Electrifying Changes: Assessing Effects of Program Support on Massachusetts Heat Pump Markets

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ABSTRACT

Policies and programs around the country are looking to long-term heat pump promotion initiatives to help achieve challenging energy efficiency and carbon reduction targets. As these efforts get underway, early and ongoing progress assessment is needed.

This paper presents the results of research conducted in 2023 to gather the baseline information needed for a future study to quantify heat pump market effects since the start of 2022 and determine the extent to which these effects may be attributed to the Massachusetts Program Administrators' energy efficiency programs. The paper presents size estimates of the 2021 Massachusetts markets for residential and C&I space heating, cooling, and water heating equipment; estimates of the percentages of these markets that comprised program-qualifying as well as program-supported heat pump equipment; and estimates of changes in heat pump sales from 2021 to 2022. It also presents the data collection and analysis methodologies used and future plans for this research. The results provide early evidence that the Program Administrators' expanded support for heat pumps has affected the Massachusetts residential and C&I space conditioning markets and the residential water heating market. The paper may appeal to jurisdictions focused on greenhouse gas reduction goals or building electrification.

Introduction

In 2022, the Sponsors of Mass Save® redesigned and expanded their support for electrification with the intent to, in the long-term, shift the Massachusetts markets for space conditioning and water heating equipment to favor heat pumps. Mass Save is a collaborative of Massachusetts' electric and natural gas utilities and energy efficiency service providers including Berkshire Gas, Cape Light Compact, Eversource, Liberty, National Grid, and Unitil. In this paper, we refer to these organizations as the Program Administrators, or "PAs." The PAs developed the program theory and logic models to document how they expected this shift to come about. NMR Group, Inc. (NMR) and DNV designed and implemented the approach to evaluating progress toward market transformation, quantifying the market effects, and assessing

attribution. We refer to NMR and DNV as the "evaluation team," "the team," or "the evaluators."[1]

The PAs first began actively promoting and incentivizing heat pumps specifically to support the displacement of oil, propane, and electric resistance space and water heating in the 2019 – 2021 term. In the 2022 – 2024 term, the PAs began investing substantially in heat pump market transformation for residential and C&I heating, including offering much more generous heat pump incentives, expanding the incentives to heat pumps that replace gas-fired heating systems, and ending incentives for central air conditioning. (Details of the program theory, evaluation, and results presented here can be found in *Heat Pump Market Effects Indicators Baseline & Interim Studies Final Report* [NMR Group and DNV, 2024a]).

Programmatic support is intended to build awareness and acceptance of heat pumps among customers, and these as well as among the trades and design firms. To this end, the expanded support comprises activities designed to affect decision-making across the residential and C&I heating and water-heating supply chains. Targeted decision makers include manufacturers, distributors and retailers, installation contractors, and customers. Among these audiences, programmatic support aims to:

1. Increase customer awareness and acceptance of heat pumps for space and water heating and the need to appropriately weatherize homes or buildings before installing a heat pump system, especially for whole-home heating.
2. Facilitate necessary training for installation contractors to size and install heat pumps correctly and to understand the importance of appropriately weatherizing the homes or buildings where they install heat pumps.
3. Encourage manufacturers and distributors to increase their heat pump training and certification offerings and routinely include information about Mass Save heat pump program support in these trainings.
4. Encourage distributors and retailers to routinely stock and sell cold-climate heat pumps for space heating as well as heat pumps for water-heating.
5. Offer education on heat pump equipment operation to C&I customers opting for custom incentives.

Quantification Approach

Before collecting any data, the evaluators developed an approach to quantifying market effects expected to accrue over time from the PAs' expanded heat pump support. This approach is meant to be carried out over three studies: (1) a Time 1 study to collect baseline (2021) market data and measure baseline indicators of market effects expected from the PAs' enhanced support for heat pumps; (2) a Time 1.5 study of progress toward market effects in 2022; and (3) a Time 2 study to quantify market effects at a future date, when there has been enough program activity and passage of time to measure market effects above the noise of other market activities. Here, we report on the results of the Time 1 and Time 1.5 studies. The Time 2 study will entail a

[1] As part of the evaluation, Tetra Tech collected survey data from residential installers and from customers but was not involved in design, analysis, or reporting.

comprehensive re-measurement of indicators and market data, with the goal of quantifying measurable cumulative market effects that may have accrued from the PAs' support by that time.

