MA ENERGY EFFICIENCY ADVISORY COUNCIL

→ CONSULTANT TEAM

EEAC EM&V FOCUSED UPDATE: RECENT RESULTS ON RESIDENTIAL HEAT PUMPS

▶ **February 26, 2025**

www.ma-eeac.org

RESIDENTIAL HEAT PUMPS: THREE RECENTLY COMPLETED STUDIES

Study	Issues Addressed	Contractor and Completion Date
Heat Pump Market Effects Indicators Update 2023-2024	• Comprehensive picture of MA heat pump market as of 2023/2024 • Market and program progress • Validity of program theory • Updates are being performed annually; 2024-2025 study under way now	NMR/DNV, February 2025
Residential Heat Pump Invoice Cost Analysis	• Establish a system for ongoing tracking of heat pump costs • Analyze trends in heat pump costs in MA 2019-2022 • Follow-Up study covering 2023-2024 under way now	NMR, October 2024
Sizing, Leakage and Filter Maintenance Study	• What is the frequency of problems from these issues and the impact on overall performance?	Guidehouse, October 2024

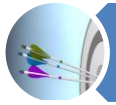
Note: many of the charts and graphs in this deck are drawn directly from the final reports by the above contractor teams.

HEAT PUMP MARKET EFFECTS INDICATORS UPDATE STUDY

- **Third in an annual study series that uses range of data sources to examine market effects of heat pump programming in MA**
- **Covers a combination of 2023 and 2024**
  - Market sizing, HP market share: 2023
  - Contractor and distributor practices: 2024
- **Guided by PA program theory**
  - Did the PAs take the actions specified by the program theory?
  - What specific changes in the market were predicted and when?
  - Did these occur as forecasted?
  - Do the posited causal linkages between different changes appear valid?
- **Methods included:**
  - Interviews with contractors, distributors and commercial participants
  - Program tracking data and sales data

HEAT PUMP MT PROGRAM THEORY: CAPSULE SUMMARY FOR RESIDENTIAL AIR SOURCE HPS AND GROUND SOURCE HPS

- **Distinguishes between:**



Activities, outputs, and outcomes

Short-term, medium-term, and long-term outcomes

Changes on the part of end-users, contractors and distributors

- **For all of the above, posits a specific sequence of causally linked changes that occur in stepwise fashion over time**

End Users	Contractors	Distributors
Increased awareness and understanding	Training and HPIN	Program activities and other market changes
↓	↓	↓
Favorable word of mouth, leading to changes in preferences	Changes in practices, new market entrants, and business strategies	Changes in stocking practices, leading to long-term shifts in sales

OVERVIEW OF RESULTS

The PAs generally took the actions and produced the outputs specified by the program theory

Majority of market indicators changed in the manner predicted by the program theory

- An important exception is contractor attitudes towards full displacement projects

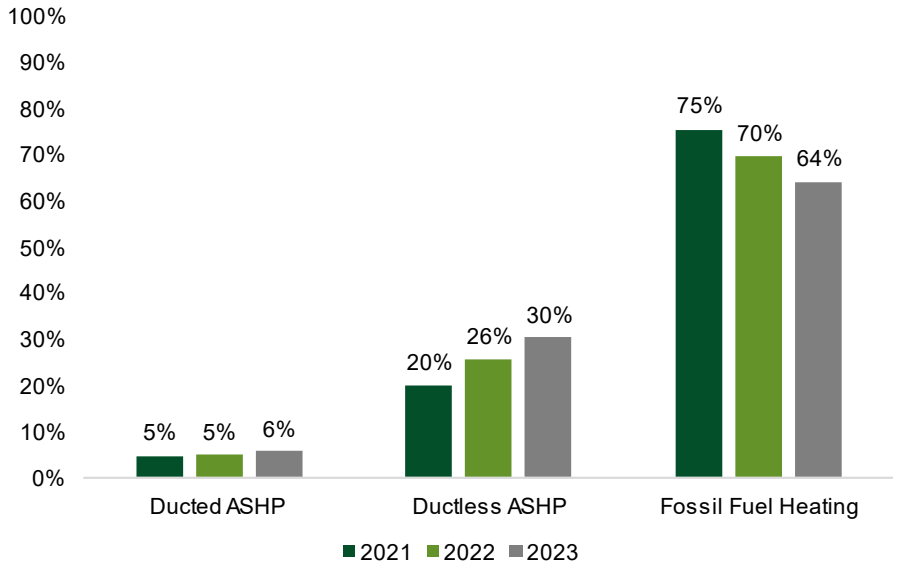
2023 heat pump market share increased in both the res and commercial sectors

