MA ENERGY EFFICIENCY ADVISORY COUNCIL

→ CONSULTANT TEAM

EEAC EM&V BRIEFING

February 14, 2024

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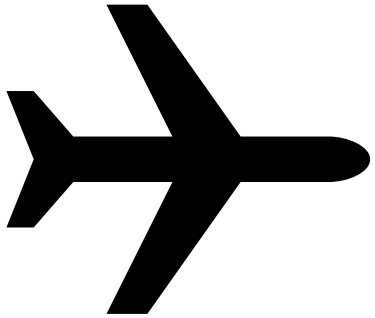
Heat Pumps (HP) and Electrification: Recent EM&V Results

HEAT PUMPS AND ELECTRIFICATION: STUDIES DISCUSSED IN THIS PRESENTATION

Study	Issues Addressed	Status
Heat Pump Market Effects Baseline Study and Interim Study	• Comprehensive picture of entire MA heat pump market (not just participants) in 2021-2022 • Market and program progress • Validity of program theory • Attribution assumptions	*Draft report*, January 2024
Residential Heat Pump Integrated Controls Study	• Effectiveness of program approach to promotion of integrated controls for residential HPs	*Completed*, October 2023
Residential Heat Pump Metering Study	• Gross savings for residential HP measures • Usage patterns • Performance in cold temperatures	*Partial draft results*, January 2024
C&I Energy Optimization Tool Update Study	• Gross savings for prescriptive C&I HP measures	*Completed*, November 2023
Custom Retrofit Electrification Study	• Gross savings for custom retrofit electrification measures	*Completed*, October 2023
Residential HP NEI Study	• Participant NEIs for residential heat pump measures	*Completed*, July 2023

RECENT EM&V RESULTS ON HEAT PUMPS: THE 30,000-FOOT VIEW



- **At a macro level, residential HP markets are showing encouraging progress**
  - Commercial sector and heat pump water heaters are getting somewhat slower traction

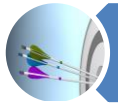
- **Some bumps in the road on specific issues**
  - Some initial over-estimation of gross unit impacts
  - Promotion of integrated controls

HEAT PUMP MARKET EFFECTS STUDIES

- **For the 2022-2024 triennium, the parties agreed to treat heat pump programming as a Market Transformation Initiative (MTI)**
  - A program theory was developed specifying how HP programs were envisioned as changing the market over time
  - To reflect hoped-for market effects, the parties agreed on negotiated net-to-gross assumptions of up to 120%
- **Given these agreements, EM&V has focused on understanding the effects of the programs on heat pump markets**
  - Both Res and C&I
- **Two closely related studies**
  - Heat Pump Market Effects Baseline Study examines status of HP markets as of 2021
  - Heat Pump Market Effects Interim Study looks at market changes 2021-2022
  - Jointly, the two studies assess market and program progress, review program theory, and inform NTG assumptions for 2025-2027
  - Henceforth referred to here as HP ME Study

