offset the high initial cost of DMSHPs with integrated controls, and to expand the market of interested customers so that manufacturers compete for this market and continue to bring down prices.

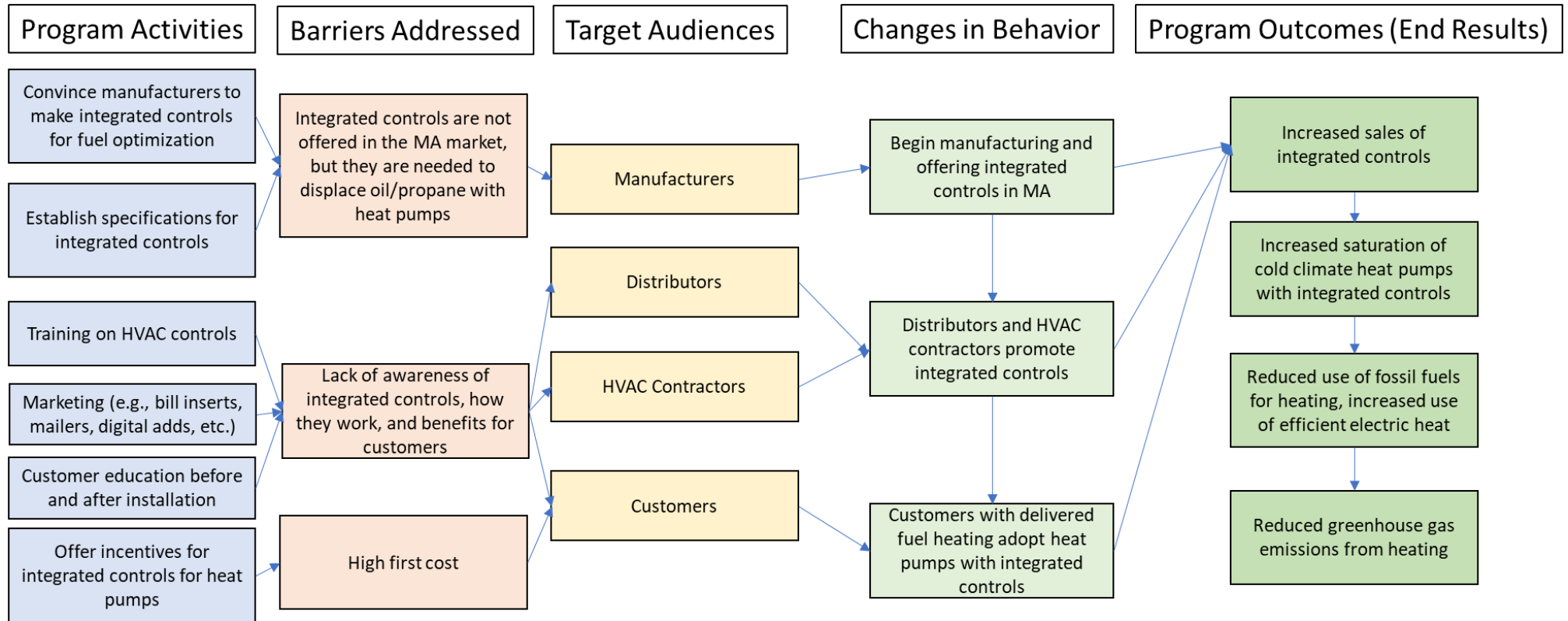
The PAs intend for these steps to reduce barriers in the market to using DMSHPs for heating by increasing availability of integrated controls to help customers stage DMSHPs and backup heating systems most efficiently. The PAs' efforts are also intended to increase familiarity of market actors (distributors, HVAC contractors, and customers) with integrated controls and their potential benefits to customers. Finally, the efforts are intended to reduce the upfront cost of integrated controls to customers.

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<sup>6</sup> Only customers who heat with oil or propane are eligible for incentives.

### 3.2 LOGIC MODEL

Figure 1: Logic Model





### 3.3 MARKET EFFECTS INDICATORS

The PAs propose to track the following metrics as indicators of market effects. To facilitate the possible extension of program support to small business customers in the future, the indicators include data about DMSHPs and DMSHP integrated controls used in small businesses as well as homes.

1. Percentage of homes and small businesses with cold-climate DMSHPs
2. Percentage of program participants using DMSHPs for heating
3. Percentage of homes and small businesses with DMSHPs that use their DMSHPs for most or all of their heating
4. Percentage of DMSHPs installed that have integrated controls (with and without program incentives)
5. Change in sales of integrated controls (inside and outside the Mass Save program)
6. Percentage of distributors and HVAC contractors that promote integrated controls
7. Price of integrated controls
8. Number of manufacturers offering integrated controls

### 3.4 CAUSAL HYPOTHESES

H<sub>1</sub> is the causal hypothesis based on the program theory underlying the heat pump integrated controls intervention:

**H<sub>1</sub>: The PAs were entirely or largely responsible for establishing or accelerating the development of the market for DMSHP integrated controls in MA.**

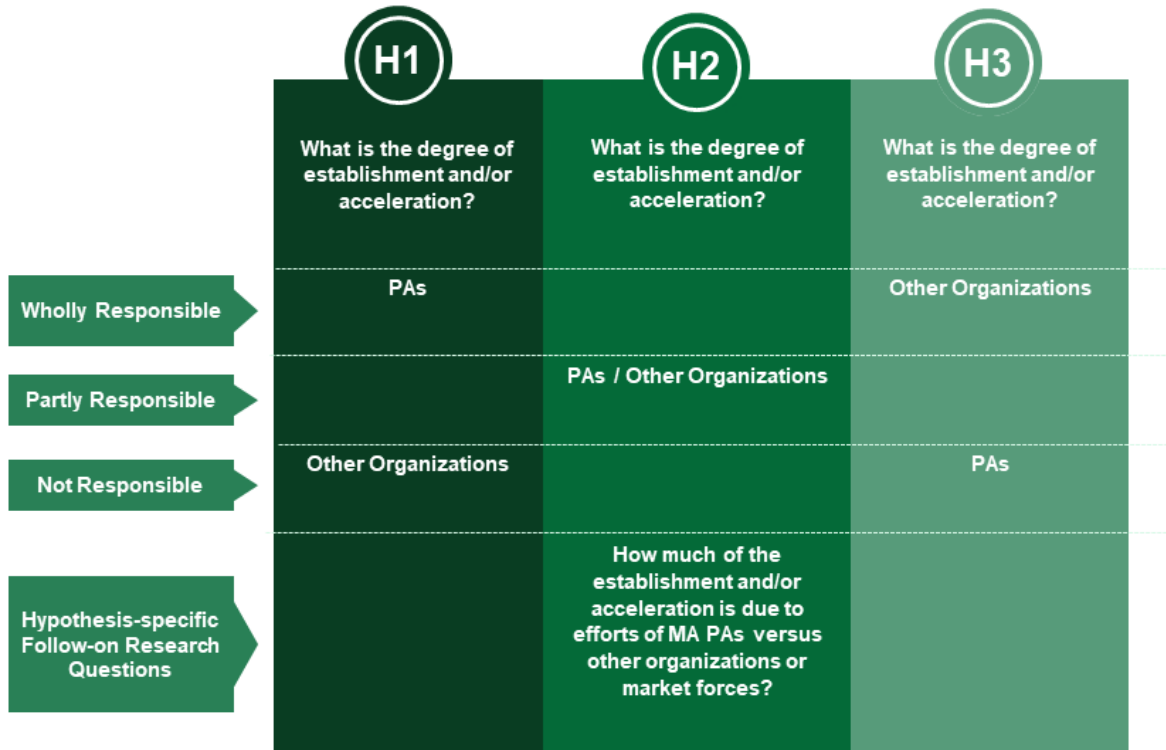
The alternative causal hypotheses are:

**H<sub>2</sub>: The PAs were partly responsible for establishing or accelerating the development of the market for DMSHP integrated controls in MA. Other organization(s), market forces, or both were also partly responsible.**

**H<sub>3</sub>: Other organization(s), market forces, or both were entirely or largely responsible for establishing or accelerating the development of the market for DMSHP integrated controls in MA.**

If the study finds support for H<sub>1</sub> or H<sub>2</sub>, it will address additional research questions about the degree of PA responsibility for the establishment or acceleration of the market for DMSHP integrated controls. [Figure 2](#) summarizes the three hypotheses and shows the additional research questions associated with each.

**Figure 2: Hypotheses and Follow-on Research Questions**



## Section 4 Historical Tracing

This section summarizes: the PAs' efforts to establish and build the residential market for DMSHPs with integrated controls; the activities and perspectives of other energy-efficiency organizations in this market; and the observations and perspectives of manufacturers, distributors, and installers of DMSHPs and integrated controls about their own and others' roles in this market. It assesses the evidence for consistency with the program theory and logic model versus the alternative causal hypotheses and discusses the relative contribution of factors affecting the outcome.

### 4.1 ABOUT DMSHP INTEGRATED CONTROLS

DMSHPs are typically controlled with remote controls, while boilers and furnaces are typically controlled with thermostats. Integrated controls automatically switch between a DMSHP and another heating system at a predetermined temperature. There are multiple ways to integrate DMSHPs with other heating systems, and some DMSHP manufacturers have multiple rebate-eligible integrated control options. One option is for a DMSHP manufacturer to develop its own integrated control device capable of communicating with both DMSHPs and other heating systems. An example of this type of device is the Mitsubishi Kumo station. Another option is to attach adaptors to DMSHPs, allowing them to communicate with a third-party dual-fuel thermostat, the cloud (to be controlled by an app), or both.

The manufacturers we interviewed did not create any new equipment to meet the Mass Save integrated controls specification. Two DMSHP manufacturers stated that they already manufactured a device (such as a thermostat) that could integrate their DMSHPs with other heating systems. The rest of the manufacturers adapted existing equipment by developing software, supplying adaptors, and/or identifying third-party thermostats or other components that enable their equipment to achieve integration with other heating systems. In most cases, an intermediary piece of equipment (i.e., an adaptor) is required to allow the DMSHPs to communicate with the rest of the system. A thermostat manufacturer described this type of configuration as “a piecemeal, Band-Aid solution, put together by people locally for a local problem, rather than a global solution for a global problem,” and added, “the better approach would be making a product specifically for DMSHPs that you don't need the middle piece of equipment for; the thermostat would directly communicate with the mini-split.” Along the same lines, a heat pump manufacturer commented, “The Mass Save incentive is so robust that people scrambled to meet the spec.” At the time of this research, two of the manufacturers were developing solutions that could integrate DMSHP and other heating systems in a somewhat more streamlined manner. However, only one of these two manufacturers attributed the decision to develop the solution – a software component – to the Mass Save intervention; the other manufacturer's solution had been in development before the Mass Save intervention.

The integrated controls specification lists the requirements, which include providing instructions, schematics, and wiring diagrams for the integrated controls.<sup>7</sup> The interviews revealed that the manufacturer developed these materials in some cases, while in other cases, the distributor or manufacturer's representative developed them. The integrated controls must utilize one of the two control strategies defined in the specification: (1) balance point operation (suggested at 30-40°F outdoor ambient temperature) or (2) simultaneous operation (i.e., *droop*) with a 15°F balance point for ASHP changeover.<sup>8</sup> In case one of the heating systems malfunctions, the controls must be able to switch from heat pump to fossil fuel heating system operation, or vice versa, without rewiring. In addition, the specification requires basement *freeze protection* to be in place to prevent frozen pipes in the event of low basement temperature during ASHP operation.

The thermostat manufacturers we interviewed explained that their thermostats are compatible with any brand of DMSHP as long as the DMSHP manufacturer makes an adaptor available. One DMSHP manufacturer we interviewed said it was necessary to coordinate with each thermostat manufacturer to make sure the controls would work with his company's DMSHPs. He said this coordination was a lot of work and it kept the company's software team "super busy." Controllers made by the DMSHP manufacturers we interviewed are only compatible with their own company's DMSHPs.

Each manufacturer's equipment is installed a different way. Most of the manufacturers we interviewed said the integrated controls were not difficult to install, but training was required to learn how to install them. The manufacturers offered various types and degrees of training, ranging from podcasts and instructional videos to hands-on workshops. Four of the six contractors interviewed had installed at least one integrated controls system. Two of these contractors indicated that it was a little complicated to install the integrated controls, and a third described it as "a pain."

## 4.2 ACTIVITIES OF THE MASS SAVE HEAT PUMP INTEGRATED CONTROLS INTERVENTION

This section describes the impetus for the Mass Save heat pump integrated controls intervention and the timing of intervention activities. The information in this section is derived from interviews with PA program staff and CLEAResult implementation staff.

In the spring of 2018, the PAs learned of new legislation that would allow them to promote strategic electrification and clean energy technologies to displace fossil fuels. This legislation – Bill H.4857 An Act to Advance Clean Energy<sup>9</sup> – was signed into law on August 9, 2018.

<sup>7</sup> See [Appendix B](#) for the full specification.

<sup>8</sup> With this control strategy the DMSHP provides heat above 40 degrees, the DMSHP is set 2-3 degrees higher than the conventional system from 40 to 15 degrees, and the conventional system provides heat below 15 degrees.

<sup>9</sup> <https://malegislature.gov/Bills/190/H4857>

A Massachusetts DMSHP evaluation completed shortly before this<sup>10</sup> had found that DMSHPs were more cost-effective to operate than oil systems down to at least 32°F<sup>11</sup> and propane systems down to -15°F, and that customers with DMSHPs were not taking full advantage of the cost savings they could achieve by heating with mini-splits instead of their oil and propane systems.

The PAs recognized this situation as an opportunity for energy optimization and concluded that to maximize customer use of DMSHPs for heating in the presence of fossil fuel heating systems, control of residential DMSHP and backup heating systems needed to be integrated in a seamless manner. PAs sought a solution and authorized the implementation vendor, CLEAResult, to reach out to manufacturers to determine if there were any solutions available on the market.

PA and implementation staff approached manufacturers including Mitsubishi, Fujitsu, LG, Samsung, Honeywell, and others. Staff explained their need for an integrated controls product to the manufacturers. Table 6 documents CLEAResult’s outreach activities from July of 2018 through March of 2019. CLEAResult held 17 meetings and eight conference calls, attended five outreach events, and initiated dozens of phone calls and emails as part of its outreach to equipment manufacturers, manufacturer reps, distributors, and contractors. As of August 2018, CLEAResult had found just one piece of equipment currently being manufactured that could serve as an integrated control for use with mini-splits and fossil fuel heating systems: Mitsubishi’s Kumo station. Mitsubishi had sold only 300 Kumo stations nationwide between releasing the product in January of 2018 and the end of 2018. When the PAs became aware of the Kumo station, it was not being marketed as a mini-split integrated control.

**Table 6: Outreach July 2018 through March 2019**

Outreach Type	Count
In-person meeting	17
Group conference call	8
Outreach event	5

In October of 2018, the PAs announced there would be new rebates for integrated controls for use with cold-climate DMSHPs and fossil fuel heating systems in homes, and implementation staff began distributor outreach to explain the details of the forthcoming rebates. The PAs released the specification for integrated controls for use with cold-climate DMSHPs and fossil fuel heating systems in November of 2018. Rebates became available in January of 2019. The PA staff interviewed believed that their outreach to manufacturers was the first and most influential activity leading to the establishment of the market for DMSHP integrated controls.

Rebates for the installation of new, cold-climate DMSHPs with integrated controls in homes that heat with oil or propane are available through the intervention. The 2019 rebate amounts were \$1,600 per ton for ductless systems with integrated controls, and \$1,000 per ton for ducted and

<sup>10</sup> <http://ma-eeac.org/wordpress/wp-content/uploads/Ductless-Mini-Split-Heat-Pump-Impact-Evaluation.pdf>

<sup>11</sup> The operational break point temperature for the cold climate heat pumps in the study was 8°F in 2015 and 26°F in 2015. The operational break point temperature for all heat pumps in the study (including those not listed as cold climate) was 12°F in 2015 and 32°F in 2016. Average winter fuel prices were used to calculate the break point temperatures for 2015 and 2016, respectively.



mixed ducted/ductless systems with integrated controls.<sup>12</sup> Rebates are also available for the addition of integrated controls to existing DMSHPs: up to \$500 per indoor unit with a maximum of \$1,500. To be eligible for the \$1,600-per-ton rebate, a DMSHP must be listed on the NEEP qualified product list<sup>13</sup> and integrated controls must be listed on the Mass Save qualified product list.<sup>14</sup> Contractors are required to program the integrated controls to alternate between the DMSHP and existing heating system at the time of installation. However, there is no mechanism in place to enforce homeowners' use of the integrated controls.