The evaluation team followed the guidance in *Methods for Measuring Market Effects of Massachusetts Energy Efficiency Programs* (NMR Group 2014) to determine how to estimate net savings from the market effects given the quantity and quality of the data that would ultimately be collected and to provide evidence for attribution. The guidance identifies four general methods to estimate net savings stemming from market effects. These are:

1. Supply-side market actor self-reported counterfactual analysis
2. Cross-sectional analysis, which may include time-series data
3. Forecasting or retrocasting the non-intervention baseline
4. Structured expert judgment

All of these methods require sales or installation data to estimate market size and market share in the baseline period and at the time of quantification. Per the guidance, to quantify market effects, the evaluation team would need to collect data to use in estimating the counterfactual or "naturally occurring savings" as well as measure indicators of behavior and related changes expected to result from the program activities and ultimately to lead to market effects.

- *Market share* refers to estimates of the ratio of sales or installations of the qualifying equipment of interest to the sum of sales or installations of both qualifying equipment and competing equipment that does not qualify. This ratio is typically developed from primary data collection with a sample of market actors or from purchased data sources.
- When market share is calculated based on primary data obtained from market actors or other sources, the data must be adjusted to reflect the full *market size*, typically by estimating the relative percentage of the market that each reporting source represents and using secondary data from sources such as saturation studies to extrapolate from the sales estimates to the entire market(s) of interest.
- The *counterfactual* or "naturally occurring savings" refers to estimating sales or market shares—and resulting savings—that would have occurred in the absence of the program. This estimation will be made as part of Time 2 reporting and so is not covered in this paper.
- Measuring *indicators of behavior and related changes* expected to result from the program activities entails gathering evidence of changes in market actor and customer behavior, attitudes, etc., expected to result from the program activities and ultimately to lead to market effects, as predicted in the program theory. This information is critical to establishing attribution (the causal relationship between the program intervention and market effects), as a credible case for a quantitative estimate of market effects cannot be made without a credible qualitative case that the market effects are due to the intervention.

The evaluation team carefully reviewed the program theory, logic models, and proposed market effects indicators to identify appropriate approaches to assessing market progress and attribution and ultimately to estimating net savings, and to identify the specific data to collect

from each of the target actors. These target actors were (1) manufacturers of heat pumps and other competing space conditioning and water heating equipment, (2) HVAC and water heating distributors and manufacturers' representatives, (3) HVAC and water heating installation contractors, and (4) customers.

Recognizing the difficulties of obtaining market share data from market actors, the evaluation team developed quantification approaches for a very ambitious best-case data collection scenario and three contingency plans for lesser degrees of success collecting sales and other data from various market actor groups in Massachusetts and the proposed comparison area (NMR Group and DNV, 2023b). The evaluation team and PAs were aware that the best-case scenario had a low probability of success, as it involved cross-sectional analysis with a comparison area and time-series data from both participating and non-participating market actors. As we describe below, the evaluation team collected usable sales and other data from participating distributors and installers in Massachusetts, as well as data from manufacturers, but despite extensive outreach efforts, the team was not able to collect data from enough non-participating ones in Massachusetts and a comparison area for the best-case scenario. Based on the data that the evaluation team successfully collected in the Time 1 study, we expect the Time 2 study will involve a combination of supply-side market actor self-reported counterfactual analysis and time-series data from participating market actors. For certain residential-duty equipment types, it will be supplemented by an analysis of purchased residential time-series sales data for Massachusetts and other states. The final details of the quantification approach that will be implemented will depend on the success of Time 2 data collection efforts.

Research Methods

This research focuses on heat pumps for use in *existing* homes and buildings, specifically:

- Air source heat pump systems (ASHPs) (air-to-air only): ducted and ductless systems (split or packaged) and VRF systems. Each compressor represents one system with capacities under 5.4 tons deemed residential-duty and capacities over 5.4 tons deemed commercial-duty. All VRFs were considered commercial-duty regardless of capacity
- Heat pump water heaters (HPWHs).[2]

For context, the studies also collected sales, installation, and other data for the following competing space conditioning and water heating equipment:

- Central air conditioning systems (CAC): residential-duty non-heat pump split or unitary systems and commercial-duty non-heat pump, split or unitary systems using direct expansion (dx) cooling, excluding chillers.
- Fossil fuel-fired heating systems: furnaces, boilers and combi boilers.
- Fossil fuel-fired and electric resistance water heaters: residential- and commercial-duty storage and instantaneous, excluding indirect water heaters.

While the PAs offer expanded support for ground source heat pump systems, the studies did not attempt to collect sales or installation data for these systems.

[2] The study did not differentiate between unitary and split HPWHs.

Data Collection

Manufacturers. In early 2023, the evaluation team interviewed a sample of ten manufacturers of the kinds of space conditioning and water heating equipment listed above. The evaluation teams sized manufacturers two ways: (1) based on estimated number of U.S.-based employees and estimated annual U.S.-based revenue and (2) by asking respondents to name the biggest manufacturers of heat pump equipment and water heating equipment in terms of U.S. market share. Together, the heat pump manufacturers interviewed appear to represent substantial portions of the U.S. share of the heat pump manufacturing market. The same is true of the U.S. share of the water heating equipment manufacturing market.