- However, progress continued to be much faster for res and space heating than C&I and water heating
- Remainder of results focus largely on res space heating and cooling

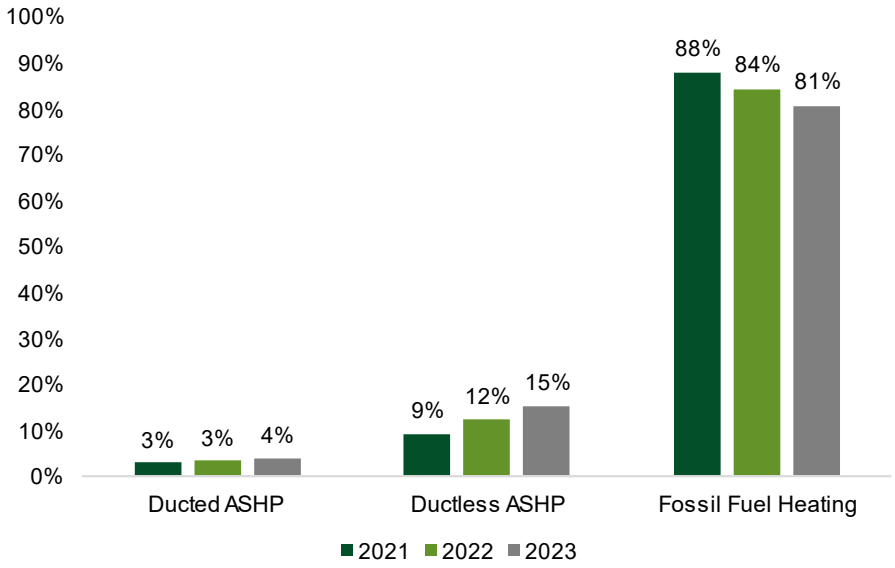
Preponderance of evidence suggests PAs' support contributed substantially to market growth