By the end of January of 2019, Kumo stations were sold out in Massachusetts. According to the implementation staff interviewee, the number of manufacturers offering qualifying models of integrated controls increased from one to ten during the first half of 2019, and sales of the Kumo station grew from 300 sold nationwide prior to January of 2019 to several hundred units sold per month in 2019.

According to implementation staff, six months after the intervention launched, most manufacturers in the residential DMSHP market, including Carrier, Toshiba, Haier, Gree, Mitsubishi, Fujitsu, LG, Panasonic, and Tyson, had developed or had agreed to develop rebate-eligible products. According to the PAs' 2019 key performance (KPI) data, the PAs rebated 1,207 new DMSHP units with integrated controls for homes heated by delivered fuels, and an additional 42 integrated controls to be retrofitted into previously installed DMSHPs in homes heated by delivered fuels.

### 4.3 ACTIVITIES OF OTHER PROGRAM ADMINISTRATORS AND NON-GOVERNMENTAL ORGANIZATIONS

Around the same period that the PAs were researching and undertaking the activities described above, other PAs and NGOs that focus on energy efficiency were undertaking studies and other efforts directly or indirectly related to DMSHP integrated controls. In addition to interviewing organizations known to be conducting research on or supporting DMSHP integrated controls, the NMR team asked all interviewees for leads on organizations offering program support for or conducting research on DMSHP integrated controls. Using this method, the team identified one other program – a pilot run by the New York State Energy Research and Development Authority (NYSERDA) – supporting DMSHP integrated controls at the time of this study.

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<sup>12</sup> The 2020 rebate amount is \$1,250 per ton for both ductless and ducted systems with integrated controls.

<sup>13</sup> Eligibility requirements were updated for 2020: a DMSHP must have a heating seasonal performance factor (HSPF) of 10 or higher, seasonal energy efficiency ratio (SEER) of 18 or higher, and capacity ratio (17°/47°) of 56% or higher. <https://ashp.neep.org>.

<sup>14</sup> [https://www.masssave.com/-/media/Files/PDFs/Save/Residential/Integrated-Controls-and-Dual-Fuel-TStats\\_Master.pdf](https://www.masssave.com/-/media/Files/PDFs/Save/Residential/Integrated-Controls-and-Dual-Fuel-TStats_Master.pdf)

### 4.3.1 NYSERDA

In April of 2019, NYSERDA launched the pilot *Maximizing the Effectiveness of Ductless Mini-split Heat Pumps in Existing Homes*. This pilot offers rebates for DMSHP integrated controls as an add-on to NYSERDA's residential Air-Source Heat Pump program. The pilot uses (with PA permission) the specification the PAs developed for the Mass Save heat pump integrated controls intervention. It differs from the Mass Save intervention in the following ways:

- Sites can qualify regardless of fuel type.
- The site owner receives one \$500 incentive for installing an integrated control package, regardless of the number of indoor units.

The NYSERDA interviewee noted that the pilot has had limited uptake so far. They attributed this to having been able to devote only limited resources to the pilot and particularly to consumer and contractor education around the technology. The interviewee anticipated that when scaled up, the program would likely focus more on customers heating with oil and propane.

NYSERDA is also conducting a study of 12 residential installations to evaluate the effects of an integrated control strategy on thermal distribution and energy savings.

### 4.3.2 Massachusetts CEC

From 2014 to March of 2019, the CEC's Residential and Small-Scale Air-Source Heat Pump Program supported DMSHPs for heating with incentives to encourage residents to switch from fossil fuels for home heating. Over 20,000 DMSHPs were installed through the program. This program ended for two reasons: (1) because Mass Save began supporting DMSHPs for heating with larger incentives for customers with integrated controls, and (2) because the CEC's program had become very popular and the CEC did not have the budget to continue running it at such a large scale. The CEC believed that continuing to offer an incentive that could be supplemented with the Mass Save incentive was not a wise use of resources.

In May of 2019, the CEC launched a much smaller pilot for whole house air-source heat pumps intended to fully replace gas heating. This pilot is only available to homes served by natural gas or to newly constructed homes with no other heating source. It does not support integrated controls. This is because it is intended to complement, not compete with, the Mass Save heat pump integrated controls intervention. It is intended for homes with residents who do not plan to maintain any fossil fuel backup heating, so integrated controls are unnecessary. Participants who keep their natural gas heating must sign an agreement that they will only use gas heating in an emergency.

Another program run by the CEC in conjunction with the Massachusetts Department of Energy Resources, Heat Smart Massachusetts, seeks to increase the adoption of small-scale clean heating and cooling technologies, including DMSHPs, in participating communities through a competitive solicitation process that aggregates homeowner buying power to lower installation prices for participants. Participants are eligible for Mass Save rebates, including the integrated controls rebate when applicable.

### 4.3.3 NEEP

In the spring of 2013, NEEP assembled a group of stakeholders to develop strategies to overcome barriers to residential air-source heat pump adoption. Stakeholders included manufacturers, regulators, utilities, PAs, engineers, consultants, and other contractors. This effort produced the *Northeast/Mid-Atlantic Air-Source Heat Pump Market Strategies*,<sup>15</sup> published in 2014, which presented market strategies for regional stakeholders to implement in order to accelerate adoption of residential air-source heat pumps. This report identified the lack of effective controls to manage multiple heating systems as one of the barriers to adoption. NEEP repeated this stakeholder process in 2016 and published the *Northeast/Mid-Atlantic Air-Source Heat Pump Market Strategies Report 2016 Update*<sup>16</sup> in 2017, which proposed a regional strategy of promoting advanced control technologies to allow automated coordination between cold-climate DMSHPs and existing heating systems.

NEEP has facilitated sessions on DMSHP integrated controls at its 2017 and 2019 ASHP market transformation workshops, which were attended by stakeholders, including utilities, PAs, heat pump and controls manufacturers, distributors, and HVAC contractors. The 2017 workshop included two presentations on integrated controls: one by a consultant presenting the concept of integrated control between DMSHP and central systems, and another by an Efficiency Maine representative presenting preliminary findings from a study that included integrated controls. The 2019 workshop included three presentations on integrated controls: one by a DMSHP manufacturer about integrated control products, one by an Eversource representative about implementation considerations, and one by a CLEAResult representative about the Mass Save integrated controls efforts.

In the summer of 2019, NEEP, in partnership with the Pacific Northwest National Laboratory, the Florida Solar Energy Center, and the Levy Partnership, began fielding a study of integrated controls. The study includes various configurations between DMSHP and central systems using multiple manufacturers' controllers. The purpose of the study is to assess which configuration achieves the highest DMSHP run times. Results from this study are anticipated in 2021.

### 4.3.4 NEEA

NEEA is currently planning a study to identify archetypal approaches to integrating existing heating and cooling systems of various types with DMSHPs, which approaches best fill which needs, and the relative cost of these approaches. The focus will be on integration with electric heating since about half of homes in the Pacific Northwest are heated with electricity. With this information, NEEA will determine how best to influence the market to pursue approaches appropriate for NEEA's service area.

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<sup>15</sup> Northeast Energy Efficiency Partnerships. 2014. *Northeast/Mid-Atlantic Air-Source Heat Pump Market Strategies Report*. January. Accessed from [https://neep.org/sites/default/files/resources/NortheastMid-Atlantic%20Air-Source%20Heat%20Pump%20Market%20Strategies%20Report\\_0.pdf](https://neep.org/sites/default/files/resources/NortheastMid-Atlantic%20Air-Source%20Heat%20Pump%20Market%20Strategies%20Report_0.pdf)

<sup>16</sup> Northeast Energy Efficiency Partnerships. 2017. *Northeast/Mid-Atlantic Air-Source Heat Pump Market Strategies Report 2016 Update*. January. Accessed from [https://neep.org/sites/default/files/NEEP\\_ASHP\\_2016MTStrategy\\_Report\\_FINAL.pdf](https://neep.org/sites/default/files/NEEP_ASHP_2016MTStrategy_Report_FINAL.pdf).

### 4.3.5 Other Organizations

While a number of utility and non-utility PAs have conducted studies or provide program support for DMSHPs, the team only found three other studies of, or program offerings for, mini-split integrated controls for use with heating.

*Maine.* Efficiency Maine Trust conducted long-term on-site metering at four homes with DMSHPs between February of 2018 and May of 2018, before and after installation of a Kumo system in each home. The study found that the Kumo system improved the operation of the homes' heating system as a whole and increased heat pump use.<sup>17</sup>

*Connecticut.* In July of 2019, Eversource and United Illuminating/Avangrid, two Connecticut utilities, began a 100-unit heat pump pilot that offers rebates for ENERGY STAR®-certified AHRI ASHP split systems with integrated controls to residential customers whose primary heating fuel is oil or propane. Participating customers also have to provide two years of prior fuel use documents and an American Society of Heating, Refrigeration, and Air Conditioner Engineers (ASHRAE) Manual J design document for ductless systems, allow for the collection of annual fuel use data post-installation, agree to respond to a survey after one year, and meet minimum requirements for attic insulation and air leakage.<sup>18</sup> The rebate amounts are \$1,000/unit for ducted heat pumps with integrated controls, \$1,000/home for ductless heat pumps (single), and \$1,200/home for ductless heat pumps (double). Additional incentives include a \$75-174 co-pay bonus with the heat pump application and \$50 for a delivered fuel use document after one year in service. In 2019, this pilot did not specify an integrated control type requirement, but program staff expect to use the Mass Save Qualifying Product List to determine eligible integrated control packages starting in 2020.<sup>19</sup>

*Rhode Island.* National Grid Rhode Island offers rebates for integrated controls for use with ducted, non-ducted, and mixed duct heat pumps in homes heated with oil or propane. The rebate structure and requirements are the same as those of Mass Save.<sup>20</sup>

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<sup>17</sup> West Hill Energy & Computing. 2019. "Efficiency Maine Trust, Home Energy Savings Program Impact Evaluation, Program Years 2014-2016." <https://www.energymaine.com/docs/HESP-Evaluation-8-23-19.pdf>

<sup>18</sup> Foley, Mark & Larry Rush. 2018. "Heat Pump Pilot Oil and Propane Homes." Presentation at the Green Energy Contractor Conference, November 7, 2019. <https://ctgreenbank.com/wp-content/uploads/2019/11/Heat-Pump-Panel.pdf>

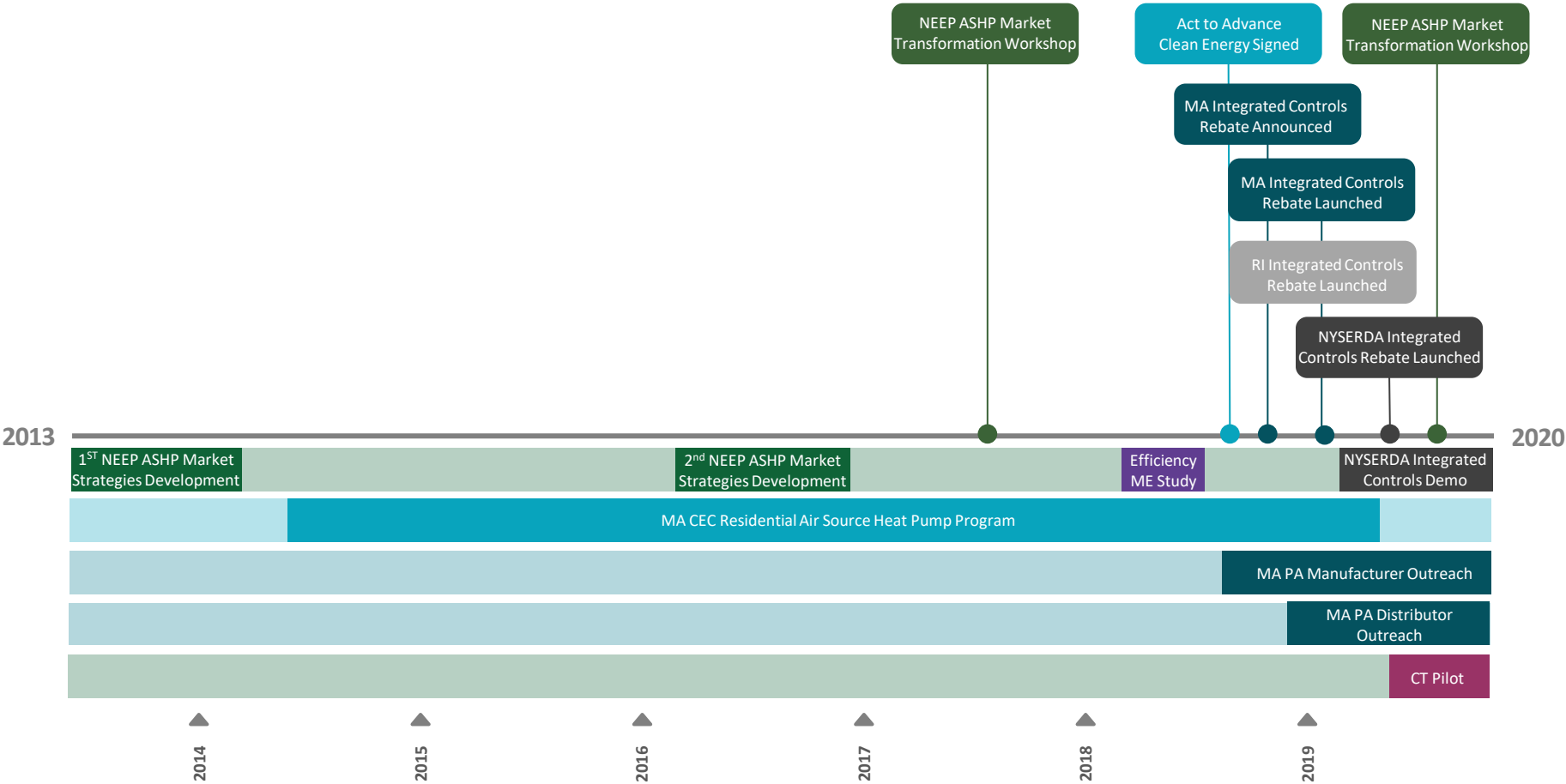
<sup>19</sup> Mark Foley, Eversource, personal communication, December 23, 2019.

<sup>20</sup> "2019 Rhode Island Residential heat pump rebate for displacement of oil or propane and replacement of electric resistance heat." From [https://www.nationalgridus.com/media/pdfs/resi-ways-to-save/ee7342-ri-hvac-rebate-\(4\).pdf](https://www.nationalgridus.com/media/pdfs/resi-ways-to-save/ee7342-ri-hvac-rebate-(4).pdf)

4.4 ACTIVITY TIMELINE

Figure 3 shows the timing of the Mass Save and NGO activities described in Sections 4.2 and Section 4.3. Mass Save activities are colored dark blue.

Figure 3: Program Administrator and Other Market Actor Activities





## 4.5 MARKET ACTOR AND NGO EXPERIENCES AND PERSPECTIVES

To understand the market role of PAs' activities and support for integrated controls, the team asked market actors (i.e., manufacturers, distributors, and contractors) and NGO staffers a series of questions to determine when they first learned about integrated controls for DMSHPs, when and why they decided to engage in the market for integrated controls, and any attribution to the PAs' efforts. At the beginning of the interview, we explained that we were researching the Massachusetts market for integrated controls. However, in recognition that national manufacturers often make decisions at the national level, most of our questions were about the market in general, not a specific state or region. We asked more questions of manufacturers than the other groups because they have the greatest amount of influence in the supply chain. Below, we summarize the key findings from the interviews with market actors and NGOs. Following the summary of key findings is the detailed information on which the findings are based.

### Key Findings

#### Timing and Source of Learning About Integrated Controls & Engaging in the Market

- One-third of the manufacturers, one-half of the distributors, and three-fifths of the contractors who could recall how they first learned about integrated controls for DMSHP said that they learned about them from the Massachusetts PAs or Mass Save intervention activities (Table 7). An additional one-third of manufacturers learned about them from multiple PAs, including the Massachusetts PAs.
- Before the Mass Save intervention, one-quarter of the manufacturers offered a device (such as a thermostat) that could integrate a DMSHP with another heating system, and one-half offered products capable of being a component of an integrated control heating system. However, none of these products were marketed as an integrated control.
- Three-quarters of the manufacturers interviewed had developed or were developing products designed to integrate control between DMSHP and other heating systems after the intervention (Figure 5).
- Only one distributor and none of the contractors interviewed offered integrated controls for DMSHPs before the Mass Save intervention (Figure 5).