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

- **Distinguishes between:**



Activities, outputs, and outcomes

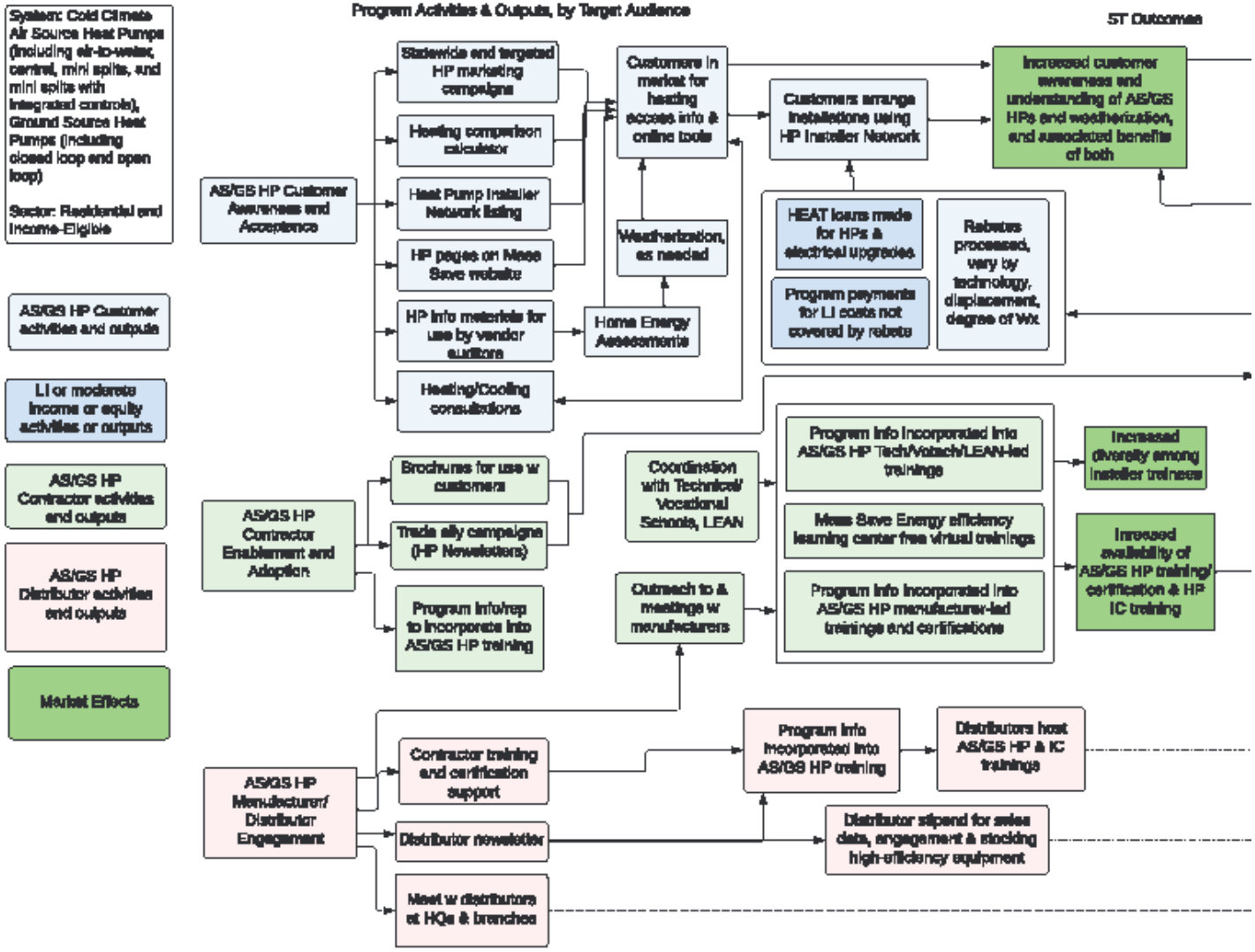
Short-term, medium-term, and long-term outcomes

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**

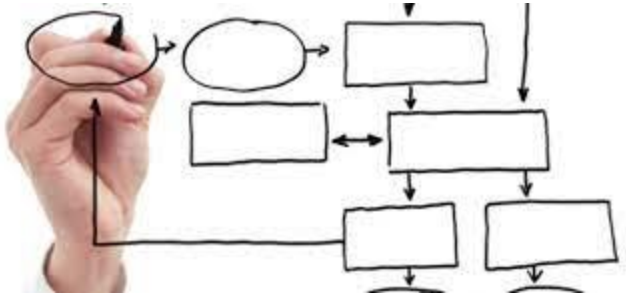
End Users	Contractors	Distributors
Increased awareness and understanding	Training and HPIN	Program activities and other market changes
↓	↓	↓
Favorable word of mouth, leading to changes in preferences	Changes in practices, new market entrants, and business strategies	Changes in stocking practices, leading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