RESIDENTIAL HEAT PUMPS: TWO DIFFERENT PERSPECTIVES ON HEATING EQUIPMENT MARKET SHARE

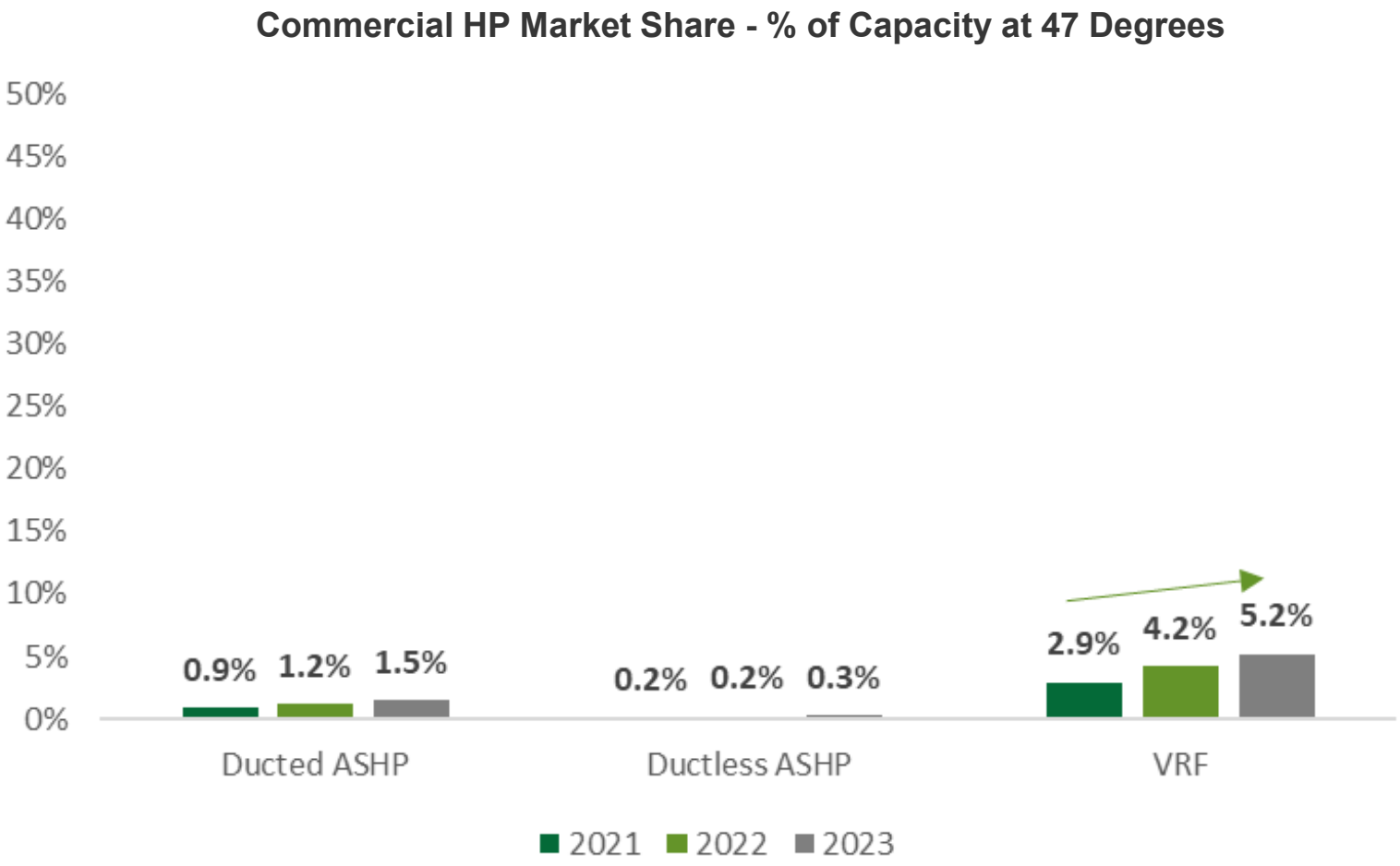
Market Share - % of Units



Market Share – % of Capacity at 47 degrees



COMMERCIAL HEAT PUMPS: HEATING EQUIPMENT MARKET SHARE



PARTICIPATING RESIDENTIAL CONTRACTORS: HIGHLIGHTS ON CHANGES IN KEY MARKET INDICATORS 2023-2024

Consistent with Program Theory

- **Growth in HPIN**
- **Contractors sizing HPs more carefully; significant increases in:**
  - % saying they always use Manual J when sizing systems
  - % saying they always select a unit that is as close as possible to Manual J result
- **More likely to report often or always recommending HPs for heating**
- **More or level reported satisfaction with a range of HP attributes**

Inconsistent with Program Theory

- **Declining contractor confidence in full displacement HP projects**
  - % agreeing that CCHPs are good full replacements for fossil fuel systems
    - Down from 50% in 2023 to 24% in 2024
  - % satisfied with ability of CCHPs to meet heating needs even on the coldest days
    - Down from 63% to 52%
  - Predictors of skeptical attitudes:
    - Larger contractors
    - More experienced contractors
    - Contractors also reporting increase in HP callbacks

MINISPLITS VS CENTRAL DUCTED

	Minisplit Heat Pumps	Central Ducted Heat Pumps
Cumulative 2021-2023 growth in market share (Capacity @47)	67%	33%
2023 program market penetration	63%	93%
Contractors who always recommended when appropriate	94%	66%