#### Motivations for Engaging in the Market

- When asked in an open-end question why they decided to manufacture, distribute, or offer installations of integrated controls for DMSHP, one-half of the manufacturers and all but one of the distributors and contractors cited the Mass Save rebates for integrated controls (Figure 6). Other reasons include selling more product, market demand, meeting utility needs, customer requests, and allowing customers to save energy.
- Later, when asked directly if the Mass Save intervention influenced their decision to manufacture, distribute, or offer installations of integrated controls for DMSHP, one-half of manufacturers and over three-quarters of the distributors and contractors said the Mass Save intervention influenced their decision (Figure 7). In addition, one manufacturer and one distributor said the intervention led them to accelerate the development of rebate-

eligible products already under development. Confirmation bias or “green” bias may have influenced both the open- and closed-ended responses, downplaying the significance of the Mass Save intervention.

### Market Influences & Expectations

- The Massachusetts PAs, working through Mass Save, were not the only organizations to influence development of the market for DMSHP integrated controls. Two of the NGO staffers and other PAs outside of Massachusetts indicated that in addition to the Massachusetts PAs, NEEP had been influential or instrumental in bringing heat pump integrated controls to market, and one also said the same of Efficiency Maine (Section 4.6, Table 7). Two interviewees were not aware of any organizations other than the Massachusetts PAs influencing the development of this market.
- Three-quarters of the manufacturers and two-fifths of the distributors indicated that the current market for DMSHP integrated controls would be less developed in the absence of the intervention; the rest said the market would not even exist (Figure 9, Table 7).
- In the absence of the intervention, one-half of the manufacturers would expect the market for DMSHP integrated controls to grow more slowly over the next two to five years (Figure 8). Three-fifths of the distributors would not expect the market to grow at all without the intervention.

### Market Changes & Drivers

- Over one-half of the interviewed market actors believe that the availability of integrated controls will affect the adoption of DMSHPs in homes that heat with oil or propane; one-fifth of the market actors do not believe it will affect the adoption of DMSHPs in homes that heat with oil or propane (Figure 11). One-fifth of the market actors answered “maybe” and the rest do not know.
- Relatively few interviewed market actors believe that the availability of integrated controls will affect the adoption of DMSHPs in small businesses that heat with oil or propane, mainly because there is no small business rebate for DMSHP integrated controls at this time (Figure 13).

#### 4.5.1 Timing and Source of Learning About Integrated Controls & Engaging in the Market

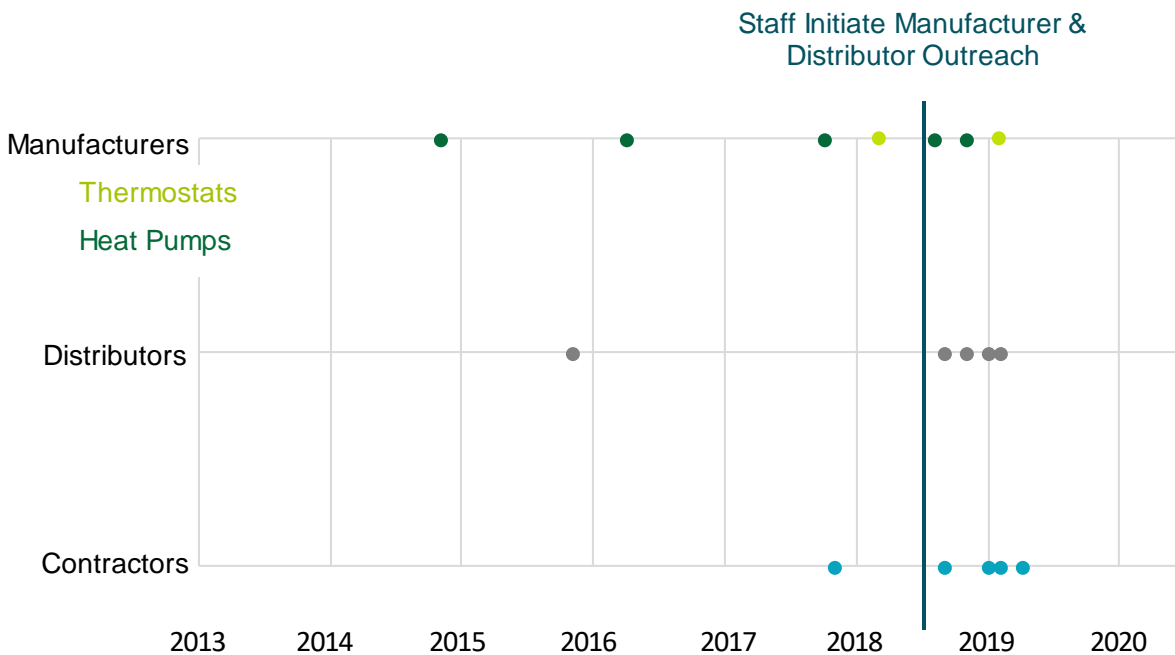
Figure 4 shows market actors’ responses to the question “How and when did your company first learn about heat pump integrated controls?”<sup>21</sup> The responses are organized by group and shown in relation to when CLEAResult and PA program staff began encouraging manufacturers to adapt existing equipment and develop new equipment to meet the need for integrated controls, and when they began reaching out to distributors and contractors about the controls. Table 7 shows how interviewees first learned about integrated controls for DMSHPs.

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<sup>21</sup> For ease of conversation, most interview questions referred to *heat pumps*, not to *mini-split heat pumps*. Both during recruiting and at the start of the interview, interviewers made it clear that the topic of the questions was integrated controls for ductless mini- and multi-split heat pumps, not for central heat pumps.

The figure shows that four of the manufacturers first learned about the concept of integrated controls for DMSHPs before July of 2018, when program staff began outreach. One of these four learned about integrated controls from a Massachusetts PA, among other sources. Three manufacturers learned about the concept of integrated controls after July of 2018; all three first learned about the concept from either Mass Save or a Massachusetts PA. The eighth manufacturer did not recall when he first learned about integrated controls.<sup>22</sup> Seven of the nine distributors and contractors we interviewed said they first learned about integrated controls for DMSHPs after July of 2018, and more than one-half (five) said they learned about them from the Mass Save intervention.

**Figure 4: When Market Actors First Learned About Integrated Controls for DMSHPs**



\*One outlying manufacturer response excluded.

<sup>22</sup> This interviewee said “don’t know” during the interview but mentioned that he could look into it. The team followed up by email. The interviewee responded “2011,” but did not explain how. We excluded this response as an outlier because of its distance from the other responses and the lack of explanation.

**Table 7: How Market Actors First Learned About Integrated Controls for DMSHPs**

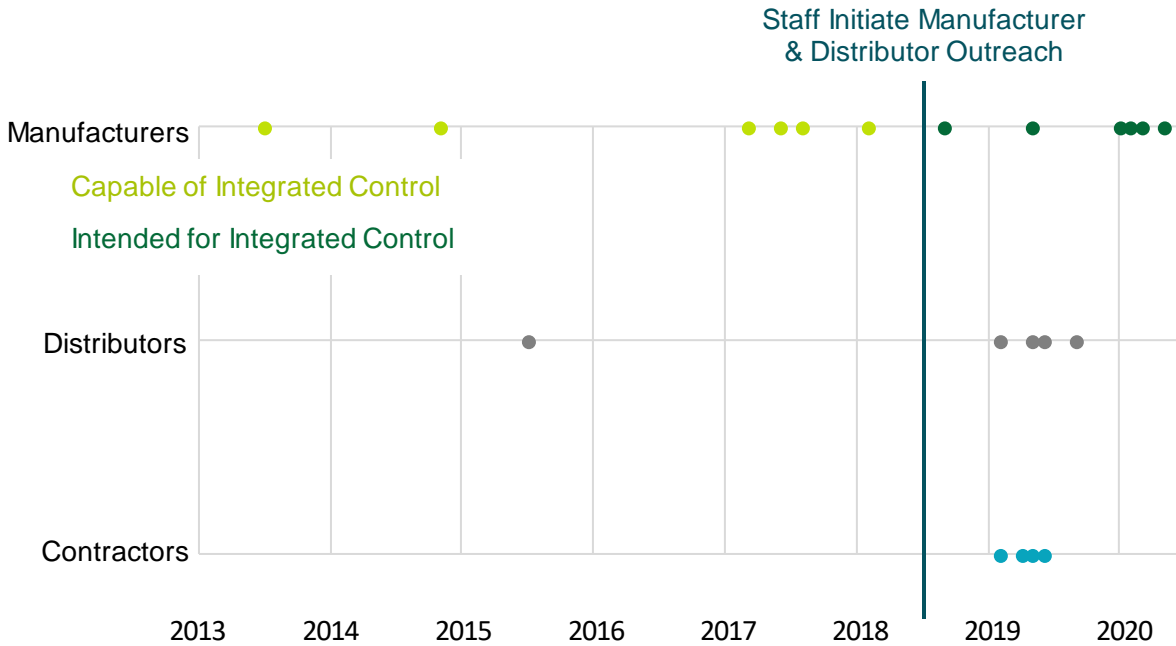
Learned About Integrated Controls From:	Manufacturers	Distributors	Contractors	Other
<i>n</i>	8	5	6	4
Mass Save or MA PA representative	2	2	3	--
MA PAs and other PAs (NY, Northwest)	2	--	--	--
NEEP	--	1	--	2
Self	1	--	--	2
Customer	1	--	1	--
Industry contacts	--	1	1	--
Don't remember	2	1	1	--

As [Figure 5](#) shows, before program staff began outreach about integrated controls, two of the manufacturers interviewed offered a device (such as a thermostat) that could integrate a DMSHP with another heating system, and four more offered products capable of being a component of an integrated control heating system (a total of six). The products included a wi-fi dual-fuel thermostat and DMSHPs capable of being relayed. None of these products were marketed as an integrated control.

[Figure 5](#) also shows when market actors first started to manufacture, distribute, or install equipment with the intended purpose of integrating control between mini-spit heat pumps and other heating systems. At the time of the interviews, six of the eight manufacturers (five heat pump and one thermostat manufacturer) had developed or were developing a product meant to be marketed for the purpose of integrating control between mini-spit heat pumps and other heating systems. Two of these products became available after program staff began outreach, and four were expected to become available in the first quarter of 2020.

All of the contractors and most of the distributors we interviewed began to offer integrated controls for DMSHPs after program staff had begun outreach. One distributor noted that they began offering a product capable of being used as an integrated control in 2015. This product had been discontinued by the time of the interview.

**Figure 5: First Began Offering DMSHPs with Integrated Controls or Standalone Integrated Controls Packages**

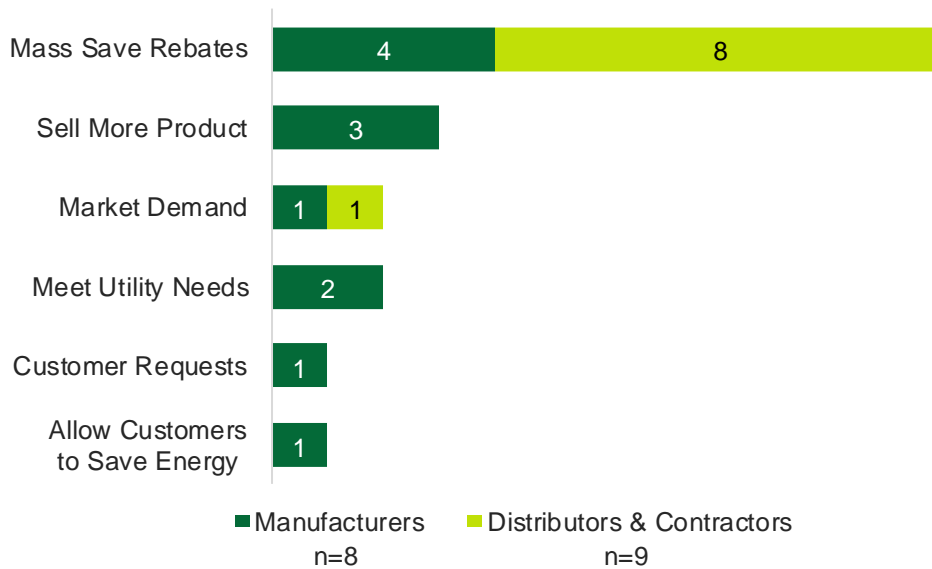


#### 4.5.2 Motivations for Engaging in the Market

The team assessed the influence of the Mass Save intervention on market actors’ decision to manufacture, distribute, or install heat pump controls by asking two questions. First, we asked an open-ended question about why they decided to offer these products; second, we directly asked if the Mass Save intervention influenced their decision. The open-ended and closed-ended questions were asked in this order to minimize bias. Even so, interviewees eager to take credit for the decision may have been susceptible to confirmation bias or “green” bias, thereby downplaying the significance of the Mass Save intervention.

To determine what motivated interviewees to engage in the market for integrated controls, the team asked them how their company came to the decision to manufacture, distribute, or offer installations of DMSHPs that incorporate integrated controls or integrated control retrofits. Multiple responses to this question were accepted. The results are displayed in Figure 6. One-half (four) of the manufacturers and almost all (eight) of the distributors and contractors cited the Mass Save rebates for integrated controls as a factor in deciding to offer these products. Some of the other motivators interviewees mentioned, including selling more product, meeting utility needs, and customer requests, may have been influenced by Massachusetts PA activities. For example, one manufacturer stated that his distributor and contractor customers were requesting integrated controls; it is possible that they were requesting them because of the Mass Save rebates.

**Figure 6: Motivation for Selling DMSHPs with Integrated Controls or Standalone Integrated Controls Packages (Multiple Responses)**



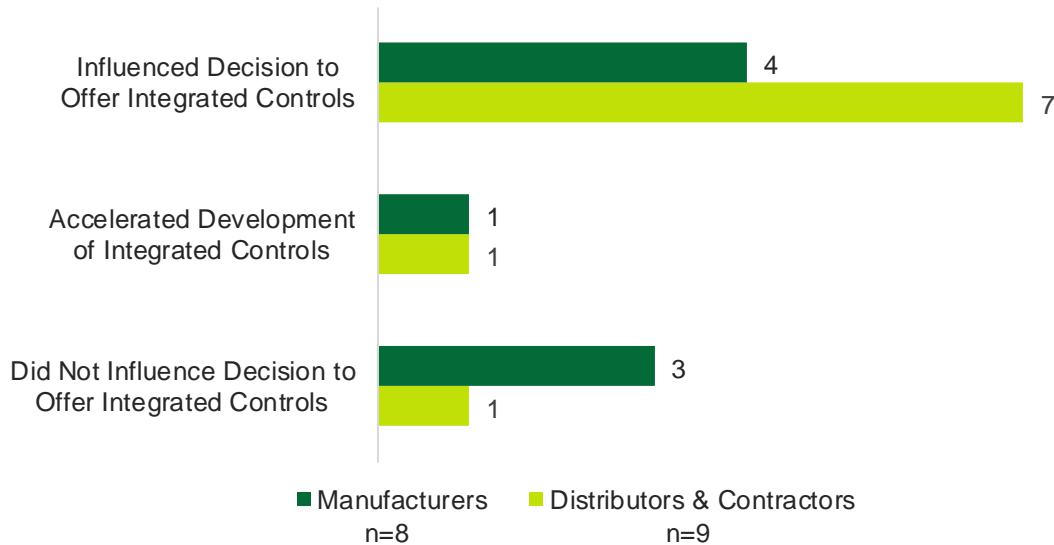
Towards the end of each interview, the team asked interviewees directly if the Mass Save intervention had influenced their decision to manufacture, distribute, or install heat pump controls. Half the manufacturers (four), including two heat pump manufacturers and both thermostat manufacturers, said the intervention definitely influenced their decision to develop their products (Figure 7). Three-quarters (seven of nine) of the distributors and contractors said the intervention definitely influenced their decision to offer these products, mainly because their customers wanted the rebates. As one distributor put it, “Without the rebates there would be no market.”

One heat pump manufacturer and one distributor said they had already decided to develop their product before Mass Save began offering rebates for these controls, but they accelerated development by six to twelve months specifically because of the intervention. The heat pump manufacturer pointed out that the company’s product development cycle is typically years long, but in this case, there were only a few months between when the intervention was conceived and when it was launched.

Three heat pump manufacturers and one distributor said the intervention did not influence their decision to develop or distribute their product because it was already on the market when the intervention started.



**Figure 7: Intervention Influence on Decision to Sell DMSHPs with Integrated Controls or Standalone Integrated Controls Packages**



**4.5.3 Market Influences & Expectations**

We asked the other PAs and NGO staffers if they were aware of any individuals or organizations that have been influential, or instrumental, in bringing heat pump integrated controls to market. One PA responded, “As far as integrated controls in general, NEEP has done the best and been most engaging.” Both this PA and the NEEP interviewee believed that NEEP had been influential in bringing heat pump integrated controls to the market. In addition, one interviewee said that Efficiency Maine had helped make the case for heat pump integrated controls. The remaining two interviewees were not aware of any other organizations that influenced the development of this market.