Participating distributors. The evaluation team conducted interviews with 15 out of a target of 16 distributors of space conditioning and water heating equipment in Massachusetts that participated in the upstream HVAC offerings in 2021. The sample frame comprised 112 distributor companies in Massachusetts using corporate data purchased from ZoomInfo.com and program data. All but 12 of these distributors (89%) had signed up to participate in the PAs' Midstream or Upstream programs in 2021 or 2022. While there was no reliable way to determine the size of these 12 non-participant distributors, it was unlikely that they comprise the largest distributors in Massachusetts. The Massachusetts distributors interviewed include nine of the 16 largest Massachusetts distributors identified by a key Mass Save program implementer, and seven of the 18 distributors identified by interviewed manufacturers as the major Massachusetts distributors of their products. Together, this suggests that the participating distributor population accounted for the vast majority of total market activity in Massachusetts in 2021 and 2022.

Participating contractors. The study included an internet survey of and interviews with HVAC and water heating installation contractors that participated in relevant residential or commercial PA programs in 2021.

Participating customers. The study included internet surveys of residential customers who installed space conditioning or water heating equipment through the market-rate residential programs in either 2021 or 2022. Many of the same questions were also fielded to general residential customers in an internet survey conducted in early 2023 as part of the Massachusetts Residential Building Use and Equipment Characterization Study (Guidehouse Forthcoming). The study included a survey of C&I customers who installed rebated space conditioning equipment through the C&I Existing Building Retrofit and C&I New and Replacement Equipment programs in 2021.

Table 1 shows contractor and customer survey sample sizes and response rates.

Table 1. Installer and Customer Survey Data Collection Approaches & Response Rates

Group Surveyed or Interviewed	Data Collection Method	Sample Size	Sampling Approach	Response Rate
Residential participating installers (2021)	Internet survey	1,378	Proportional to size	3%
Residential participating customers (2021)	Internet survey	11,206	Stratified random sample	7%
2022 Residential participating customers (2022)	Internet survey	6,419	Stratified random sample	11%

General residential customers (2023)	Internet survey	110,816	Stratified random sample	5%
C&I participating installers (2021)	Telephone interviews	92	Census attempt	22%
C&I participating customers (2021)	Mixed mode	847	Stratified random sample	11%

Market Sizing

The evaluation team originally intended to size the Massachusetts markets for space conditioning and water heating equipment by collecting data from larger distributors in the state and using distributors' estimates of their own market share of each equipment type to expand the results to each state. This was not possible as most Massachusetts distributors declined to provide estimates of their own market share in the state, saying they had very little confidence in their accuracy. We also considered expanding distributor sales information based on employment. This proved unworkable because of the inconsistency of the employment data available and the lack of any clear relation between employment and sales in the data we did have. The evaluation team ultimately estimated the size of the market using other sources as described below, because it was the most reliable way of estimating the market given the data we obtained. We then divided the distributors' reported sales by the separately estimated market sizes to estimate the share of the market comprised by our interviewed distributors and provide other useful insights. For details of how we estimated the size of each market, see the Massachusetts Heat Pump Market Insights section.

Going forward we expect to see improvements in the secondary data available for sizing markets, particularly for HPWHs. At a minimum, we expect there to be more data available for HPHWs as they become more common, and the data to include more reliable equipment age data as states focus more on carbon reduction and electrification.

Caveats

Below we note some limitations and sources of uncertainty to bear in mind about the results presented in this paper:

- Since there was no way to identify the entire population of the market actors, the authors had to rely on some assumptions subject to uncertainty to extrapolate the findings to the entire population.
- The study attempted to understand multiple residential and C&I equipment types at the same time. Not all distributors sell all equipment or sell all equally. Similarly, not all installers install all equipment or install all equally. The variation in the types and volume of equipment sold or installed across market actors makes it difficult, if not impossible, to achieve a sample that is sufficiently representative across all equipment types.
- Market actors could not always provide the data requested due to differences in how they track their data versus what the survey asked and various other reasons.
- The study findings are based on data from participating distributors and installers only and thus may not represent the entire residential or C&I equipment markets, especially

for the equipment types more likely to be sold or installed through non-participating distributors and installers.