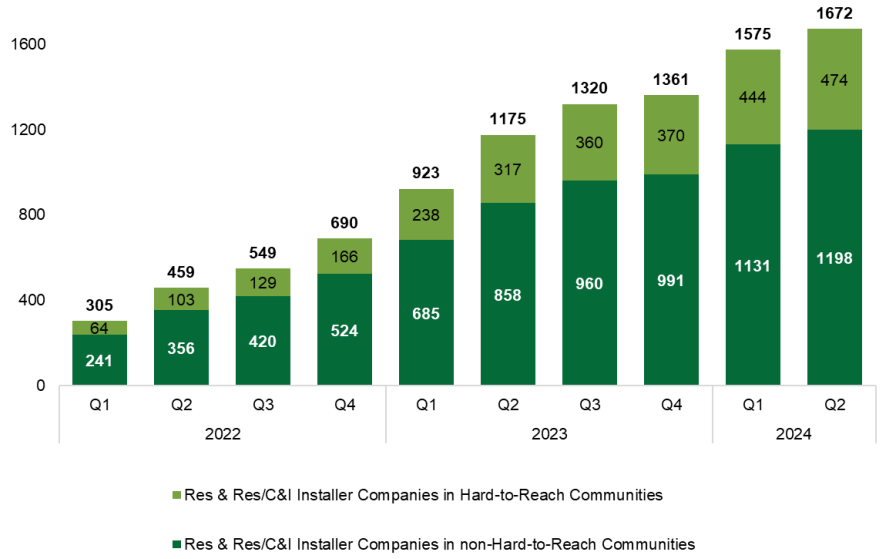
Market sizing results suggest that installers may be recommending ductless systems to replace failing central air conditioners, despite existing duct work.

HP ME STUDY RESULTS, RESIDENTIAL: DISTRIBUTOR MARKET INDICATORS

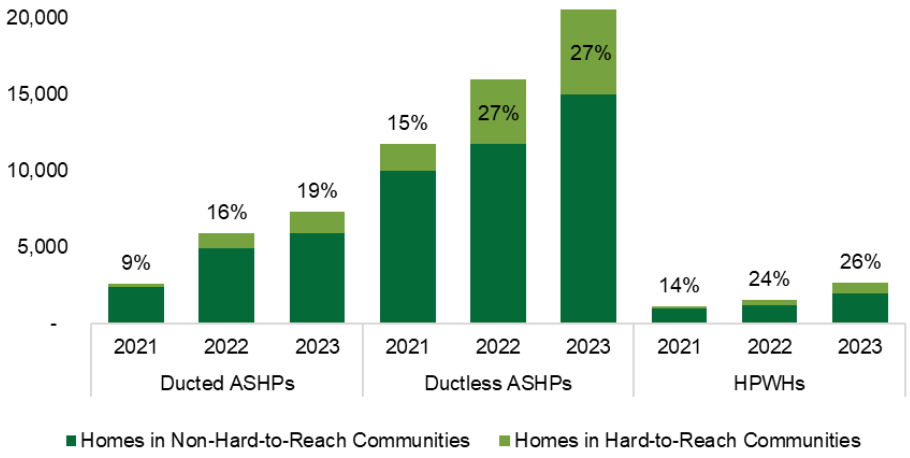
- **For the third year in a row, distributors continue to report shifting their stocking practices toward heat pumps**
  - In 2024 compared to 2023:
    - Cooling equipment: virtually all distributors stocked more HPs
    - Water heating equipment: 63% of distributors stocked more HPs