Figure 8 shows manufacturer and distributor responses to questions about the changes they expect to see in the market for DMSHP integrated controls over the next two to five years. As the figure shows, three-quarters (six of eight) of the manufacturers expect the market for DMSHP integrated controls to grow in this period. They expect to see improvements in existing integrated controls products, additional market entrants, and growth in sales of DMSHPs, as well as integrated controls. According to one distributor, “There will be more manufacturers making more products to choose from.” A thermostat manufacturer commented, “More manufacturers will get involved, more contractors will get involved, and more state agencies.” One DMSHP manufacturer stated, “There will be a more suitable solution,” while another commented, “The trend of applying integrated controls will cause manufacturers’ (it actually is already causing manufacturers’) R&D departments overseas to come up with solutions that don’t exist today for smart building control with integrated heating devices.” A distributor specified that the market for DMSHP had been “growing at a rate of 20% per annum” and he expects this trend to continue.

More than half (three of five) of the distributors expect to see market growth only in areas with rebates for these products. As one distributor explained, “It depends on the rebate. If the rebate goes away the integrated controls go away.” More than half (five of eight) manufacturers also

stressed the importance of the rebates on consumer demand. According to one manufacturer, “Sales have increased only in Massachusetts; it’s entirely program related.” Another manufacturer said that consumer marketing of integrated controls would “be falling on deaf ears if there weren’t deep financial incentives to do it.”

Two manufacturers and one distributor did not expect the market to grow. One of these manufacturers commented “It might change if more states require it, but we don’t have any reason to believe that that’s going to happen.” The other manufacturer said the heat pump industry had yet to determine the right strategy for homes and businesses in New England, with integrated controls being one potential strategy, and that integrated controls would be “as important as they are now” in two years’ time. The distributor said he did not expect manufacturers to invest in integrated controls in the near term because the market for cold-climate DMSHPs was too small.

We also asked NGO interviewees about the changes they expect to see in the market. Over the next two to five years, NGO interviewees anticipate increasing awareness of integrated controls for DMSHP among contractors and homeowners, and lessons learned from early customer experiences. One NGO staffer thinks it will be a “bumpy ride” at first while contractors progress up the learning curve, making mistakes with integrated controls installations along the way.

**Figure 8: Market Expectations for DMSHPs Integrated Controls in Two to Five Years**

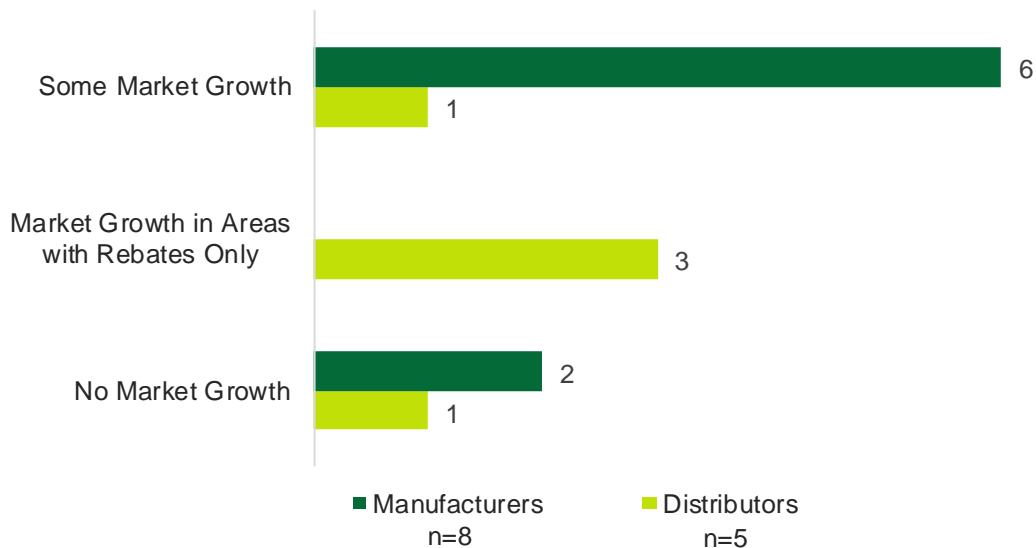
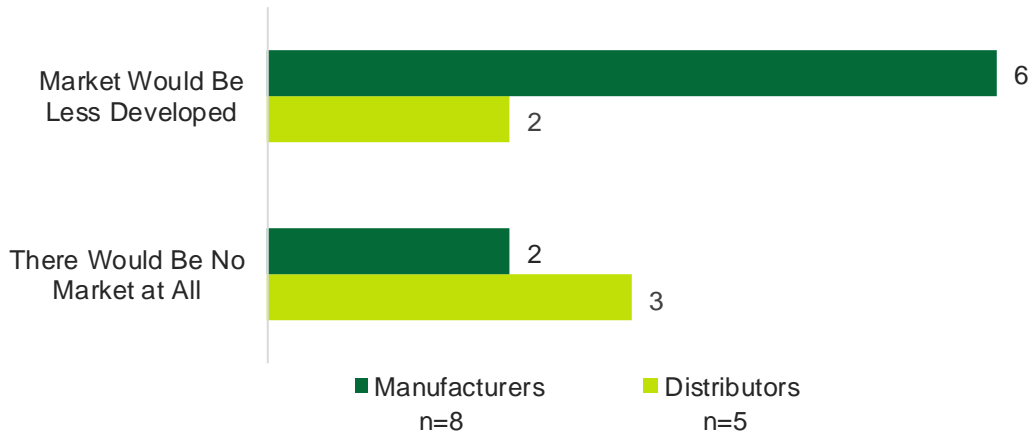


Figure 9 shows what the market actors believe the market for integrated controls would look like today had Mass Save not developed a specification and started offering the rebate. Three-quarters (six) of the manufacturers said the market would be less developed today and one-quarter (two) said there would be no market at all. Interviewees speculated that fewer manufacturers would have developed products specifically for this purpose and there would be less adoption of heat pump integrated controls. According to one manufacturer, “when utility programs put money behind a technology, it validates the technology and its benefits to manufacturers and consumers. That is how programs are effective in increasing adoption.” The rate of distributors’ responses was very similar to that of manufacturers, but more distributors said

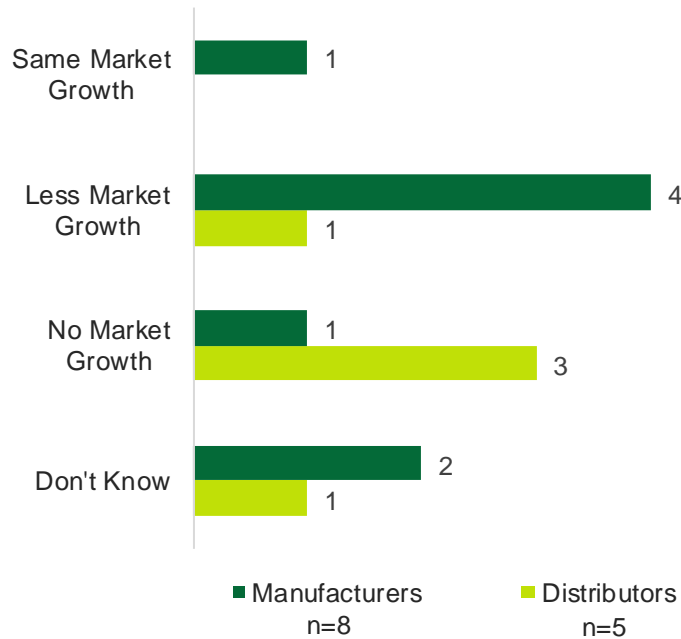
that the market would not exist today (three) than that it would be less developed (two) (Figure 9).

**Figure 9: Current Market for DMSHPs Integrated Controls in Absence of Mass Save Intervention**



The team also asked interviewees what the market for DMSHP integrated controls would look like in two to five years had Mass Save not developed a specification for heat pump integrated controls and started offering the rebate (Figure 10). One-half (four) of the manufacturers and one distributor still expected the market would grow without a rebate, but not as quickly. One manufacturer and three distributors did not expect the market would grow at all without the rebates. One manufacturer expected the market to grow at the same rate. He stated that electrification was advancing in other states and said, “there will be a lot more incentives available for this type of technology, regardless of Mass Save.”

**Figure 10: Market Expectations in Two to Five years for DMSHPs Integrated Controls in Absence of Mass Save Intervention**

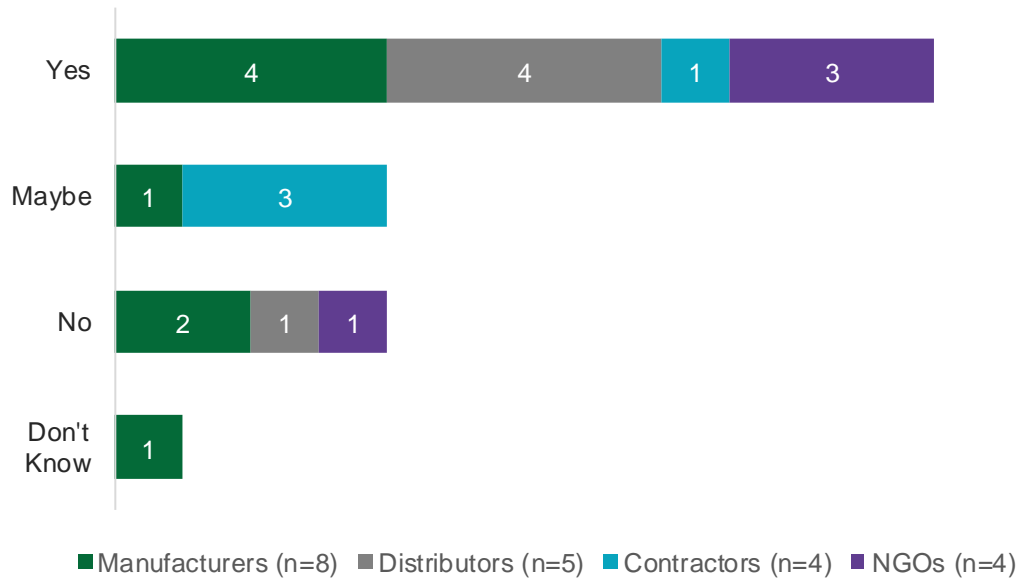


**4.5.4 Market Changes & Drivers**

The team asked interviewees if they believe the availability of integrated controls for DMSHPs would affect the adoption of DMSHPs in homes that heat with oil or propane. As Figure 11 shows, a majority (12 of 21, or 57%) of the manufacturers, distributors, and NGO interviewees answered “yes.” Four explained that the rebate would drive sales of integrated controls, which in turn would drive sales of DMSHPs. Another four said that integrated controls allow homeowners to keep their existing heating systems while adopting a new low-cost home heating solution. One interviewee explained that the residential DMSHP market is shifting away from single zones towards multiple zones, and integrated controls eliminate the need for homeowners to manually switch each one on and off. The interviewees who answered “maybe” generally thought the integrated controls might raise awareness of DMSHPs, thereby affecting their adoption, but two specified that this would only happen if the rebate stayed in place.

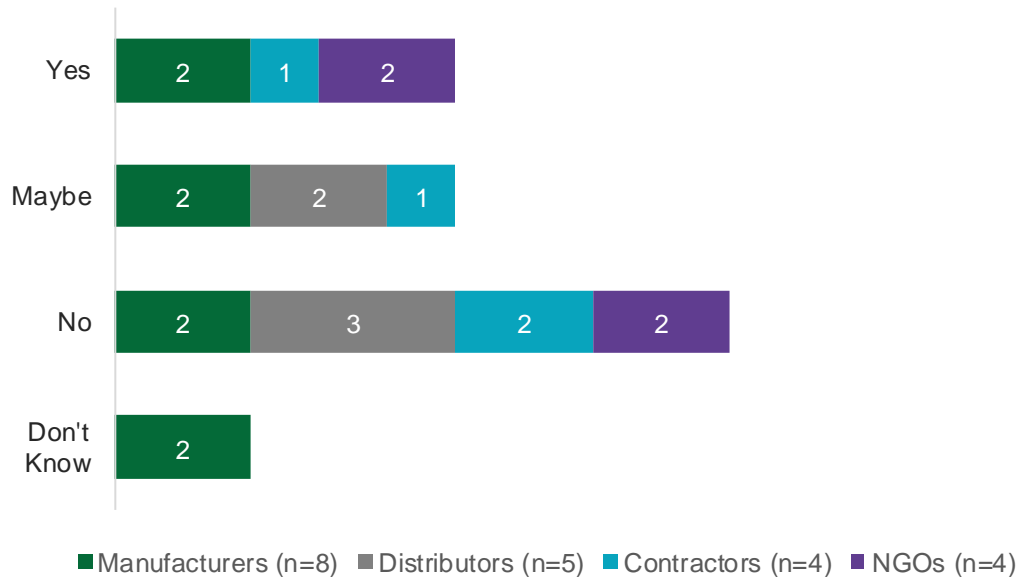
Interviewees who do not believe the availability of integrated controls for DMSHPs would affect the adoption of DMSHPs in homes that heat with oil or propane explained that few customers understand integrated controls and their benefits and that saving energy is not a top priority for homeowners or contractors.

**Figure 11: Availability of Integrated Controls Affecting Adoption of DMSHP in Homes that Heat with Oil or Propane**



Interviewees were less inclined to expect the availability of integrated controls to affect the adoption of DMSHPs in homes that heat with gas (24%) (Figure 12). Four explained this was because there was no rebate available for homes that heat with gas, and three said it was because of relatively low gas prices. Respondents who answered ‘maybe’ said it was conditional on factors such as rebates becoming available for homes that heat with gas, contractors explaining the benefits of these products to homeowners, and homeowners valuing factors such as reducing greenhouse gases over energy costs.

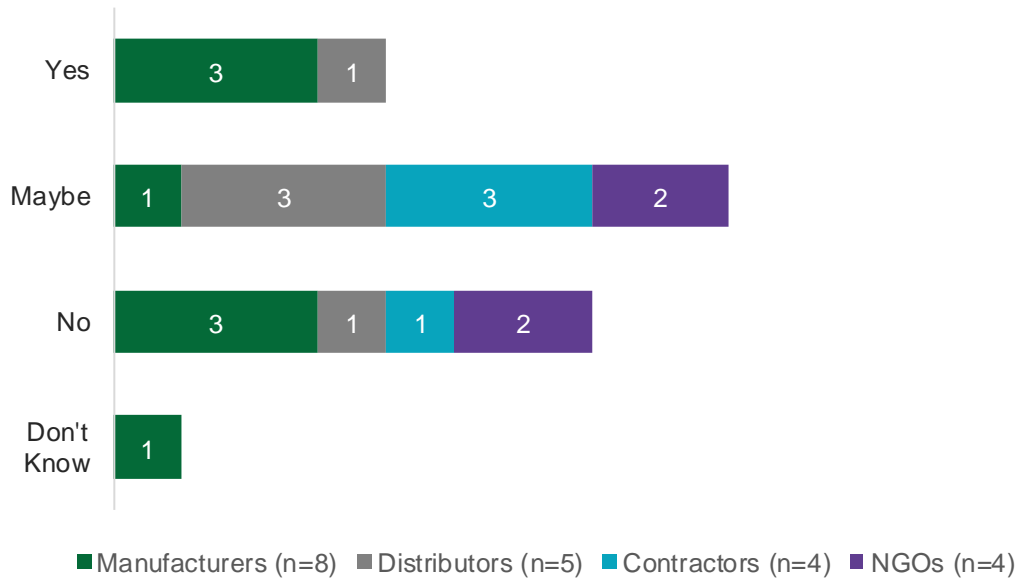
**Figure 12: Availability of Integrated Controls Affecting Adoption of DMSHP in Homes that Heat with Gas**



To better understand the prospects for integrated controls in the small business sector, the NMR team asked interviewees how they expected the availability of integrated controls for DMSHPs in the market would affect their adoption by small businesses. Fewer interviewees (4 of 21, or 19%) believe that, compared to homes, small businesses that heat with oil or propane would increase their adoption of DMSHPs because of the availability of integrated controls (Figure 13). Interviewees who did not believe that integrated controls would increase the adoption of DMSHPs among small businesses pointed out that there was no rebate for small businesses, that small businesses are too busy to worry about their heating systems, and that DMSHPs were not appropriate for certain types of small businesses. Other interviewees suggested that small businesses might adopt DMSHPs if rebates for integrated controls were available, the benefits were clearly conveyed to them, or both.