- In 2021 there was no industry standard definition for cold-climate air source heat pumps, especially for commercial duty equipment. In the survey instruments, they were referred to as air source heat pumps that were marketed or certified as suitable for cold climates. Since this could be interpreted differently by respondents, the study estimates of the share of heat pumps sold or installed that are cold-climate, especially for the C&I equipment, contains uncertainty related to the lack of a standard cold-climate definition at the time.
- Neither the study nor the program tracking data consistently collected information separately for heating and cooling capacity. It was not clear if the respondents reported their average capacity numbers in terms of cooling or heating capacity.
- To reduce respondent burden, the study asked about the changes in sales or installations from 2021 to 2022 only for heat pump equipment. As a result, it was not possible to determine the size of the market for non-heat pump equipment in 2022 based on the 2021 market size estimates and the changes from 2021 to 2022.

The evaluation team is attempting to address some of these caveats in a follow-on study to track market progress. To increase the likelihood of obtaining more representative results from market actors, the follow-on study is offering distributors and installers double the previous incentive. It is attempting to recruit the same distributors as in the baseline study plus additional ones and is increasing the targeted sample size for installers of both heat pumps and competing space conditioning and water heating equipment.

Massachusetts Heat Pump Market Insights

Here, for each sector, we present the approach we took to sizing the markets for each sector, and estimates of 2021 market size, program penetration, and changes in each market from 2021 to 2022. This is followed by evidence of program influence on heat pump adoption. The market size estimates are based on customer type rather than equipment size, given that the underlying data sources align with customer types more than equipment sizes. Since distributors do not have visibility into where equipment is installed, they provided data by residential- and commercial-duty capacities rather than by the type of customer. The residential estimates only include equipment installed in existing homes, excluding new construction. The C&I estimates includes all equipment installed in C&I settings, regardless of size.

The tables and results presented below quote the draft report (NMR Group and DNV, 2024a, 22).

Residential Market Size and Program Penetration

Residential Market Sizing Approach. The evaluation team estimated market sales of space conditioning equipment installed in residential settings based on an average of estimates derived from three data sources. This allowed the team to triangulate estimates from both a top-down and bottom-up approach.

The first estimate is based on the proportion of equipment manufactured in 2021 using data from the *Massachusetts Residential Building Use and Equipment Characterization Study* for 2020 and 2021 (Guidehouse 2022). The evaluation team considers this the most reliable source

of data on existing homes in Massachusetts, with several iterations of the study conducted prior to 2021 and follow-up iterations of the study that will provide data on continued changes in equipment end-uses beyond 2021. The study surveyed residential customers in Massachusetts to gather data on a variety of end-uses, including HVAC and water heating equipment saturation estimates by fuel type. The data includes an on-site verification adjustment, home-level saturation estimates, quantity of equipment per home, and equipment manufacturing dates, which the evaluation team applied to overall end-use saturation results to estimate the annual HVAC and water heating sales for 2021.

The second approach utilizes the 2020 Residential Energy Consumption Survey (RECS 2020), which leveraged state-specific estimates and year-made variables to estimate total sales in 2021. The third approach leveraged data purchased from CoMetrics that estimates statewide sales for certain equipment (for this study, ducted and ductless heat pumps, central air conditioners, and furnaces).[3] The recommended volume of equipment sold in 2021 was an average of the estimates from the three approaches. The evaluation team also leveraged average equipment capacities derived from program tracking data and the market estimates to estimate capacity-based sales in 2021.

To estimate 2021 sales of water heating equipment installed in residential spaces, the evaluation team leveraged the *Massachusetts Residential Building Use and Equipment Characterization Study* for 2020 and 2021 and the state-level 2020 *Residential Energy Consumption Survey*. Due to limitations with the year-made data for water heating equipment in both data sources, the team estimated water heating equipment sales using a stock turnover method. The evaluation team divided the count of equipment by the effective useful life for each equipment type from the Massachusetts Technical Reference Manual to estimate the amount of equipment that would need replacement in 2021. Given that water heater replacements are generally made during emergency situations, in addition to the static saturation of HPWHs in the 2021 market, the team determined that in the absence of reliable year-made data, a stock turnover approach was the most appropriate estimation technique for water heating equipment.

Table 2 shows 2021 Massachusetts statewide sales shares for residential space heating, central cooling, and water heating equipment that resulted from the market size estimates from the approaches described above. Following are observations from these results.

Ductless and ducted heat pumps comprised about one-fifth of the Massachusetts residential space heating market in terms of units sold in 2021 but represented only one-tenth of heating capacity. Ductless systems accounted for 17% of units but just 8% of capacity, while ducted heat pumps made up less than 5% of units and 3% of capacity sold. Fossil-fueled systems still dominated, comprising 75% of heating units and an even higher 90% of heating capacity sold. Cold-climate heat pump share estimates are based on distributor interviews (46% of ducted and 66% of ductless heat pumps).