EQUITY INDICATOR: ACTIVITY IN HTR COMMUNITIES AS PERCENTAGE OF STATEWIDE IS STEADILY INCREASING

HTR Communities vs Rest of State: HPIN Contractors

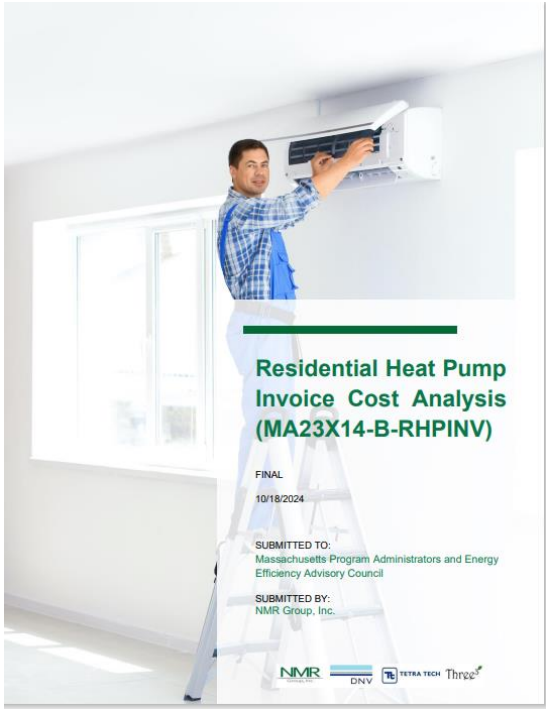


HTR Communities vs Rest of State: Rebates



RESIDENTIAL INVOICE TRACKING STUDY

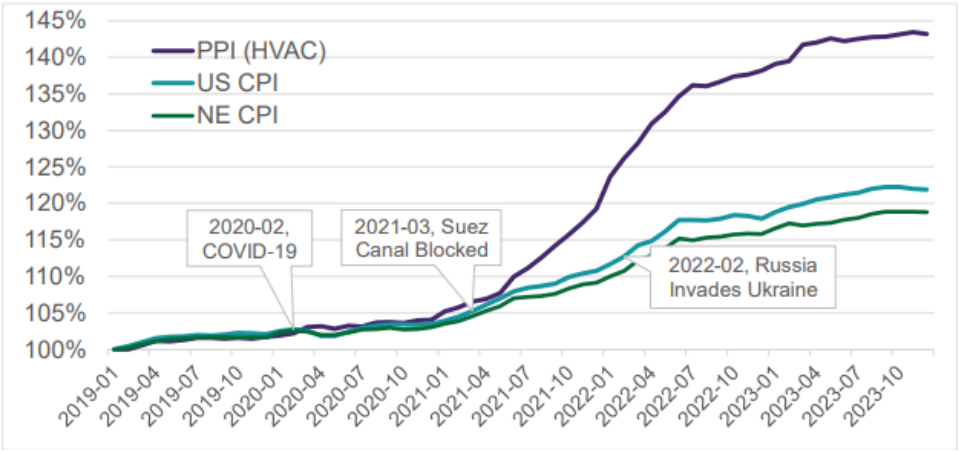
- **Heat pump project cost info needed to:**
  - Quantify incremental costs for purposes of cost-effectiveness analysis
  - Understand whether program activity is affecting prices (either positively or negatively)
- **Project developed a repeatable approach to tracking price trends, and analyzed trends for 2019 through 2022-2023**
  - Results generally inflation adjusted and normalized to per-ton basis
- **Two data sources:**
  - Primary: Contractor invoices
    - Extensive info on project costs, but previously inaccessible due to format and inconsistencies in content
  - Secondary: Web-scraping
    - Large-scale downloading of price data from vendors who list prices on-line
- **Next annual update already underway**



INVOICE TRACKING STUDY: SUMMARY OF RESULTS

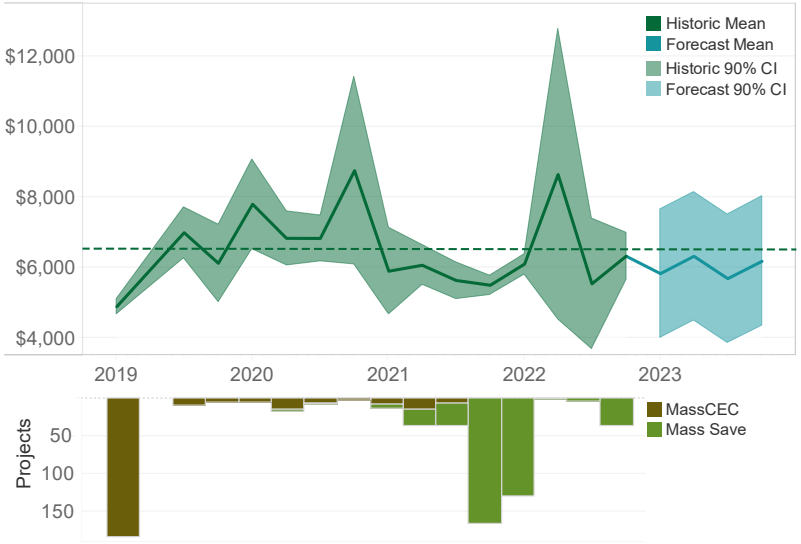
- **Retail prices showed the following trends:**
  - Equipment costs increased more rapidly than overall inflation rate
  - Distribution of project costs shifted toward equipment and away from labor
  - Trends in total project costs were mixed
    - Minisplits: slight increase
    - CHP and GSHP: no significant trend
- **So what was behind the increase in equipment costs?**
  - Global market factors such as supply chain interruptions played a clear role
  - Program-induced effects cannot be ruled out as a contributor, but little indication of this thus far
  - Follow-up study now in progress is digging more deeply into drivers of any ongoing price changes