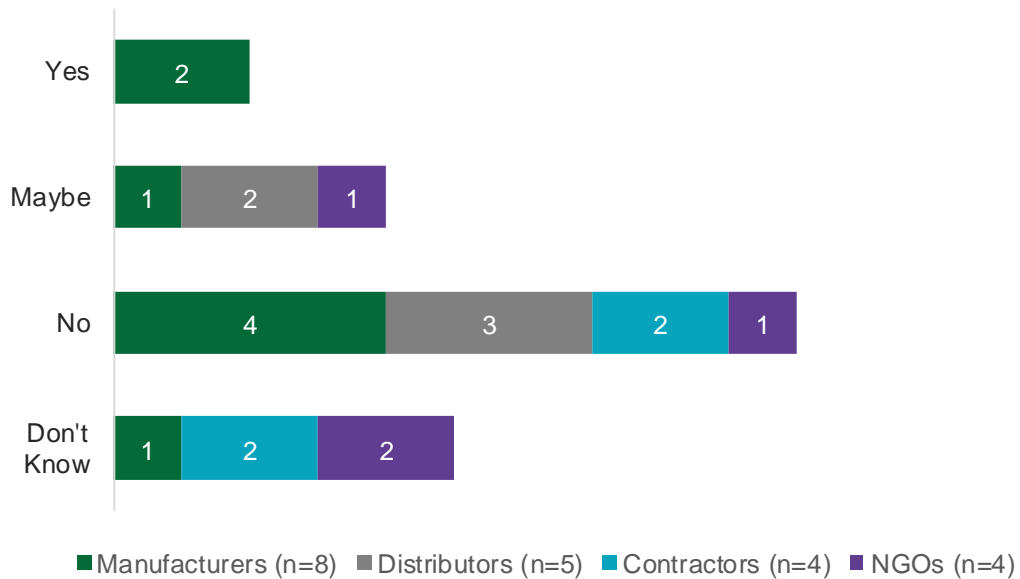


**Figure 13: Availability of Integrated Controls Affecting Adoption of DMSHP in Small Businesses that Heat with Oil or Propane**



As Figure 14 shows, few interviewees (2 of 21, or 9%) believe the availability of integrated controls will affect the adoption of DMSHPs in small businesses that heat with gas, mainly because rebates are unavailable and gas is relatively inexpensive.

**Figure 14: Availability of Integrated Controls Affecting Adoption of DMSHP in Small Businesses that Heat with Gas**



## 4.6 WEIGHT OF EVIDENCE CONCLUSION FROM HISTORICAL TRACING

Of the three causal hypotheses offered in [Section 3.4](#), the evidence presented above most closely supports Hypothesis 2.

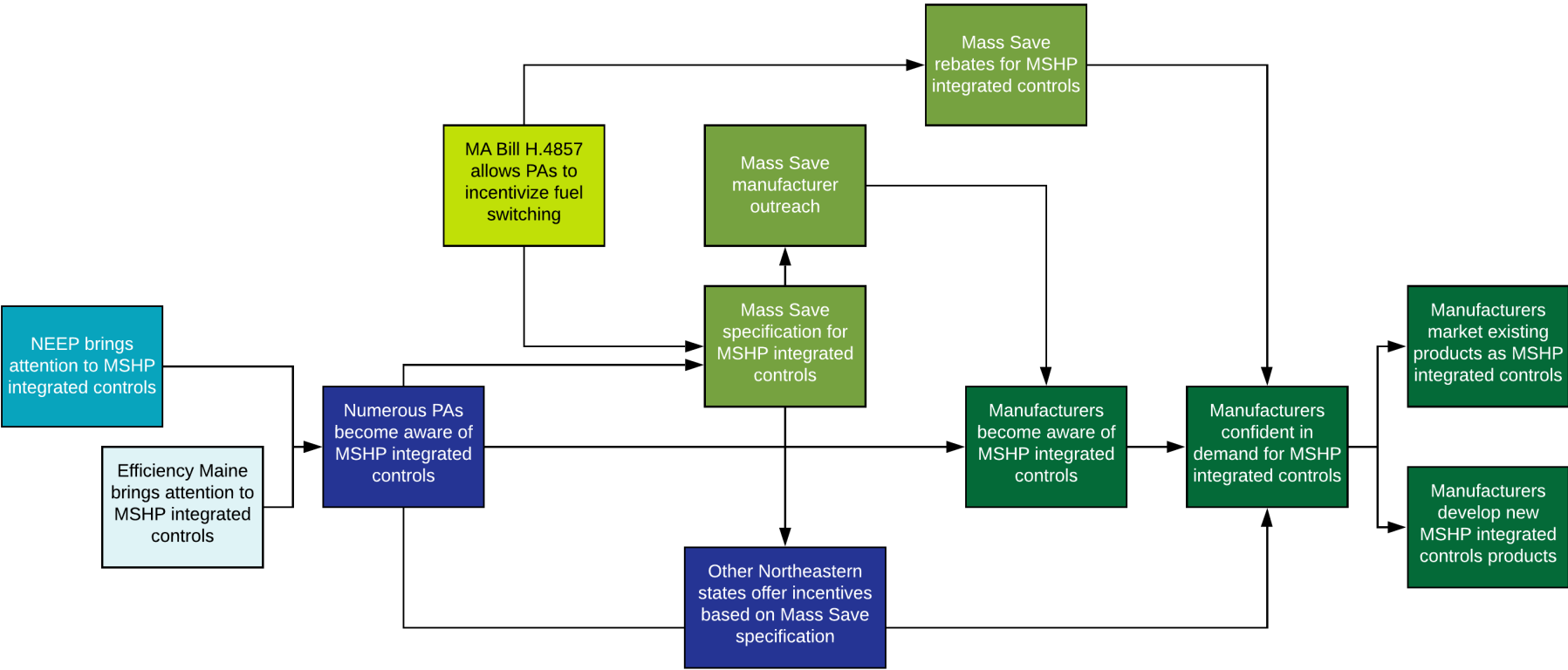
- The PAs are partly responsible for launching the Massachusetts market, but it is not yet established.
- The PAs are partly responsible for accelerating the development of the Massachusetts market for DMSHP integrated controls for use in homes heated primarily by delivered fuels.
- The PAs are also partly responsible for accelerating the development of the market for DMSHP integrated controls for use in homes heated primarily by delivered fuels in the Northeast region.

Here, we explain the reasoning behind this conclusion. In [Section 5.1](#), we offer evidence that the market has been launched, but is not yet established.

[Figure 15](#) shows a flowchart of influences on the market for DMSHP integrated controls in Massachusetts, summarized from the information gathered from interviewees. The figure illustrates the following:

- The interviewed PAs and NGOs most frequently mentioned NEEP as a source of awareness of the need for integrated controls. They also mentioned that Efficiency Maine was the first to include integrated controls in a published study.
- MA Bill H.4857 allowed the PAs to incentivize fuel switching, empowering the Massachusetts PAs to reach out to manufacturers about integrated controls.
- Manufacturers generally learned about integrated controls from PAs, including the Massachusetts PAs and other PAs. One-half of the manufacturers said the Mass Save intervention had influenced their decision to offer integrated controls for DMSHP.
- The Mass Save rebates provided manufacturers a reason to believe a demand would arise in Massachusetts for DMSHP integrated controls for use in homes heated primarily by delivered fuels. Preliminary Mass Save rebate data show that the share of all Massachusetts residential DMSHP systems that included integrated controls for use in homes heated primarily by delivered fuels, or “DMSHP integrated controls delivered fuels market share,” increased from 0% in Q1 to 34% in Q4 in 2019, the first year of offering rebates. In addition, within less than a year of first offering rebates through Mass Save, three other Northeast states (Rhode Island, New York, and Connecticut) announced or launched programs supporting DMSHPs with integrated controls in homes heated with delivered fuels. These were all based on the Mass Save specification and relied on the Mass Save Qualifying Product List. Thus, the Mass Save effort also affected the market in the Northeast region.
- Once they became aware of the concept and confident in the demand for integrated controls, manufacturers adapted and marketed existing products capable of integrating control between DMSHP and other heating systems, and some began developing new products for this purpose.

Figure 15: DMSHP Integrated Controls Market Development Influences



**Responsibility for awareness of integrated controls.** While neither NEEP nor Efficiency Maine offers program support for DMSHP integrated controls, they share some responsibility for influencing the development of this market in Massachusetts. In 2017, NEEP proposed a regional strategy of promoting advanced control technologies to allow automated coordination between cold-climate DMSHPs and existing heating systems. Since then NEEP has facilitated sessions on DMSHP integrated controls at various workshops and meetings that have been attended by heat pump and controls manufacturers and distributors and HVAC contractors. Two of the other PAs and one market actor noted that they first heard of integrated heat pump controls from NEEP. One NGO staffer said that Efficiency Maine's activities were important in raising awareness of integrated controls, and the Efficiency Maine study demonstrates their potential for increasing DMSHP use for heating.

The Massachusetts PAs were partly responsible for making manufacturers aware of the concept of DMSHP integrated controls. As discussed in [Section 4.5.1](#), one-third of the manufacturers who could recall how they learned about DMSHP integrated controls learned about them solely from the Massachusetts PAs, and an additional third learned about them partly from the Massachusetts PAs.

**Responsibility for acceleration of the integrated controls market.** The Massachusetts PAs also played a significant role in influencing development of the market for these products. All the manufacturers interviewed indicated that the current market for DMSHP integrated controls would be less developed than it was at the time of this study had Mass Save not established a specification for heat pump integrated controls and started offering the rebate. Additionally, most of the manufacturers said that had the PAs not intervened, the market would be less developed in two to five years than they currently expect it to be.

The Massachusetts PAs were also partly responsible for motivating manufacturers to offer integrated controls products. As discussed in [Section 4.5.2](#), half of the manufacturers and almost all of the distributors and contractors cited the Mass Save rebates for integrated controls as a factor in deciding to offer these products. One-half of the manufacturers agreed that the Mass Save intervention influenced them to manufacture their products, and one additional manufacturer said the intervention influenced them to accelerate the development of a product that would meet the specification.

## Section 5 Market Status & Qualitative Estimate of Market Effects

### 5.1 MARKET STATUS

To understand the state of the market for mini-split integrated controls, the NMR team calculated very rough estimates of the potential size of the Massachusetts market for DMSHPs with integrated controls in homes heated by delivered fuels, of 2019 market adoption of DMSHPs with integrated controls among these homes, and of 2019 market share of DMSHPs with integrated controls. The team also compiled relevant market information, such as price trends, end-user awareness, and market barriers.

#### Key Findings

- The team developed a rough estimate of the rate of adoption of DMSHPs with integrated controls by the target market (Massachusetts homes of one to nine units heated with delivered fuels that could potentially use DMSHPs for heating and benefit from an integrated control). In 2019, this rate was 0.4%.
- There are substantial opportunities for progress in this market. The team's rough estimate of the remaining number of Massachusetts homes in the target market was about 338,000 as of January 2020.
- A market for DMSHP integrated controls for use in homes heated primarily by delivered fuels did not exist in Massachusetts or elsewhere at the beginning of 2019, but preliminary evidence indicates that this market grew rapidly in Massachusetts over the course of 2019. The team calculated a preliminary estimate of the 2019 Massachusetts share of all residential DMSHP systems that included integrated controls for use in homes heated primarily by delivered fuels, or "DMSHP integrated controls delivered fuels market share." This estimate was based on the assumption that 100% of the DMSHP integrated controls sold in Massachusetts for use in homes heated primarily by delivered fuels in 2019 were rebated. This assumption is supported by comments from manufacturers, distributors, and contractors about the importance of the rebate to the Massachusetts market for DMSHP integrated controls for use in homes heated primarily by delivered fuels (discussed in [Section 4.5.2](#)). The data suggest that the market share of DMSHP systems with integrated controls destined for homes heated by delivered fuels in 2019 increased from 0% in Q1 to 34% in Q4, and averaged 13% for the year. This estimate should be recalculated with final rebate data when these data become available.
- Despite the rapid growth of DMSHP integrated controls for use in Massachusetts homes heated primarily by delivered fuels in 2019, this market is still at the beginning of the early adopters stage of the innovation adoption curve. Insights from the market actor interviews illustrate the infant state of the market for integrated controls. The equipment is new to contractors and takes a considerable amount of training to learn and time and effort to

install. Rebates, not end-user demand, are driving the market, and end-users are largely unaware of integrated controls. While prices would be expected to fall in a market that is moving up the innovation adoption curve from innovators and early adopters to the early majority, the prices of integrated controls appear to be largely unchanged since the equipment was first marketed for this purpose.

### 5.1.1 Potential Market Size and Preliminary Estimates of Market Adoption and Market Share

The NMR team used 2018 U.S. Census data<sup>23</sup> and the Massachusetts Residential Baseline Study<sup>24</sup> to develop a very rough estimate of the target market – Massachusetts customers in housing units<sup>25</sup> heated with delivered fuels that could potentially use DMSHPs for heating and benefit from an integrated control (i.e., existing single- and multifamily oil- and propane-heated homes of up to nine units per structure, without ducts).<sup>26</sup> As neither the proportion of homes with ducts nor the number of homes heated by delivered fuels is reported in the Massachusetts Residential Baseline Study, the team used as a proxy the proportion of homes heated with a boiler powered by a fuel other than natural gas, a total of 339,000. The PAs' 2019 KPI data<sup>27</sup> provide a preliminary estimate of the number of integrated controls rebates associated with new DMSHPs for 2019. This estimate is preliminary because it is based on data that have not yet been through the PAs' tracking data vetting process, which is performed annually by DNV GL. It should be recalculated after the 2019 tracking data vetting process is complete. Subtracting out this preliminary number from the number of housing units in the target market yields a potential remaining market size of 338,000 homes (rounded).

In addition to the calculation of potential market size described above, [Table 8](#) shows a preliminary estimate of the rate of adoption of DMSHPs with integrated controls in 2019 by the target market. For this, and for the market share estimate also shown in the table, we assumed that 100% of the DMSHP integrated controls sold in Massachusetts in 2019 for use in homes heated primarily by delivered fuels were rebated. We based this assumption on comments from manufacturers, distributors, and contractors about the importance of the rebate to the Massachusetts market for DMSHP integrated controls for use in homes heated primarily by delivered fuels.<sup>28</sup> The rate of adoption is calculated as the ratio of rebates for DMSHP systems with integrated controls for use in homes heated primarily by delivered fuels to the total number of homes in the target market in

<sup>23</sup> Specifically, [ACS 5-year data profiles](#).

<sup>24</sup> Navigant. 2019. Massachusetts Residential Baseline Study. April. Prepared for the Electric and Gas PAs of Massachusetts. Accessed from <http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-Residential-Baseline-Study-Comprehensive-Report-2019-04-30.pdf>.

<sup>25</sup> Includes one to nine unit homes.

<sup>26</sup> As it is not possible to identify high-rise buildings from the ACS data, the team used homes of ten or more units as a proxy for high-rise buildings, and excluded them from the estimate since they are very unlikely to be heated primarily with delivered fuels.

<sup>27</sup> [4th Quarter 2019 Program Administrators' KPI Data](#)

<sup>28</sup> There were some 2019 rebates for Integrated controls retrofitted to a previously installed DMSHP. For purposes of calculating market share, these rebates were excluded. They were also excluded from the calculation of potential market size in January 2020, as the number of these rebates was very small and their effect would be lost in rounding.



2019. The team's rough estimate of the rate of Massachusetts market adoption of integrated controls by the target market in 2019 is 0.4%.

Table 8 also shows a preliminary estimate of the 2019 share of all Massachusetts residential DMSHP systems that included integrated controls for use in homes heated primarily by delivered fuels, or "DMSHP integrated controls delivered fuels market share." Figure 16 shows this estimate by quarter. This estimate was calculated as follows:

- The numerator is preliminary 2019 counts of rebates for DMSHP integrated controls for use in homes heated primarily by delivered fuels.
- The denominator is 2019 Massachusetts sales of residential DMSHPs purchased from D+R International (i.e., Heating, Air-conditioning, & Refrigeration Distributors International [HARDI] data). The HARDI data are derived from sales invoices from HVAC distributors that are members of HARDI.<sup>29</sup> As it is not possible to reliably identify cold-climate DMSHPs from the HARDI data or the type or heating fuel of the homes in which the DMSHPs were installed, we included sales of all Massachusetts DMSHP systems reported in the HARDI data.

As the table and figure show, these data suggest that the share of DMSHP systems with integrated controls destined for homes heated by delivered fuels in 2019 increased from 0% in Q1 to 34% in Q4. It averaged 13% for the year. This estimate should be recalculated with final rebate data when these data become available.

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<sup>29</sup> For more information about the HARDI data, see [TxC65 Analysis of Residential HVAC Sales Data from HARDI Distributors Memo](#).