In 2021, heat pumps accounted for about one-third of the residential central space cooling market in terms of both units and total capacity sold in Massachusetts. Ductless heat pumps comprised 27% of units and 24% of cooling capacity, while ducted heat pumps comprised smaller shares (5% of units and 8% of capacity). Central air conditioners still dominated the market, highlighting the remaining potential to displace more sales and installations with efficient heat pumps for both cooling and heating applications. Homes adding

[3] CoMetrics obtains the sales data from members of the organization Heating, Air Conditioning, and Refrigerator Distributors International (HARDI). It is also known as “HARDI” data.

first-time central cooling or transitioning from window/portable units may increase overall cooling capacity sales over time.

Ductless and ducted heat pumps have a larger cooling market share than heating share. This is due to several reasons:

- Not all homes have central cooling, lowering the overall market size and increasing share.
- Homes without permanent cooling, such those with window or portable air conditioners, are excluded from cooling estimates.
- Central air conditioners are more similar in size to heat pumps than to fossil fuel heating systems.
- Some ductless heat pumps only partially displace heating loads.

The factors above, especially partial displacement and smaller equipment sizes, explain why the heat pump capacity shares for units are smaller than for tons. Ductless systems on average provide less than half the heating capacity of fossil-fuel systems. Ducted heat pumps are also smaller, further reducing capacity share but less extremely than ductless units.

In 2021, program-supported residential ducted heat pumps accounted for one-third of total ducted heat pump market sales and nearly three-quarters of all cold-climate ducted units sold in Massachusetts. Program-supported residential ductless systems made up over one-third of all ductless sales and over half of cold-climate ductless units sold.

While residential heat pumps have seen some mainstream market traction, especially for cooling, overall Massachusetts residential heat pump market shares appear to have remained relatively low in 2022. Table 2 shows that from 2021 to 2022, ductless sales grew substantially (34%), with more modest ducted growth (10%). For ducted units, cold-climate sales rose faster than non-cold-climate (14% versus 8%). The programs focus on heating capabilities, and the higher cold-climate share and high growth in sales of ductless cold-climate models are in keeping with the program theory. (Note that the evaluation team did not estimate the size of the 2022 market to talk confidently about the market shares for 2022.)

However, even faster non-cold-climate ductless growth appears outside of the program, likely for cooling-only purposes. This highlights further potential for displacing central air conditioner sales while underscoring the need to promote full/partial heating displacements with contractors, distributors, and customers. Focusing on educating stakeholders about efficient cold-climate models can help avoid missed heating conversion opportunities in the future.

The sizeable remaining potential for displacement and continued post-2021 growth highlights the opportunity for the Massachusetts residential programs to further drive heat pump adoption for space conditioning. Ductless heat pump installations rose 34%, aligning with distributors' sales increases. However, ducted heat pump program-supported units grew 123%, outpacing the distributors' reported cold-climate share and 10% sales increase seen in the market.

Given limited additional data, this larger program growth likely signals that a higher proportion of 2022 sales were non-cold-climate ducted heat pumps being supplanted by cold-climate models rather than a sharp total sales increase. In other words, more ducted heat pump purchases occurred through the program incentive than in prior years. Overall, there is still significant potential to drive the market towards efficient electrified heating.

While total Massachusetts residential HPWH market penetration was low in 2021 at 2%, strong alignment between reported sales increases and program unit growth points to heavy and growing program influence on this emerging technology market. Heat pump water heaters comprised just 2% of the 2021 residential water heating market – much lower than heat pump space conditioning shares. However, distributors reported substantial HPWH sales increases nearly mirroring 2021 – 2022 program unit growth (38% versus 41%). (While this growth sounds impressive, note that it is from a low base.) Manufacturers and distributors indicate HPWH sales rely heavily on program incentives.

Table 2. 2021 Massachusetts Residential Equipment Market-level Sales, Program Penetration, and Market Changes, by Unit

Equipment Type	% of Space or Water Heating Unit Sales	% of Space Cooling Unit Sales	2021 Program Penetration	Increase in Program Participation 2021-2022	Increase in HP Unit Sales 2021-2022
Space Conditioning					
Ducted Air Source Heat Pumps*	5%	6%	34%	123%	10%
Ductless Air Source Heat Pumps**	20%	27%	37%	34%	34%
Central Air Conditioners		66%			
Fossil Fuel-fired Heating	75%				
Water Heating					
Heat Pump Water Heaters	2%		40%	38%	41%
Fossil Fuel-fired & Electric Resistance Water Heaters	98%				

* The increase in residential ducted ASHP sales from 2021 to 2022 was 14% for cold-climate systems versus 8% for other ducted systems.

** The increase in residential ductless ASHP sales from 2021 to 2022 was 31% for cold-climate systems versus 8% for other ductless systems.