Figure 2: Price Index Comparisons

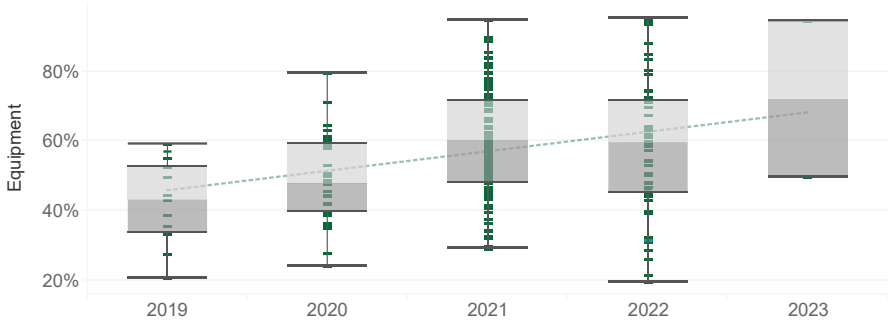


INVOICE TRACKING STUDY
EXAMPLES OF DETAILED RESULTS:
TRENDS IN MINISPLIT PROJECT COSTS

Minisplits: Total Project Costs

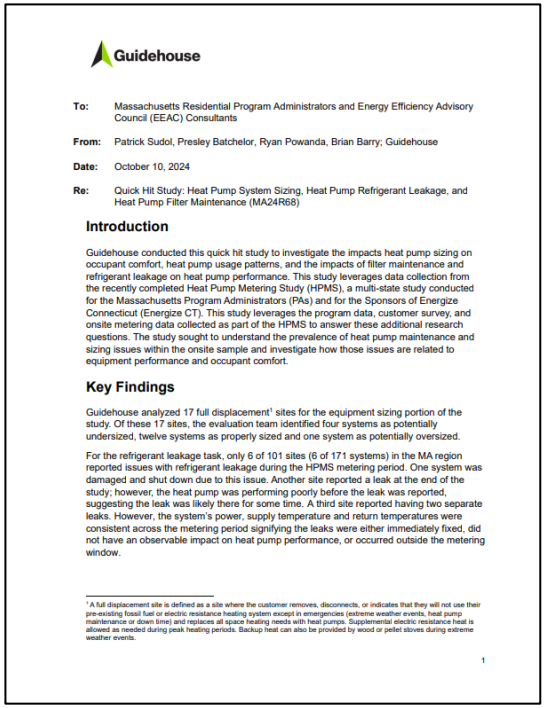


Minisplits: Equipment Portion of Total Project Cost



HEAT PUMP SIZING, REFRIGERANT LEAKAGE, AND FILTER MAINTENANCE STUDY

- **Study assessed the frequency and impact of three issues that can affect performance:**
  - Over- and under-sizing
  - Refrigerant leakage
  - Filter maintenance problems
- **Specific data used and analysis techniques varied across issues but included:**
  - Survey data
  - Performance trends over time
  - Equipment and home size
  - Run-times under different weather conditions



Guidehouse

To: Massachusetts Residential Program Administrators and Energy Efficiency Advisory Council (EEAC) Consultants

From: Patrick Sudol, Presley Batchelor, Ryan Powanda, Brian Barry; Guidehouse

Date: October 10, 2024

Re: Quick Hit Study: Heat Pump System Sizing, Heat Pump Refrigerant Leakage, and Heat Pump Filter Maintenance (MA24R68)