**Table 8: Potential Market Size and Preliminary Estimates of Adoption by the Target Market and Market Share**

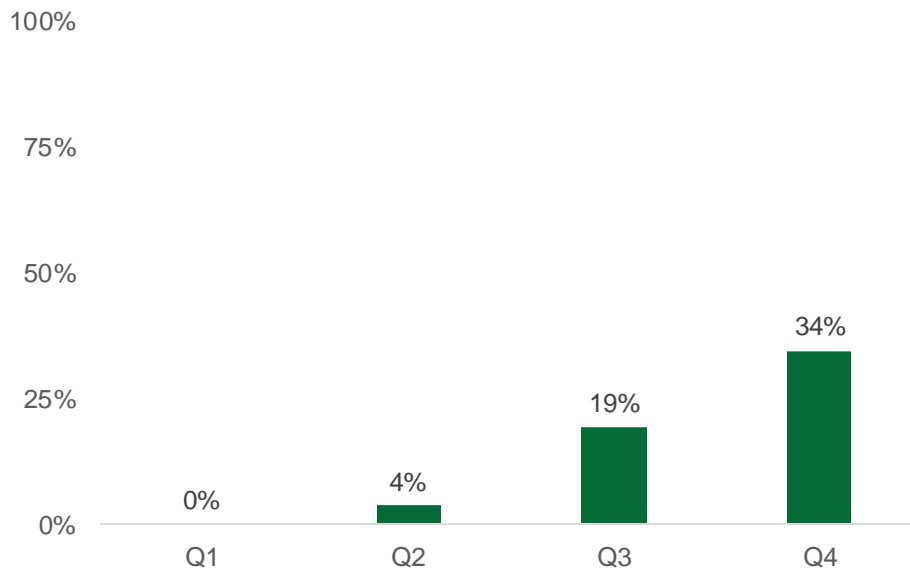
MA SF & MF Housing Units (up to nine/structure)	Percent of All Housing Units	Number of Units <sup>1</sup>
A. All housing units	100%	2,420,000
B. All housing units heated with fuel oil or “other fuel” boiler	14%	339,000
<b>Preliminary 2019 Adoption &amp; Market Share</b>		
C. Preliminary count of 2019 rebates for DMSHP integrated controls for use in homes heated primarily by delivered fuels		1,207 <sup>2</sup>
D. Potential target market size as of January 2020 (B-C, rounded)		338,000 <sup>3</sup>
E. Preliminary 2019 rate of target market’s adoption of DMSHPs with integrated controls (C/B)		0.4%
Preliminary 2019 DMSHP integrated controls delivered fuels market share (C/2019 MA DMSHP sales from HARDI data)		13.4%
Preliminary Q4 2019 DMSHP integrated controls delivered fuels market share (C for Q4/Q4 2019 MA DMSHP sales from HARDI data)		34%

<sup>1</sup> Rounded to nearest thousand. Includes one to nine unit homes. Source: U.S. Census, ACS five-year data profiles for 2018.

<sup>2</sup> Excludes rebates for integrated controls installed as retrofits to DMSHPs already in use.

<sup>3</sup> Rounded to nearest thousand.

**Figure 16: Preliminary Quarterly 2019 MA DMSHP Integrated Controls Delivered Fuels Market Share**



### 5.1.2 Price Trends, End-user Awareness, and Market Barriers

- It takes training, time, and effort for contractors to install the integrated controls.** Each manufacturer's equipment is installed a different way, and seven of the eight manufacturers said that training was needed to install their integrated controls. (The eighth manufacturer did not respond directly to this question.) The manufacturers offer training in various ways, including workshops and classes delivered by their representatives or distributors, instructional videos, and technical bulletins. One manufacturer noted that their training is two hours long. Two manufacturers noted that installation involves cutting into walls and snaking wires, and is time consuming. One distributor noted that in addition to providing hands-on installation training in their lab, they offer technical support to installers in the field. Four of the six contractors had, or were currently, putting staff through installation training. Of the four who had installed integrated controls, one found it "a little complicated" and the other "a little all over the place – mostly fine, but we need to work out the bugs because it's new to us."
- End-users are largely unaware of integrated controls. They need education to understand the benefits they provide and learn how to use the controls properly.** Five of seven manufacturers who spoke about consumer awareness of integrated controls mentioned that consumers are largely unaware of integrated controls, of their benefits, and of how to use them. Four mentioned that consumers need to be taught how to use the controls properly. The two contractors who spoke about consumer awareness and understanding of the controls also noted that both were low, as did one distributor. Two other manufacturers and one distributor felt that consumers were beginning to be aware of the controls.
- Prices of integrated controls are steady.** All five distributors and five of eight manufacturers said that they had seen no change in the prices of integrated controls, or mini-splits that include integrated controls, in the time since they first began to offer them. The one manufacturer who noted a price change said that the price had dropped – but this drop was during the period before the equipment was advertised as an integrated control.
- As described in [Section 4.1](#), **the integrated controls products currently available were adapted hastily from existing equipment, not designed from the ground up for the purpose of serving as an integrated control. This likely contributes to the difficulty of their installation and the perceived need to educate consumers in how to use them.**

## 5.2 APPROACH TO QUANTIFYING MARKET EFFECTS

[Methods for Measuring Market Effects of Massachusetts Energy Efficiency Programs](#) (2014) offers guidance for quantifying market effects from Massachusetts programs. This document recommends taking a market-focused approach to measuring net-to-gross (NTG) in order to capture market effects. The generic market-focused NTG equation is:

$$NTG = (total\ savings - naturally\ occurring\ savings) / within-program\ savings$$

Accordingly, the NMR team proposes that PAs capture market effects through a market-focused approach to measuring NTG, using the Structured Expert Judgement Method, one of the four approaches outlined in the methods document. Below, we provide a high-level summary of this approach.

As with all of the four methods for quantifying market effects and the energy savings associated with them described in the [Action Plan for Measuring Market Effects](#), this approach requires estimates of the market-level gross savings from the energy-efficiency measure, the within-program level of adoption of the measure, and the naturally occurring (counterfactual) level of adoption. Current policy in Massachusetts calls for a prospective NTG estimate to be applied to future program years, which also requires developing estimates of *future* within-program and naturally occurring sales (but not gross savings, which can be updated annually). In turn, this requires an estimate of the total size of the target market.

### 5.2.1 Gross Savings

To date, the PAs have not conducted an impact evaluation to estimate the incremental gross savings from integrated controls used with DMSHPs in homes with delivered fuel-fired heating equipment (i.e., the difference between gross savings from using integrated controls with DMSHP systems in homes with fuel-fired heating equipment and gross savings from DMSHP systems *without* integrated controls in homes with fuel-fired heating equipment). The rapid growth of rebates for DMSHPs with integrated controls in Massachusetts in 2019 suggests that the PAs should consider estimating the incremental gross savings soon. The NTG ratio that would be developed with the approach described here would be applied to this gross savings estimate.

### 5.2.2 Market Size

As the program currently only provides residential support, the NMR team proposes to define the market for integrated controls as existing single- and multifamily oil- and propane-heated homes of up to nine units per structure, without ducts, in Massachusetts. The team would estimate the market size using data from the PAs' ongoing residential baseline study. This conservative definition excludes partial-load applications, since it is not clear how a partial-load application could be integrated with a whole-house furnace if the furnace's heating system is not zoned.

### 5.2.3 Within-Program Level of Adoption

For the 2025-2027 cycle (or possibly earlier if Massachusetts NTG policy changes), the evaluator would convene a Delphi panel consisting of upstream suppliers (manufacturers and distributors), PAs who have supported integrated controls or conducted studies, and industry experts. The evaluator would ask panelists to estimate what sales of integrated controls would be in specific future years assuming continued program support for integrated controls. To help with their estimates, the evaluator would provide panelists with key data from this Phase 1 study, program-supported sales of integrated controls, a description of past and current program support for integrated controls and for DMSHPs in Massachusetts and other states, an estimate of the size of the market, a summary of the PAs' program theory, and a summary of measured values for the indicators of market effects outlined in the program theory.

### 5.2.4 Naturally Occurring Level of Adoption

The evaluator would ask the Delphi panel to estimate the sales of integrated controls in future years assuming the PAs had never intervened in the market for integrated controls, but continued to support DMSHPs.

### 5.2.5 NTG Estimate

The evaluator would develop a prospective NTG estimate for DMSHP integrated controls for use in homes heated primarily by delivered fuels, which would involve the following:

- A. Gross program sales (number of PA rebates provided for integrated controls)
- B. Market-level sales of integrated controls assuming continued support (from the Delphi panel)
- C. Market-level sales of integrated controls assuming the PAs had never intervened in the market (from the Delphi panel)
- D.  $NTGR = (B - C) / A$

## 5.3 INTERIM NTG ESTIMATE

PAs will need to develop NTG ratios in 2021 for the 2022-2024 cycle. As we note in [Section 5.1.1](#), the market for DMSHP integrated controls for use in Massachusetts homes heated primarily by delivered fuels is still at the beginning of the early adopters stage of the innovation adoption curve. Market effects take time to accrue, and there is risk in measuring them before there is enough progress in the market for the effects to be measurable. While the PAs could use the approach we describe above to measure NTG with market effects in time for the next planning cycle, it would be costly for the relatively small magnitude of market effects likely to have accrued so early on. Given this, PAs may wish to consider taking a simpler approach to measuring NTG in the 2022-2024 cycle, and towards the end of the cycle, assess the appropriateness of measuring NTG at the market level for the 2025-2027 cycle. This assessment could be informed by the market progress indicators, the planned impact study, other research likely to take place in the interim, secondary market data, and implementers' observations about market progress since this study. Below, we offer two interim NTG estimate options for the PAs to consider.

Given manufacturers' and other market actors' observations about the market, for the next one to two years, and possibly somewhat longer, it seems reasonable to assume that program-supported sales of integrated controls will constitute the vast majority of market-level sales, and that market-level sales would be close to zero without the program. Taking this approach, the NTG ratio would be 1.0, as shown below. The PAs could consider using this NTG ratio for the 2022-2024 period.

$$NTG = (total\ savings - naturally\ occurring\ savings) / within-program\ savings$$

Where:

$$Total\ savings = Program-reported\ sales * per-unit\ gross\ savings$$

$$Naturally\ occurring\ savings = 0$$

$$Within-program\ savings = Within-program\ adoption * gross\ savings = Program-reported\ sales * per-unit\ gross\ savings$$

A second approach that program administrators have sometimes been known to take in situations like this is to use a negotiated NTG ratio. Informed by this and other studies or secondary market data that may become available in the interim, and by implementers' observations about market progress, the PAs and EEAC could work towards agreement on a NTG ratio that would reflect the likely magnitude of market effects over the 2022-2024 period.

Regardless of the approach the PAs take to estimating an interim NTG ratio, should the three-year NTG lock be relaxed, the PAs might want to consider estimating market-level NTG before the 2022-2024 period is over, depending on what the market effects tracking indicators suggest in the meantime.



## Section 6 Key Findings and Considerations

### 6.1 FINDINGS BY RESEARCH QUESTION

#### 6.1.1 Validity of Program Theory

*Research Question: Is the underlying theory about the status of the market for residential and small commercial DMSHPs correct?*

The information gathered for the historical tracing validates the underlying program theory. The lack of an easy way for customers to optimize using DMSHPs efficiently in combination with fossil fuel heating equipment is a major barrier to more widespread adoption and use of cold-climate DMSHPs for heating. Other PAs and NGOs have recognized this barrier and have undertaken studies of the effectiveness of DMSHP integrated controls and facilitated meetings and workshops about the opportunity. Most of the studies are still in early stages, but one small sample study by Efficiency Maine<sup>30</sup> is complete. Findings from this study suggest that DMSHP integrated controls are effective at increasing heating with the heat pumps in homes that had shown lower heat pump heating usage.

Evidence gathered for the historical tracing also validates the program logic. All of the activities, barriers, target audiences, and changes in behavior displayed in the logic model (Figure 17) were substantiated by the market actor interviews. For example, the manufacturer interviews confirmed that products meant to work as integrated controls were not available prior to the intervention, and that PA outreach and development of the specification influenced manufacturers to make them available. However, as reported in Section 4.5.2, four of the manufacturers said they decided to offer integrated controls products because of the rebates. The rebates created a pool of likely customers, thereby reducing manufacturer uncertainty. Therefore, the NMR team believes an arrow should be added to the logic model from the program activity of “Offer incentives for integrated controls for heat pumps” to the barrier of “Integrated controls are not offered in the Massachusetts market, but they are needed to displace oil/propane with heat pumps.”

As discussed in Section 5.1.2, most of the manufacturers and a number of other market actors mentioned that consumers are largely unaware of integrated controls, their benefits, and how to use them, validating this barrier in the program logic. At the time the NMR team interviewed the PAs, consumer marketing and education had not yet been initiated. However, the team believes these activities are appropriate and will lead to increased customer awareness.

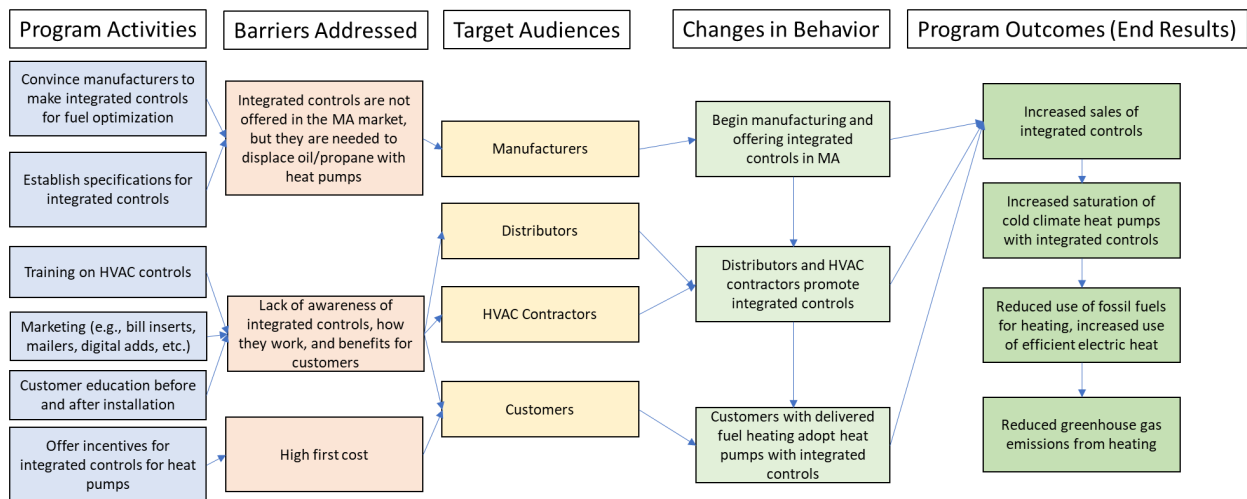
Also discussed in Section 5.1.2, the interviewees confirmed that contractor training is required to install the integrated controls. Therefore, contractor training on HVAC controls is a necessary program activity and it will raise contractor awareness as indicated in the logic model. However, findings from the interviews suggest an additional barrier exists beyond contractor awareness: contractor confidence in the technology. Contractors do not want their customers to call back

<sup>30</sup> <https://www.energymaine.com/docs/HESP-Evaluation-8-23-19.pdf>

because they are experiencing problems with their equipment. One contractor we interviewed who had installed a number of these systems expressed concerns that the systems might not perform well nor achieve substantial energy savings this winter. Another contractor who had installed just one system said he had received multiple callbacks about the equipment malfunctioning. A third contractor who had not yet decided to offer integrated controls explained, “We don’t like making our customers guinea pigs. I mean, I never recommend a guy get a car the first year it was made.” The NMR team believes “Lack of contractor confidence in integrated controls” should be added as a barrier to the logic model, with an arrow leading to it from “Training on HVAC controls” and from it to “HVAC contractors”.

The NMR team found a program outcome missing from the logic model. Increased saturation of DMSHPs with integrated controls will result in decreased fossil fuel use only if customers use them to heat their homes. Mass Save requires contractors to install and program the integrated controls, but it does not have a way of enforcing their use by homeowners. Several of the contractors we interviewed suspected that some of their customers were switching the integrated controls off after installation. These customers wanted the \$1,600/ton rebate but did not want to heat their homes with the DMSHP. The appropriate location for “Increased use of cold-climate heat pumps for heating” is between “Increased saturation of cold-climate heat pumps with integrated controls” and “Reduced use of fossil fuels for heating, increased use of efficient electric heat.”

**Figure 17: Program Logic Model**



The stated goal of the intervention is “to transform the market so that installing integrated controls becomes standard practice for DMSHPs installed in homes and small businesses with oil and propane heating systems, and that these customers heat their whole homes/small businesses with the DMSHPs.” As discussed in Section 4.5.4, relatively few interviewed market actors believe that the availability of integrated controls will affect the adoption of DMSHPs in small businesses that heat with oil or propane. Since the intervention does not currently offer rebates for integrated controls to small businesses, they still face the barrier of high first costs. Therefore, the PAs might consider revising the stated goal to target homes only or adding a program activity to address high first cost for small businesses. If the PAs decide they want to keep small businesses in the

state goal, they should consider whether there are any barriers unique to small businesses that should be added to the logic model.