Commercial Market Size and Program Penetration

C&I Market Sizing Approach. The evaluation team explored multiple ways of sizing the C&I market for heat pumps and decided that the most reliable method leveraged a 2023 stock study of existing C&I buildings to create a bottom-up estimate. The study included surveys with respondents from 846 commercial properties across Massachusetts and 180 on-site verification visits from among those survey respondents. The team estimated the total count of units in the population installed in the past five years by multiplying the survey-based estimate of the proportion of buildings with each equipment type by the onsite-observed average number of units per building, for buildings that have the equipment type. This count was scaled to the population by multiplying by the counts of commercial buildings in the state from tax parcel data. The evaluation team identified only units sold in the year 2021 by dividing the count for the most recent five-year age bin by five. For space conditioning equipment, this is a reasonable assumption because 2021 was the mid-point of the five-year span and the team assumes heat pump sales had been growing throughout the five-year span.

The evaluation team then estimated total capacity by multiplying the count of each equipment type by an average capacity for each equipment type. Average equipment capacity was based on capacity data from the on-site inspections and program data.

For water heaters, the same approach does not properly identify the share of HPWHs installed in 2021 in commercial settings. For HPWHs, market actor interviews and program data indicate that HPWH sales were near zero in 2021 and only started taking off in 2022 and later after the program moved HPWH incentives upstream. Hence, the average installed per year over a 5-year bin ending in 2023 is not a good estimate of 2021 HPWH installations. Therefore, to estimate the size of the HPWH sales in the C&I market, the evaluation team scaled up responses from the C&I installer interviews based on the estimated share of total C&I installer employees comprised by interviewed installers' companies.

The results below reference Table 3, which presents 2021 Massachusetts statewide sales shares by capacity for C&I space heating, central cooling, and water heating equipment. The table and text quote the draft report (NMR Group and DNV, forthcoming, 25).

The Massachusetts C&I space conditioning heat pump market in 2021 was much smaller than the residential heat pump market. The total C&I space conditioning heat pump capacity sold in 2021 was 13% of the total capacity installed in the residential market. Additionally, C&I heat pumps represent a smaller portion of C&I heating capacity sales than residential heat pumps did of residential capacity sales (4% in C&I versus 11% in residential) and a smaller portion of cooling capacity sales (12% in C&I versus 32% in residential). Note that the C&I analysis excludes chillers, which serve large loads not easily met by heat pumps. When considering the whole cooling market, C&I cooling heat pump penetration is lower than 12%.

The vast majority of C&I ducted and ductless ASHPs installed in Massachusetts in 2021 were residential-duty systems, and all commercial-duty space conditioning heat pumps were VRFs. A review of program tracking data and data from the on-site visits of 180 businesses found no ducted or ductless ASHPs over five tons. In follow-up calls, two distributors said there are no ductless ASHPs over five tons.

VRFs constituted the majority of C&I heat pump capacity installed in Massachusetts in 2021 (69%) but ducted ASHP represented the majority of units sold (53%). This is the result of VRFs' use for larger capacity needs than ducted and ductless ASHPs.

Massachusetts program penetration in 2021 was relatively low for ducted and ductless ASHPs (13%) in 2021, while VRF penetration was higher (46%). This could mean that the C&I ASHP market was mostly composed of early adopters who wanted to install heat pumps regardless of program support. Mass Save heat pump activity data, such as trainings, show the heat pump activities started focusing on C&I more substantially in late 2022, suggesting that program efforts around ducted and ductless ASHPs in 2021 were more focused on the residential sector. Since VRFs are a commercial application, Mass Save heat pump support for VRFs in 2021 focused on the C&I sector.

Massachusetts program participation increased significantly in 2022 after the restructuring of the Mass Save heat pump support and the increase in heat pump incentives. Ducted and ductless ASHP participation increased by 347% and VRF participation increased by 71% between 2021 and 2022.

Market actors indicated that their Massachusetts sales of heat pumps for space conditioning increased from 2021 to 2022. C&I installers estimated that their heat pump sales increased by about 40% to 45% from 2021 to 2022. Similarly, distributors estimated that their

VRF sales increased by 44% over that same period. Manufacturers estimated that sales of commercial-duty ducted ASHPs and VRFs increased by about 12% to 14% in Massachusetts.

The Massachusetts C&I HPWH market was near zero in 2021. HPWHs comprised only 1% of the water heating capacity sold in 2021 in the C&I market. There were no HPWHs in the Mass Save heat pump program tracking data. The two interviewed installers who installed any HPWHs in 2021 in C&I locations installed only residential-duty systems.