Introduction

Guidehouse conducted this quick hit study to investigate the impacts heat pump sizing on occupant comfort, heat pump usage patterns, and the impacts of filter maintenance and refrigerant leakage on heat pump performance. This study leverages data collection from the recently completed Heat Pump Metering Study (HPMS), a multi-state study conducted for the Massachusetts Program Administrators (PAs) and for the Sponsors of Energize Connecticut (Energize CT). This study leverages the program data, customer survey, and onsite metering data collected as part of the HPMS to answer these additional research questions. The study sought to understand the prevalence of heat pump maintenance and sizing issues within the onsite sample and investigate how those issues are related to equipment performance and occupant comfort.

Key Findings

Guidehouse analyzed 17 full displacement[1] sites for the equipment sizing portion of the study. Of these 17 sites, the evaluation team identified four systems as potentially undersized, twelve systems as properly sized and one system as potentially oversized.

For the refrigerant leakage task, only 6 of 101 sites (6 of 171 systems) in the MA region reported issues with refrigerant leakage during the HPMS metering period. One system was damaged and shut down due to this issue. Another site reported a leak at the end of the study; however, the heat pump was performing poorly before the leak was reported, suggesting the leak was likely there for some time. A third site reported having two separate leaks. However, the system's power, supply temperature and return temperatures were consistent across the metering period signifying the leaks were either immediately fixed, did not have an observable impact on heat pump performance, or occurred outside the metering window.

[1] A full displacement site is defined as a site where the customer removes, disconnects, or indicates that they will not use their pre-existing fossil fuel or electric resistance heating system except in emergencies (extreme weather events, heat pump maintenance or down time) and replaces all space heating needs with heat pumps. Supplemental electric resistance heat is allowed as needed during peak heating periods. Backup heat can also be provided by wood or pellet stoves during extreme weather events.

1

SIZING, REFRIGERANT LEAKAGE AND FILTER MAINTENANCE STUDY: RESULTS

Refrigerant Leakage

- Out of 101 total sites analyzed for this task, 6 reported refrigerant leakage
- Sites varied in the observable impacts on performance
- Analysis wouldn't have captured leaks too gradual for homeowners to notice

Sizing

- Out of 17 full-displacement sites analyzed, 4 were deemed potentially under-sized and 1 potentially over-sized
- EEAC consultants advise caution in interpreting this particular result
  - Some data limitations
  - Small sample sizes

Filter maintenance

- Out of 46 sites analyzed, 11 had observable impacts to supply air temperatures due to filter cleanliness issues

SIZING, LEAKAGE, AND FILTER MAINTENANCE RESULTS, CONT.

- **For leakage and filter maintenance, additional analyses took a top-down approach**
  - Comparing system performance for all cases with sufficient data to the specific cases identified as having issues

Analysis of performance trends over time found that:

- Not all cases that had leakage or filter issues had decreases in performance over time
- A few sites without observed leakage or filter issues did have decreases in performance over time, suggesting undiagnosed issue

For sites with enough data to quantify system performance, no statistically significant effects found from the three issues