HP MT PROGRAM THEORY: ILLUSTRATIVE EXCERPT FROM RES ASHP LOGIC MODEL



HP ME STUDY: METHODS

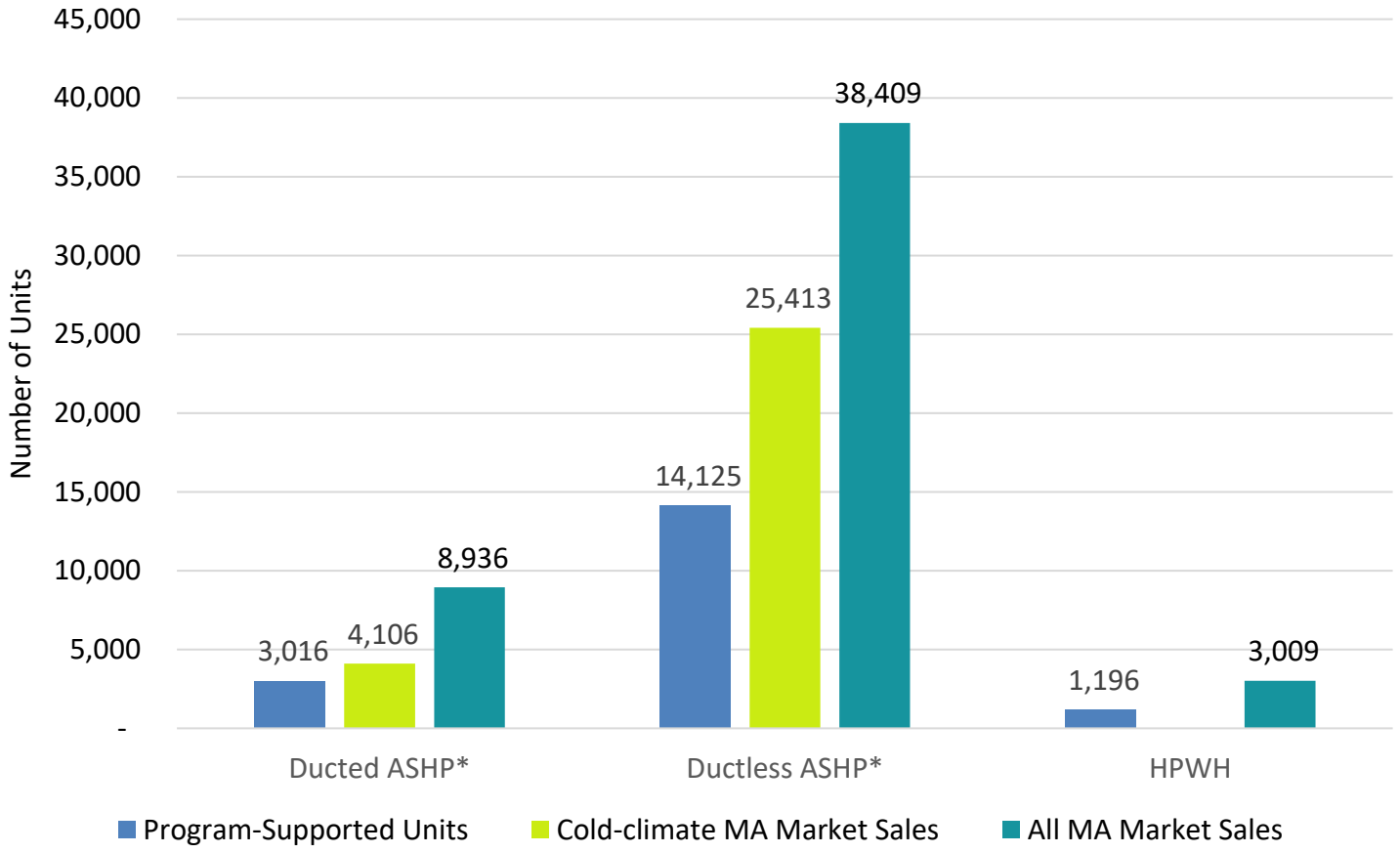
- **Evaluations of market transformation initiatives must:**
  - Seek to understand the effects of program on entire market – not just participants
  - Recognize that market transformation typically takes a long time
  - Be guided by the program theory
    - What specific changes in the market were predicted and when?
    - Did these occur as forecasted?
    - Do the posited causal linkages between different changes appear valid?
- **Accordingly, HP ME study drew on a wide range of data sources**
  - Interviews with Participating (P) and Non-Participating (NP) manufacturers, distributors, contractors, and end-users
  - Sales tracking data
  - Program tracking data
  - Comparison state data (Ohio)
  - Coordination with other MA EM&V studies