Massachusetts sales of C&I HPWHs increased from 2021 to 2022, after Mass Save heat pump incentives increased and moved upstream. After having no C&I HPWH program participants in 2021, there were 20 in 2022. More than three-quarters (77%) of interviewed installers indicated their companies started installing HPWHs in C&I settings in 2022 or 2023. Similarly, manufacturers indicated that their companies only started to introduce products for the commercial market in 2022 or 2023.

Table 3. 2021 Massachusetts C&I Equipment Market-level Sales, Program Penetration, and Market Changes

Equipment Type	% of Space or Water Heating Capacity Sales	% of Space Cooling Capacity Sales	2021 Program Penetration	Increase in Program Participation 2021 - 2022	Increase in HP Capacity Sales 2021 - 2022
Space Conditioning					
Ducted Air Source Heat Pump systems	1%	3%	13%	347%	40%
Ductless Air Source Heat Pump systems	0%	1%	13%	347%	42%
Air Source VRF systems	3%	9%	46%	71%	45%
Air Conditioning systems		88%			
Fossil Fuel-fired Heating systems	96%				
Water Heating					
Heat Pump Water Heaters	1%		0%	--*	--**
Fossil Fuel-fired & Electric Resistance Water Heaters	99%				

* The count of program-support C&I HPWHs increased from 0 in 2021 to 20 in 2022.
** 77% of interviewed C&I water heater installers indicated their companies started selling HPWHs in 2022 or later.

Attribution

Evidence of Program Influence on Heat Pump Adoption

The evaluation measured changes between 2021 and 2022 for 14 of 20 expected outcomes from the PAs' support for residential heat pumps. For 12 of these outcomes, the direction of changes in one or more of the indicators increased as theorized.

The evaluation measured changes between 2021 and 2022 for five of 12 expected outcomes from the PAs' support for commercial and industrial heat pumps. For four of these five outcomes, the direction of changes in the indicator measured increased as theorized. The fifth showed a possible upward trend.

That the indicators of these outcomes have changed in the predicted direction serves as preliminary evidence that the changes in the markets from 2021 to 2022 are due at least in part to

the PAs' support for heat pumps. The evidence for attribution is particularly strong for residential heat pumps, for which there are indicators showing changes in participating customer decision-making and behaviors between 2021 and 2022. The following additional qualitative evidence supports this conclusion:

- **Market actors indicated that the program is partially responsible for the growth in both residential and commercial heat pump sales from 2021 to 2022.** Interviewed manufacturers, distributors, and installers all credited rebates and program incentives with increasing interest in heat pumps and heat pump sales. Similarly, distributors and installers credited the program for an increase in the share of cold-climate heat pumps sold.
- **Distributors indicated that, since 2021, they had increased supply chain resources devoted to both residential and commercial heat pump markets partially due to the programs.** A majority of distributors of residential- or commercial-duty cooling equipment reported that they had increased their inventory of air source heat pumps at the expense of cooling equipment, and over one-third of distributors of residential- or commercial-duty heating equipment had changed the types of heating equipment they keep in inventory to accommodate increased stocks of air source heat pumps, most at the expense of boilers. The majority of distributors cited the changes in rebates, incentives, or both as among the reasons for the changes. Since 2021, more than one-quarter of distributors that sell residential- or commercial-duty water heating equipment increased their inventory of heat pump water heaters. Only one of the three distributors that did so offered a reason why, attributing the change entirely to the programs.
- **Market actors indicated that the number of heat pump trainings and the attendance at heat pump trainings increased partially due to the program and that the program influenced the topics at trainings.** Five in six manufacturers said attendance increased for space conditioning trainings. Four in six manufacturers said attendance increased for water heating trainings. Additionally, the two manufacturers that could speak to activities in both Massachusetts and Ohio indicated that training attendance was higher in Massachusetts than Ohio. Program records showed that the number of individuals attending a heat pump specific training course (whether residential or C&I) has increased since early 2022.
- **The percentage increase in program-supported Residential and C&I equipment in the tracking data are larger than the market actor-estimated percentage increases in overall heat pump sales for each respective market.** This could mean that the programs are driving the increases in residential and C&I heat pump sales from 2021 to 2022, or the programs could be grabbing larger shares of natural market adoption. Given market actors citations of the programs for their increases in sales and demand, the evaluation team suspects the programs are the primary drivers of the increase in heat pump sales.
- **The direction of changes in indicators of 12 of the 13 residential market effects outcomes with data for both 2021 and 2022, and in indicators of the five commercial market effects outcomes with data for this period, provides support for attribution from the program of these outcomes in the residential and commercial space conditioning and water heating markets to date.** Table 4 shows the outcomes expected in the residential markets for which at least one indicator was measured for both 2021