### Considerations

- **In the logic model, consider connecting “Offer incentives for integrated controls for heat pumps” to “Integrated controls are not offered in the Massachusetts market, but they are needed to displace oil/propane with heat pumps” in the logic model.** The incentives played a critical role in reducing manufacturer uncertainty about demand for DMSHP integrated controls.
- **Consider adding “Lack of contractor confidence in integrated controls” to the barriers in the logic model.** Interviews revealed that contractor apprehension about this new technology is a barrier to wider adoption of DMSHP integrated controls.
- **Consider adding “Increased use of heat pumps for heating” to the outcomes in the logic model. Also consider assessing the in-service rate for rebated integrated controls.** Some interviewees expressed skepticism that end-users were using the integrated controls for heating as intended.
- **Consider making the following changes to the market effects indicators listed in Section 3.3:**
  - 1. Percentage of homes and small businesses with cold-climate DMSHPs: It is not possible to identify cold-climate heat pumps with HARDI sales data. It is likely that cold climate will only be identifiable through baseline study site visits and program tracking data. It is also the only indicator that specifies cold-climate DMSHPs. Consider the possibility of tracking the percentage of homes and businesses with DMSHPs, not cold-climate DMSHPs specifically.
  - Consider rewording “4. Percentage of DMSHPs installed that have integrated controls (with and without program incentives)” to “4. Percentage of DMSHPs sold or installed that have integrated controls (with and without program incentives) (i.e., market share).”
  - It may be difficult to track sales of integrated controls on their own. Consider rewording “5. Change in sales of integrated controls (inside and outside the Mass Save program)” to “5. Change in sales of DMSHPs with integrated controls (inside and outside the Mass Save program).”
- **Consider adding “Rate of adoption by the target market of DMSHPs with integrated controls” as a market progress indicator.**
- **Consider narrowing the market transformation goal to residences only, or alternatively, expanding the rebates to small businesses.** Widespread adoption of integrated controls by small businesses is unlikely without addressing the barrier of high first costs.
- **Consider conducting a study to estimate baselines for some or all of the market effects indicators described in Section 3.3 with the revisions suggested here. Also, consider assessing consumers’ awareness, understanding, and use of integrated**

**controls.** These could be done together, as separate studies, or added to data collection efforts undertaken for other residential studies.

### 6.1.2 Market Status

*Research Question: What is the state of the Massachusetts market for integrated controls?*

As the evidence presented in [Section 5.1](#) shows, while a market for DMSHP integrated controls for use in homes heated primarily by delivered fuels did not exist in Massachusetts or elsewhere at the beginning of 2019, it was launched and grew rapidly in Massachusetts over the course of 2019. Despite this rapid growth, the integrated controls market in Massachusetts is at the beginning of the early adopters stage of the innovation adoption curve. The team's rough estimate of the rate of adoption of DMSHPs with integrated controls by the target market (Massachusetts homes of one to nine units heated with delivered fuels that could potentially use DMSHPs for heating and benefit from an integrated control) in 2019 was 0.4%. Insights from the market actor interviews indicated that the equipment is new to contractors and takes a considerable amount of training to learn and time and effort to install. Rebates, not end-user demand, drive the market, and end-users are largely unaware of integrated controls. While prices would be expected to fall in a market that is moving up the innovation adoption curve from innovators and early adopters to the early majority, the prices of integrated controls appear to be largely unchanged since the equipment was first marketed for this purpose.

There are substantial opportunities for progress in this market. The team's rough estimate of the remaining number of Massachusetts homes in the target market was about 338,000 as of January 2020.

The team calculated a preliminary estimate of the 2019 Massachusetts share of all residential DMSHP systems that included integrated controls for use in homes heated primarily by delivered fuels, or "DMSHP integrated controls delivered fuels market share." This estimate was based on the assumption that 100% of the DMSHP integrated controls sold in Massachusetts for use in homes heated primarily by delivered fuels in 2019 were rebated. This assumption is supported by comments from manufacturers, distributors, and contractors about the importance of the rebate to the Massachusetts market for DMSHP integrated controls for use in homes heated primarily by delivered fuels. The data suggest that the 2019 market share of DMSHP systems with integrated controls destined for homes heated by delivered fuels increased from 0% in Q1 to 34% in Q4, and averaged 13% for the year. This estimate should be recalculated with final rebate data when these data become available.

### 6.1.3 Attribution

*Research Question: To what degree are the PAs responsible for establishing or accelerating the appearance of integrated controls on the market in Massachusetts?*

Of the three causal hypotheses offered in [Section 3.4](#), the evidence presented here most closely supports Hypothesis 2.

- The PAs are partly responsible for launching the Massachusetts market, but it is not yet established.

- The PAs are partly responsible for accelerating the development of the Massachusetts market for DMSHP integrated controls for use in homes heated primarily by delivered fuels.
- The PAs are also partly responsible for accelerating the development of the market for DMSHP integrated controls for use in homes heated primarily by delivered fuels in the Northeast region.

#### 6.1.4 Future Market Effects Tracking & Quantification

Research Question: *What market effects indicators would be appropriate for measuring the market effects expected from the PAs' efforts to establish this market, as well as the effects of support from Mass Save on the market? For which indicators is it realistic to expect to gather data?*

The market progress indicators proposed by the PAs are currently appropriate and measurable.

#### Considerations

- **If PAs act on the consideration in Section 6.1.1 above to add “Lack of contractor confidence in integrated controls” to the barriers in the logic model, they should add a corresponding market progress indicator.**

Two indicators suggest that the intervention is targeting small business and residential customers (“Percentage of homes and small businesses with cold-climate DMSHPs” and “Percentage of homes and small businesses with DMSHPs that use their DMSHPs for most or all of their heating”). However, the rebate is currently not available to small businesses. In addition, as discussed in Section 4.5.4, fewer market actors believe that, compared to homes, small businesses that heat with oil or propane would increase their adoption of DMSHPs because of the availability of integrated controls. Thus, even if an integrated control rebate is extended to small businesses, PAs should expect the rate at of growth of the percentage of small businesses that use their DMSHPs for most or all of their heating to be slower than for residences.

It is the NMR team’s opinion that it is realistic to gather data for all the indicators originally identified by the PAs, as well as the indicator the team suggests the PAs consider adding. Table 9 shows the data sources the team proposes for each indicator and the outcome for which each indicator is meant to track progress.

#### Considerations

- **Consider developing a plan to operationalize and collect market progress indicator data.**

**Table 9: Market Progress Indicators & Data Sources**

Indicator	Data Source	Associated Outcome*	Notes
<b>Previously Identified by PAs</b>			
1. Percentage of homes and small businesses with cold-climate DMSHPs	Saturation data coupled with HARDI HVAC data	Customers with delivered fuel heating adopt heat pumps with integrated controls	Consider dropping small businesses unless program offers them a rebate
2. Percentage of program participants using DMSHPs for heating	Customer survey	Customers with delivered fuel heating adopt heat pumps with integrated controls	
3. Percentage of homes and small businesses with DMSHPs that use their DMSHPs for most or all of their heating homes Short Term, small businesses Long Term	Add-on question for saturation study participants	Customers with delivered fuel heating adopt heat pumps with integrated controls	Consider dropping small businesses unless program offers them a rebate
4. Percentage of DMSHPs installed that have integrated controls (with and without program incentives)	Contractor survey Saturation studies	Increased saturation of cold-climate heat pumps with integrated controls	
5. Change in sales of integrated controls (inside and outside the Mass Save program)	Contractor survey & rebate data coupled with HARDI HVAC data	Increased sales of integrated controls	
6. Percentage of distributors and HVAC contractors that promote integrated controls	Contractor survey Distributor interviews	Distributors and HVAC contractors promote integrated controls	
7. Price of integrated controls	Distributor interviews	None	
8. Number of manufacturers offering integrated controls	Distributor interviews Manufacturer websites	Begin manufacturing and offering integrated controls	
<b>Proposed Addition</b>			
9. Contractor confidence in the effectiveness and reliability of integrated controls	Contractor survey	Lack of contractor confidence in integrated controls (recommended)	

\* Outcomes include changes in behavior.



Research Question: *How can future evaluations quantify market effects from these efforts? What are the steps and timelines?*

The combination of this study's validation of the underlying program theory, the PAs' partial responsibility for launching and accelerating the development of the market for integrated controls among the target audience, the early state of controls adoption, and the potential size of the target market suggest that there could be additional savings from market effects due to the PAs' early activities in the market and ongoing program support for the product. [Section 5.2](#) lays out how an evaluator could quantify these market effects through a market-focused approach to measuring NTG, using the Structured Expert Judgement method. [Section 5.2](#) also presents the general steps involved. As with all of the four methods for quantifying market effects and the energy savings associated with them described in the [Action Plan for Measuring Market Effects](#), this approach requires estimates of the following:

- *The market-level gross savings from the energy-efficiency measure.* For this measure, this is the incremental gross savings from integrated controls used with DMSHPs in homes with delivered fuel-fired heating equipment (i.e., the difference between gross savings from using integrated controls with DMSHP systems in homes with fuel-fired heating equipment and gross savings from DMSHP systems *without* integrated controls in homes with fuel-fired heating equipment).
- *The within-program level of adoption of the measure.* This would be obtained via a Delphi panel consisting of upstream suppliers (manufacturers and distributors), PAs who have supported integrated controls or conducted studies, and industry experts.
- *The naturally occurring (counterfactual) level of adoption.* This would also be obtained via the Delphi panel. Current policy in Massachusetts calls for a prospective NTG estimate to be applied to future program years, which also requires developing estimates of *future* with-program and naturally occurring sales (but not gross savings, which can be updated annually). In turn, this requires an estimate of the total size of the target market.

The evaluator would develop a prospective NTG estimate for DMSHP integrated controls for use in homes heated primarily by delivered fuels, which would involve the following:

- A. Gross program sales (number of PA rebates provided for integrated controls)
- B. Market-level sales of integrated controls assuming continued support (from the Delphi panel)
- C. Market-level sales of integrated controls assuming the PAs had never intervened in the market (from the Delphi panel)
- D.  $NTGR = (B - C) / A$

PAs will need to develop NTG ratios in 2021 for the 2022-2024 cycle. While the PAs could use the approach described above to measure NTG with market effects in time for the next planning cycle, it would be costly for the relatively small magnitude of market effects likely to accrue so early on. Given this, PAs may wish to consider taking a simpler approach to measuring NTG in the 2022-2024 cycle, and towards the end of the cycle, assess the appropriateness of measuring NTG at the market level for the 2025-2027 cycle. We offer two simpler NTG estimate options for the PAs to consider for the 2022-2024 cycle:

1. Assume that program-supported sales of integrated controls will constitute the vast majority of market-level sales, and that market-level sales would be close to zero without the program. Taking this approach, the NTG ratio would be 1.0.
2. Use a negotiated NTG ratio.

### Considerations

- **When PAs conclude that sufficient time has passed so that the magnitude of accrued market effects might be large enough to warrant the cost of measurement, consider quantifying market effects from the PAs' efforts to establish and accelerate the Massachusetts market for DMSHP controls. If a NTG ratio is needed before this, consider using one of the two simpler NTG measurement NTG estimation approaches suggested here.**

#### 6.1.5 Implications for Fuel Optimization

The availability of integrated controls for DMSHPs is likely to encourage fuel switching among residential customers. A majority of market actors (57%) believe that the availability of integrated controls for DMSHPs would affect the adoption of DMSHPs in homes that heat with oil or propane.

The availability of integrated controls for DMSHPs is less likely to encourage fuel switching among small business customers than among residential customers. Just one-fifth (19%) of market actors believe small businesses that heat with oil or propane would increase their adoption of DMSHPs because of the availability of integrated controls. Their rationale for the difference between their answers for residential and small business customers was that there is no integrated control rebate for small businesses, small businesses are too busy to worry about their heating systems, and DMSHPs are not appropriate for certain types of small businesses.

Due to low gas prices and the absence of rebates for integrated controls, customers who heat with gas are less likely than customers who heat with delivered fuel to switch to heating primarily with DMSHPs. Only one-quarter (24%) of market actors expect that the availability of integrated controls would affect the adoption of DMSHPs in homes that heat with gas, and only 9% expect that they would affect the adoption of DMSHPs among small businesses that heat with gas. However, it is worth examining in future research whether the availability of the PAs' rebates for DMSHP integrated controls in homes heated primarily with delivered fuels increases awareness of and experience with integrated controls among installers and customers, thus contributing to increased installation of DMSHPs with integrated controls in homes heated with natural gas.

The NMR team identified two other implications of integrated DMSHP controls for switching from fossil fuels to electric heat pump heating worthy of consideration for program planning. First,

DMSHPs are better able to serve as the primary heating source in homes with minimal air leakage. Therefore, customers will experience the benefits of DMSHP heating more fully if their homes are weatherized. Integrated controls installations represent an opportunity to cross-sell PA incentives for building shell improvements, achieving further energy savings. The PAs could instruct contractors to emphasize the importance of building shell improvements in attaining maximum benefits from DMSHPs. Contractors could then point customers towards Mass Save incentives for building shell improvements.

Second, two of the manufacturers we interviewed brought up the topic of smart homes. In the future, they foresee comprehensive integration of energy-consuming devices including heating equipment. Both interviewees mentioned Google and Amazon as potential manufacturers for whole-home integrated controls. This may result in new program opportunities. PAs should expect to adapt support for integrated controls to the home automation market over time.

### Considerations

- **Consider cross-selling building shell improvements to DMSHP integrated controls customers.**
- **Keep apprised of developments in smart home technology.**
- **Assess the effects of the PAs' integrated controls efforts on the adoption of DMSHPs with integrated controls in homes heated by natural gas.**

## 6.2 ADDITIONAL IMPLICATIONS

In addition to encouraging contractors to promote and install DMSHP integrated controls by providing training and education, the PAs could encourage wider adoption by helping overcome contractor apprehension about the effectiveness and reliability of the technology by providing support to defray the cost of callbacks. Below are this and other considerations that could help contractors promote this technology.

### Considerations

- **Consider providing financial support to defray the cost of callbacks for contractors to help eliminate this barrier to the installation of integrated controls.** Just as a warranty eases a customer's mind, knowing that some degree of financial support is available to in the event of callbacks can serve as an insurance policy that installers would not be fully on the hook for the cost of handling customer complaints, helping them overcome concerns about the technology. If PAs choose to pursue this path, it should be done with the support and financial contribution of manufacturers.
- **Publicize successful case studies to contractors.**
- **Work closely with a few large contractors who are receptive to DMSHP integrated controls.** The PAs might consider targeting a few large contractors with education and training, including case studies of successful installations. While a number of the market actors interviewed brought up contractor reservations regarding integrated controls, we also heard of a few contractors having embraced the technology and installed numerous systems. Two market actors pointed out that contractors who do not offer integrated

controls will be motivated to offer them so as not to lose business to competitors who do. This suggests a multiplier effect with regards to contractor outreach.

- **Work with manufacturers to assist in improving the technology.** Most of the integrated controls solutions offered by the manufacturers we interviewed require intermediary equipment, such as adaptors, in order to achieve integration. The PAs might consider working with manufacturers to develop more streamlined integrated controls solutions.

While integrated controls provide a solution to the lack of an easy way for customers to optimize using DMSHPs in combination with fossil fuel heating equipment, their efficacy is uncertain. We only identified one published study evaluating the impacts of integrated controls used with DMSHP and fossil fuel heating equipment. While this Efficiency Maine metering study found that heat pump use increased, it had an extremely small sample size and only utilized one brand of integrated controls. Energy savings from DMSHP with integrated controls can be affected by a variety of factors, including DMSHP efficiency ratings, proper installation of the DMSHP, proper installation of the integrated controls, outdoor temperatures, and the temperature switchover setting. Integrated controls will only result in decreased fossil fuel use if customers use them to heat their homes, and several interviewed contractors suspected that customers were switching them off after installation. The PAs are planning an impact evaluation to estimate the gross savings from integrated controls for DMSHPs working in conjunction with delivered fuel-fired heating equipment.

### Considerations

- **The planned impact evaluation should include an estimate of the incremental gross savings from integrated controls used with DMSHPs in homes with delivered fuel-fired heating equipment.**

## Appendix A Interview Guide

Name:

Company:

Title:

Telephone:

Email:

Interview Date:

*Note: Both during recruiting and at the start of the interview, interviewers made it clear that the topic of the questions was integrated controls for ductless mini-split heat pumps, and that for ease of conversation, they might refer to these as "mini-split heat pumps" and "heat pumps" interchangeably. For the few questions that interviewers asked about central heat pumps, they make it clear they were asking about a different type of equipment.*

### CONTROL MANUFACTURERS, HEAT PUMP MANUFACTURERS, DISTRIBUTORS AND CONTRACTORS

#### Introduction

**Group 1 Manufacturers & distributors:** On behalf of the sponsors of Mass Save, NMR Group is researching the Massachusetts market for integrated controls for use with mini-split heat pumps. By installing an integrated control, the system can automatically switch from heating with the heat pump to heating with the conventional system based on a preselected outdoor temperature. As part of this effort, we have some questions for you about the market. If you qualify, you will receive a \$100 gift card.