HP ME STUDY RESULTS: AN OVERVIEW

- **The programs are generally conducting the activities called for by the program theory**
- **Particularly for residential heat pumps, these activities are generally yielding the early outputs called for by the program theory**
  - Commercial sector and residential HPWH are tending to lag
  - Remainder of this discussion focuses primarily on residential HPs
- **While it is very early to look for market effects, we already appear to be seeing some for residential HPs**
- **Attribution for a market transformation initiative needs to adopt a longer-term perspective, but near-term indicators on attribution in residential sector are encouraging**

HP ME STUDY RESULTS: IN- VS OUT-OF-PROGRAM RES HP SALES IN 2021



Source: NMR draft report

A SNAPSHOT OF THE MA RESIDENTIAL HP MARKET, 2021-2022

Residential Equipment Type	% of Sales - All HP Systems		% of Space Heating Only HP Sales*		% of Space Cooling Only Sales		2021 Program Penetration	Increase In Program-Supported Units 2021 - 2022	Increase in HP Sales 2021-2022
	Unit	Ton	Unit	Ton	Unit	Ton			
Space Conditioning									
Ducted ASHPs	5%	3%	5%	3%	6%	8%	34%	123%	10%
Cold-climate ducted ASHPs									14%
Other ducted ASHPs									8%
Ductless ASHPs	20%	9%	17%	8%	27%	24%	37%	34%	34%
Cold-climate ductless ASHPs									31%
Other ductless ASHPs									40%
Central Air Conditioners					66%	68%			
Fossil Fuel-fired Heating	75%	88%	78%	90%					
Water Heating									
HPWH	2%						40%	38%	41%
Fossil Fuel-fired & Electric Resistance Water Heaters	98%								

Source: NMR draft report

*Excluding Cooling-Only

HP ME STUDY RESULTS, RESIDENTIAL: END-USER MARKET INDICATORS

- **Satisfaction with HPs is generally good**
  - Better for participants than non-participating heat pump purchasers, suggesting program makes a difference for this outcome
- **2021-2022 saw the following favorable increases among participants:**
  - Attention to weatherization
    - Percentage of HP participants reporting their contractor talked to them about weatherization (2021: 47%; 2022: 56%)
    - Percentage of HP participants reporting weatherizing their home before or at the same time as installation (2021:56%; 2022: 64%)
  - Frequency of full-displacement of fossil fuel systems
  - Participants reporting their contractor recommended use of HP for most heating needs, even on coldest days
  - Self-reported attribution
- **2021-2022 saw an increase in awareness of heat pumps among non-HP participants**
  - Suggests the message is getting out

HP ME STUDY RESULTS, RESIDENTIAL: CONTRACTOR MARKET INDICATORS

- **HPIN rapidly growing**
- **Participating contractors represent at least 75% of all HVAC equipment installations**
- **Portion of HPIN contractors in EJ communities is growing**
- **Contractor satisfaction with HPs generally good, with some exceptions in specific areas**
  - Callbacks, maintenance, and ability to meet heating needs on coldest days

- **Among participating contractors as of 2023:**
  - Majority report often recommending HPs for heating as well as cooling
  - 50% agree cold-climate ASHPs are good full replacements for oil, propane, and gas heating systems
  - 62% report being satisfied with the ability of cold-climate ASHPs to meet customer space heating needs even on the coldest days
  - Only (27%) agreed that that ductless heat pumps should be used only for cooling