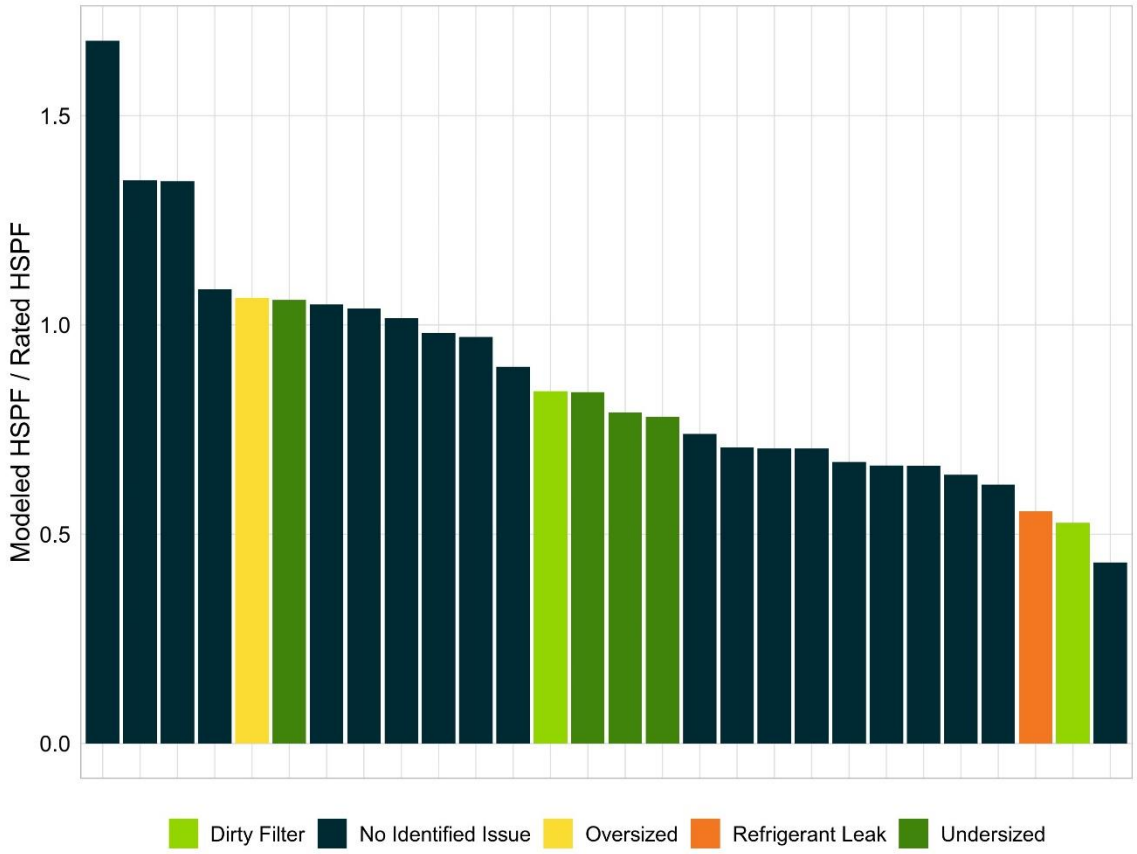
- See graphic next slide

Results seem to suggest that leakage and filter maintenance are both moderate issues

- Not severe, but not trivial either

SIZING, LEAKAGE AND FILTER MAINTENANCE ISSUES: A VISUAL DEPICTION OF IMPACT ON OVERALL PERFORMANCE

Performance sites: modeled vs rated performance



BROADER CONTEXT: STUDIES DISCUSSED TODAY ARE ONLY A SMALL SUBSET OF KEY ONES COMPLETED IN THE LAST 12 MONTHS

RESIDENTIAL AND CROSS-CUTTING

- Residential Energy Storage DR Study (March 2024)
- Heat Pump Market Effects Baseline Study (April 2024)
- Minority- and Women-Owned Business Enterprise Study (July 2024)
- Heat Pump Metering Study (August 2024)
- RCD Impact Evaluation (August 2024)
- RNC Baseline Study (September 2024)
- Income Eligible Impact Evaluation (September 2024)
- Income Eligible Process Evaluation (October 2024)
- 2013-2022 Residential Non-Participant Study (October 2024)
- **Heat Pump Sizing, Refrigerant Leakage, and Maintenance Study (October 2024)**
- **Residential Heat Pump Invoice Tracking Study (October 2024)**
- LI Battery NEI Study (December 2024)
- **2023-2024 Heat Pump Market Effects Study (February 2025)**

COMMERCIAL

- Impact Loadshape Study (February 2004)
- Process Evaluation of Custom Pathway (April 2004)
- C&I Existing Buildings Baseline Study (May 2004)
- Non-Residential New Construction NTG Study (June 2004)
- C&I Electric NTG Study (June 2024)
- Custom Electric Impact Evaluation (July 2004)
- Energy Optimization Model Update (September 2024)
- C&I Non-Participant Study (December 2024)

Additional Studies can be found at: https://ma-eeac.org/studies/

Thanks!

Ralph Prahl
EEAC Consultant Team Lead for EM&V
Ralph.Prahl@gmail.com
(608) 334-9942

February 14, 2024