and 2022, and the direction of change. Table 5 shows the same for the C&I markets. In these tables, each circle represents the results of one indicator for the respective outcome. Green circles indicate that the value of the indicator increased, in line with the program theory, and that the change was statistically significant. Empty circles indicate there was no change. The outcomes are organized from those expected earliest to those expected later on, per the program theory. The residential outcome measurements are from a combination of manufacturer and distributor interviews, a residential installer survey, and surveys of 2021 and 2022 participating residential customers and general residential customers in 2023. The C&I outcome measurements are from a combination of interviews with manufacturer, distributors, and C&I installers. For a complete list of the indicators measured for each outcome and the results, see the "Market Effects Indicators" section of *Heat Pump Market Effects Indicators Baseline & Interim Studies Final Report* (2024a).

Table 4: Changes in Residential Market Effects Indicators from 2021 to 2022

Outcome	Change in Indicator(s)
● Indicator changed in expected direction ○ No change in indicator	
Residential	
A. Increased customer awareness and understanding of ASHP/GSHPs/HPs and weatherization, and associated benefits of both	● ● ○
B. Customers are satisfied with heat pumps/Customers entering heating or water heating market hear positive reviews from customers with HPs	●
C. Increased availability of HP training/certification	●
D. Increased number of contractors trained on heat pumps and importance of weatherization	●
G. Contractors educate customers on weatherization as needed and install HPs correctly	●
H. High contractor confidence in ability of HPs to meet all customer heating/cooling/water heating needs	●
I. Shifts in distributor inventory and stocking practices	●
J. Increased supply chain resources devoted to MA heat pump market	●
L. Increased customer demand for heat pumps and concurrent weatherization measures	● ○
M. Contractors increasingly recommend HPs for heating/water heating	●
O. New heat pump market entrants	●
Q. Increased customer preference for ASHP/GSHP/HPWH over non-HP heating and cooling or water heating equipment	○
S. High customer reliance on AS/GS HP for both heating and cooling	● ○

C&I	
D. Increased number of contractors trained on HPs & weatherization	●
I. Shifts in distributor inventory and stocking practices	●
J. Increased supply chain resources devoted to MA heat pump market	●
O. New heat pump market entrants	●
Q. Increased customer preference for heat pumps over non-heat pump equipment	○

Other Causal Factors in 2021 and 2022

In 2021 and 2022 there was little support for residential or C&I heat pumps outside of the PAs' offerings via Mass Save. The evaluation team found no evidence of support specifically targeting either residential or commercial heat pumps in Massachusetts in 2022 other than that offered by the PAs, and little evidence of support targeted at heat pumps other than tax credits. For residential customers, the Mass CEC provided support for heat pumps only until mid-2021, leaving them with the Mass Save Sponsors and the $300 federal tax credit for installing a ground source heat pump. The team heard from one distributor that limited municipal grants had supported the installation of some residential heat pumps. In both 2021 and 2022, grants were available for efficiency projects in school buildings through the Massachusetts School Building Authority, but these did not specifically target heat pumps. While the Inflation Reduction Act (IRA), passed in 2022, includes support for heat pumps through a variety of means, activity was limited in 2022. The IRA also increased tax credits for both residential and C&I heat pumps; however, the expanded tax credit did not go into effect until January 1, 2023.

Conclusions

The electrification of space and water heating by converting fossil-fuel-fired heating to heat pumps is an important tool in addressing greenhouse gas emissions. The results presented here suggest that the Massachusetts market for heat pumps, especially for use in homes, is evolving rapidly. Having tools in place for tracking heat pump programs and market progress will prove valuable as heat pump technologies and markets progress, especially as support from the IRA becomes increasingly available.

The results provide early evidence that the PAs' expanded support for heat pumps has already affected the Massachusetts residential and C&I space conditioning markets and the residential water heating market. The evidence is particularly strong for the PAs' support for residential heat pumps, an expected outcome given that the PAs have supported residential heat pumps for longer than C&I heat pumps. The results also suggest that in 2021 there was already significant heat pump activity in the Massachusetts residential space conditioning and water heating markets.

In 2021, heat pump adoption in Massachusetts was farther along in the residential than in the C&I sector. This indicates that any market effects from the PAs' support for heat pumps will likely take longer to materialize in the C&I sector than the residential sector.

At the time of these studies, the interviewed manufacturers and distributors were just at the stage of gathering information on which of their products would qualify for IRA tax credits

and rebates. The Time 2 study will need to address the complexity of controlling for the impacts of the IRA on the heat pump markets when assessing attribution.

The report from which this paper draws provides detailed guidance for jurisdictions interested in assessing progress towards the transformation of space conditioning and water heating markets and in quantifying savings from market effects.

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