Are you familiar with Mass Save? IF NO: Mass Save is a collaborative of Massachusetts' natural gas and electric utilities and energy-efficiency service providers. They include Berkshire Gas, Blackstone Gas, Cape Light Compact, Columbia Gas of Massachusetts, Eversource, Liberty Utilities, National Grid, and Unitil. Mass Save empowers residents, businesses, and communities to make energy-efficient upgrades by offering a wide range of services, rebates, incentives, trainings, and information.

**Group 2 manufacturers & distributors:** On behalf of the sponsors of Mass Save, NMR Group is researching the Massachusetts market for integrated controls for use with mini-split heat pumps. By installing an integrated control, the system can automatically switch from heating with the heat pump to heating with the conventional system based on a preselected outdoor

temperature. As part of this effort, we have some questions for you about the market. If you qualify, you will receive a \$100 gift card.

Are you familiar with Mass Save? IF NO: Mass Save is a collaborative of Massachusetts' natural gas and electric utilities and energy-efficiency service providers. They include Berkshire Gas, Blackstone Gas, Cape Light Compact, Columbia Gas of Massachusetts, Eversource, Liberty Utilities, National Grid, and Unitil. Mass Save empowers residents, businesses, and communities to make energy-efficient upgrades by offering a wide range of services, rebates, incentives, trainings, and information.

**Contractors:** On behalf of the sponsors of Mass Save, NMR Group is researching the Massachusetts market for integrated controls for use with mini-split heat pumps. By installing an integrated control, the system can automatically switch from heating with the heat pump to heating with the conventional system based on a preselected outdoor temperature. As part of this effort, we have some questions for you about your experiences with mini-split heat pump installations in existing homes and small businesses. If you qualify, you will receive a \$100 gift card.

Are you familiar with Mass Save? IF NO: Mass Save is a collaborative of Massachusetts' natural gas and electric utilities and energy-efficiency service providers. They include Berkshire Gas, Blackstone Gas, Cape Light Compact, Columbia Gas of Massachusetts, Eversource, Liberty Utilities, National Grid, and Unitil. Mass Save empowers residents, businesses, and communities to make energy-efficient upgrades by offering a wide range of services, rebates, incentives, trainings, and information.



Question	Mfrs	Dist	Con
<p>1. Does your company manufacture/distribute/install:</p> <ul style="list-style-type: none"> <li>a. Mini-split heat pumps?</li> <li>b. Mini-split heat pumps with integrated controls?</li> <li>c. Central heat pumps?</li> <li>d. Central heat pumps with integrated controls?</li> <li>e. Standalone integrated controls packages for adding to new or previously installed mini-split heat pumps?</li> <li>f. Standalone integrated controls packages for adding to new or previously installed central heat pumps?</li> </ul>	✓	✓	✓
<p>2. IF NO to either 1.b or 1.e (<i>manufactures/distributes/installs MSHP with integrated controls or standalone integrated controls for MSHP</i>):</p> <ul style="list-style-type: none"> <li>a. Why is that?</li> <li>b. Do you have plans to manufacture/distribute/install these in the future? IF YES: About when would that be?</li> </ul> <p style="text-align: center;"><b><i>Thank you – you do not qualify for our survey and the gift card, but we appreciate your time. [TERMINATE]</i></b></p> <p>3. IF YES to 1.b (<i>manufactures/distributes/installs standalone integrated controls for MSHP</i>):</p> <ul style="list-style-type: none"> <li>a. When did you first start to manufacture/distribute/install mini-split heat pumps with integrated controls?</li> </ul> <p>4. IF YES to 1.e (<i>manufactures/distributes/installs MSHP with integrated controls</i>):</p> <ul style="list-style-type: none"> <li>a. When did you first start to manufacture/distribute/install standalone integrated controls packages for adding to new or previously installed mini-split heat pumps?</li> </ul>	✓	✓	✓
<p>5. How and when did your company first learn about integrated controls for mini-split heat pumps? [PROBE FOR TIMING AND SOURCE OF AWARENESS. KEY DATES TO KEEP IN MIND BUT NOT BRING UP: NOVEMBER 2018 MASS SAVE RELEASED A SPECIFICATION FOR HEAT PUMP INTEGRATED CONTROLS; JANUARY 2019 MASS SAVE BEGAN OFFERING REBATES FOR HEAT PUMP INTEGRATED CONTROLS.]</p>	✓	✓	✓

Question	Mfrs	Dist	Con
6. How did your company decide to offer installations of mini-split heat pumps with integrated controls or integrated controls to retrofit on previously installed mini-split heat pumps? a. What factors influenced your decision?	✓	✓	✓
7. How have sales of integrated controls for mini-split heat pumps changed in the time since you first began to manufacture/offer/install them? a. What is driving the changes you've seen? b. To the extent that you can differentiate sales by state, how have sales to customers in Massachusetts compared to those to customers in other states or regions in this time? c. What is driving the differences in sales between Massachusetts and other states or regions?	✓	✓	✓
8. How have prices of integrated controls, or mini-splits that include integrated controls, changed in the time since you first began to offer them?	✓	✓	
9. In homes that heat with oil or propane, do you expect the availability of integrated controls for mini-split heat pumps to affect the adoption of mini-split heat pumps? IF YES: How? With gas? IF YES: How? a. In small businesses that heat with oil or propane? IF YES: How? With gas? IF YES: How?	✓	✓	✓
10. How do you expect the market for integrated controls for mini-split heat pumps to change in the next two years, and why? In the next five years? PROBE FOR: Changes in sales volume, price, availability, how controls are sold (e.g., as part of existing heat pump or separately).	✓	✓	
11. IF YES TO 1.b ( <i>manufacturers MSHP with integrated controls</i> ) a. Are there any brands of standalone integrated controls made by other manufacturers that work with any of the mini-split heat pump models you manufacture? b. If yes: Did your company have to coordinate with each brand's manufacturer to make sure the controls would work with your mini-split heat pumps? IF YES: What kinds of things did you need to coordinate about? 12. IF YES TO 1.e ( <i>manufactures standalone integrated controls package for MSHP</i> ) a. Are your stand-alone integrated controls meant to work with any brand of mini-split heat pump, or only certain brands?	✓		

Question	Mfrs	Dist	Con
<p>b. Did your company have to coordinate with each brand's manufacturer to make sure the controls would work with their brand? IF YES: What kinds of things did you need to coordinate about?</p>			
<p>13. IF YES TO 1.b (<i>manufacturers MSHP with integrated controls</i>): How simple, or complicated, is it to install an integrated heat pump control made by another manufacturer so that it works with a mini-split heat pump made by [manufacturers: your company/ distributors/contractors: the company that makes the heat pumps your company sells/installs]? Is any training needed?</p> <p>14. IF YES TO 1.e (<i>manufactures standalone integrated controls package for MSHP</i>): What is typically involved in installing one of your standalone controls so that it works with another company's brand of mini-split heat pump? Is any training needed?</p>	✓		
<p>15. Are you familiar with...</p> <p>a. the Mass Save specification for heat pump integrated controls?</p> <p>b. the Mass Save rebates for heat pumps with integrated controls and integrated controls retrofits?</p>	✓	✓	
<p>16. Had the Mass Save program not developed a specification for heat pump integrated controls and started offering the rebate they did [IF NEEDED: SUPPLY REBATE INFO], what do you think the market for heat pump integrated controls would look like today? Why do you say that?</p> <p>a. What do you think the market would look like in the next two years without the Mass Save specification and rebate? Why do you say that?</p> <p>b. In the next five years? Why do you say that?</p>	✓	✓	
<p>17. IF YES to either 1.b or 1.e (<i>manufactures/distributes/installs MSHP with integrated controls or standalone integrated controls packages</i>): Do you feel the Mass Save program influenced your decision to manufacture/distribute/install HP controls? IF YES: How so?</p>	✓	✓	✓
<p>18. Are you aware of any programs other than Mass Save that offer support for heat pump integrated controls? If yes: What programs?</p>	✓	✓	✓
<p>19. IF AMONG NOT CONTACTED SAMPLE FRAME: Has anyone from CLEAResult contacted you about integrated controls for mini-split heat pumps? IF YES: Who contacted you, in what context? Roughly when?</p>	✓	✓	✓

Question	Mfrs	Dist	Con
20. IF YES to 1.f and NO to 1.e ( <i>manufactures standalone integrated controls for central heat pumps but <b>not</b> MSHP</i> ) Earlier you said that your company manufactures integrated controls [standalone integrated controls packages] for central heat pumps but not for mini-split heat pumps. Why not for mini-split heat pumps?	✓		
21. The Sponsors of Mass Save are offering very generous rebates for heat pump integrated controls. It would help them continue to offer these if they had access to more data about unit sales than just the units they rebated.  Would your company consider sharing its unit sales of mini-split heat pumps by state with the sponsors? The sponsors and NMR would keep your data strictly confidential. The data would be reported only in aggregate, so that no outside entity would see your company's individual data.  [IF YES, DESCRIBE FORMAT AND FREQUENCY OF HARDI DATA AND ASK IF THEY CAN SUPPLY SIMILAR DATA. THIS MAY REQUIRE FOLLOW UP CONVERSATIONS]		✓	
22. Is there anything else about the market for mini-split heat pumps or integrated controls that you feel we should know?	✓	✓	✓
23. LOW PRIORITY, ASK AT END, IF TIME: In 2019, what (if any) changes have you seen in the adoption of mini-split heat pumps in homes or businesses that heat with oil or propane? In homes or businesses that heat with gas? Where have you seen these changes? [PROBE FOR DIFFERENCES BETWEEN MA AND OTHER STATES].	✓	✓	✓
Total questions per group:	19	17	12

Closing

Contractors: You've been so helpful! You may be hearing from Navigant Consulting asking if they can interview you for another study by the sponsors of Mass Save. I hope you will consider talking with them.

Everyone else: You've been so helpful! Thank you for sharing your insights.

## MA CEC, NEEP, NEEA, CEE AND CEE MEMBERS

### Introduction

On behalf of the Massachusetts Program Administrators, NMR Group is researching the roles of various organizations in the market for heat pump integrated controls. By installing an integrated control, the system can automatically switch from heating with the heat pump to heating with the conventional system based on a preselected outdoor temperature. Our focus is particularly on integrated controls for use with mini-split heat pumps. As part of this effort, we have some questions for you about your organization's activities in this market.

IF NEEDED: 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, Columbia Gas of Massachusetts, Eversource, Liberty Utilities, National Grid, and Unitil. Mass Save empowers residents, businesses, and communities to make energy-efficient upgrades by offering a wide range of services, rebates, incentives, trainings, and information.

IF NEEDED: Mass Save currently offers rebates of up to \$1600 per ton, or \$500 per indoor unit, for mini-split heat pumps with integrated controls.

1. How and when did your organization first learn about heat pump integrated controls? [IF NOT AWARE OF INTEGRATE CONTROLS, TERMINATE]
2. What efforts has your organization or its [members][sponsors] been involved in to bring mini-split heat pump integrated controls to market? *Probe for specific activities, organizations, individuals, and timing.*
3. IF NO PROGRAMS FOUND SEARCHING WEB: Does [ORGANIZATION], or [ORGANIZATION]'s members/sponsors, offer program(s) in support of heat pump integrated controls? Why or why not?
  - a. IF YES: Tell me about the support that is offered.
  - b. When did was this support first offered?
4. Do you expect the availability of integrated controls for mini-split heat pumps to affect the adoption of mini-split heat pumps in homes that heat with oil or propane? IF YES: How? With gas? IF YES: How?
  - a. In small businesses that heat with oil or propane? IF YES: How? With gas? IF YES: How?
5. F YES TO ANY OF 4: Has your organization developed any quantitative estimates of the changes you expect to see in adoption of mini-split heat pumps in homes that heat with oil, propane or gas? In small businesses that heat with oil, propane or gas?
  - a. IF YES: Can you share those with us?

6. How do you expect the market for integrated controls for mini-split heat pumps to change in the next two years, and why? In the next five years? PROBE FOR: Changes in sales volume, price, availability, how controls are sold (e.g., as part of existing heat pump or separately).
7. **MA CEC only:** How and when did the CEC decide to offer the Whole-Home Air Source Heat Pump Incentives pilot program?
  - a. To what extent did the existence of integrated controls affect the program design?
8. **MA CEC only:** What effect, if any, did the CEC incentive have on the uptake of integrated controls in homes that retained supplemental gas heating? Why do you say that?
9. **MA CEC only:** Why did the CEC discontinue incentives for mini-split heat pumps?
10. Are you aware of any individuals or organizations that have been influential, or instrumental, in bringing heat pump integrated controls to market? Who are they, and why do you say this?
11. [IF NEEDED] Are you aware of the activities of the Massachusetts Program Administrators to encourage manufacturers to develop integrated controls to optimize the use of mini-split heat pumps with other heating systems, or Mass Save rebates for heat pumps with integrated controls and integrated controls retrofits? PROBE FOR WHAT THEY KNOW. IF THEY OFFER ANY PROGRAM SUPPORT FOR HPs, THEN ASK:
  - a. How has the Mass Save program influenced [ORGANIZATION'S PILOT OR PROGRAM], if at all? If not, why not?
12. Are you aware of any program support for heat pumps with integrated controls that we have not already talked about? IF YES: Who should I reach out to for more information about that?
13. Is there anything else about the market for mini-split heat pumps or integrated controls that you feel we should know?

Closing

You've been so helpful! Thank you for sharing your insights.

## Appendix B Integrated Controls Specification for Heat Pumps

Integrated Controls for Cold Climate Heat Pump/Fossil Fuel Systems Specification for 2019  
Mass Save Heating and Cooling Program

CLEAResult / NEHVAC Programs

January 30, 2019

The 2019 Mass Save Heating and Cooling program (the H&C Program) has identified the use of heat pumps as a beneficial method for assisting the state of Massachusetts in achieving its Greenhouse Gas emissions reduction goals; the "80/50" goal. The development and installation of Integrated Controls (IC) to use an air source heat pump (ASHP) for space heating for a significant portion of the heating season is a technical and economical method for forwarding this objective. These controls are intended to operate the heat pumps as primary equipment, with existing fossil fuel equipment (specifically fuel oil and propane) as secondary heat during colder weather. 2019 Mass Save H&C program incentives will be offered to subsidize the implementation of this strategy.

This specification is intended to define acceptable IC installations. Only systems that meet these criteria will be eligible for Program incentives.

1. The installed IC system will provide automatic changeover from Heat Pump to existing heating system operation by one of two acceptable strategies
  - a. Balance point operation (suggested at 30-40F outdoor ambient temperature) or
  - b. Simultaneous operation, aka "Droop", with existing heating system set 2-3F lower than ASHP, both systems powered, with a 15F Balance Point for ASHP changeover.
2. IC configurations must be supported/documented by OEM instructions, wiring diagrams, and schematics (either from the equipment or control manufacturers) to facilitate troubleshooting in the event of control or equipment failure in the future. Field fabricated control strategies not supported by OEM documentation will not be Program eligible.
3. IC strategies shall have an indoor thermostat or temperature sensor (wired, wireless, infrared, Wi-Fi or other) for each indoor heating system. The thermostat/sensor shall be set in a location appropriate for the space being conditioned and must be mounted or set in the Occupied Zone, 2-5 feet off the floor (the "comfort zone") and provide temperature control and Occupied Zone temperature readout. Temperature readout and control may be provided using a wifi app on mobile device. The thermostat/sensor setting must reflect actual Occupant Zone temperature. For ductless systems, each head must be controlled by the IC system.



4. IC systems shall have a method to switch from Heat Pump to fossil fuel heating system operation, if one of the heating systems malfunctions, without rewiring. OEM software application acceptable. Simultaneous operation (as in 1b above) meets this requirement.
5. Basement "freeze protection" must be considered to prevent frozen pipes in the event of low basement temperature during ASHP operation. A conventional thermostat may be installed in the basement, wired in parallel to R and W, set for 32F+/-, to operate the central heating system. Alternate "freeze protection" methods including simultaneous operation (as in 1b above), boiler systems that are used to provide domestic hot water, and other scenarios where the boiler or furnace remain operating in basement, will be considered as "Freeze Protection."
6. All installations subject to QC inspection at the option of the Program.