HP ME STUDY RESULTS, RESIDENTIAL: DISTRIBUTOR MARKET INDICATORS

- **Between 2021-2022, many participating distributors shifted their stocking practices toward carrying more heat pumps**
  - More than half increased stocking of heat pumps at the expense of non-HP cooling equipment
  - More than 1/3 increased stocking at the expense of non-HP heating equipment
- **Participating distributors account for the vast majority of total residential HVAC sales**
- **Thus, the distributor stocking practices experienced by the typical contractor and residential end-user probably shifted toward HPs**
- **Distributors attribute these changes largely to the programs**

HP ME STUDY RESULTS, RESIDENTIAL: MANUFACTURER MARKET INDICATORS

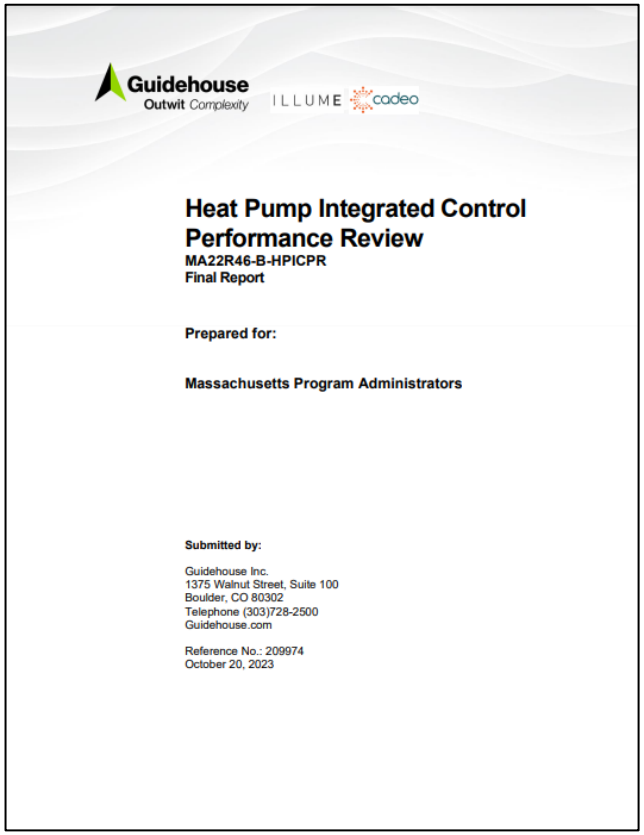
- **Manufacturers report total sales of residential HPs in MA are increasing about 1.6 times as fast as comparison state of Ohio**
- **Manufacturers anticipate that as a result of the programs, MA will be better positioned than most other states to take advantage of IRA funding**

HP ME STUDY RESULTS, RESIDENTIAL: EVIDENCE ON NEAR-TERM ATTRIBUTION

- **Findings regarding near-term attribution for residential HPs are generally encouraging**
  - Self-reported attribution by participants is fairly high by historical standards, and increasing
  - Contractors and distributors report that a substantial portion of their sales would not have occurred in the absence of the program
  - There are a substantial number of out-of-program sales of HPs, which creates a mechanism for potential spillover effects
    - Roughly 2/3 of all residential HP sales are in-program
    - However, out-of-program units tend to be lower-displacement and used less for heating
  - Manufacturers report that HP sales are increasing much more quickly in MA than in comparison state of Ohio

RESIDENTIAL HEAT PUMP INTEGRATED CONTROLS STUDY

- **Examined the effectiveness of program efforts to support the adoption of integrated controls (ICs) for residential minisplits**
  - Technical performance of ICs
  - End-user and contractor usage and acceptance
- **Methods**
  - Product secondary research
  - Contractor and manufacturer interviews
  - End-user surveys and interviews
- **Study completed October 2023**


Guidehouse
Outwit Complexity
ILLUME
cadeo

Heat Pump Integrated Control Performance Review
MA22R46-B-HPICPR
Final Report

Prepared for:

Massachusetts Program Administrators

Submitted by:

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Reference No.: 209974
October 20, 2023

RESIDENTIAL HEAT PUMP INTEGRATED CONTROLS STUDY: RESULTS

- **Study results indicate that there are significant problems surrounding the current approach to promoting ICs for minisplits**

  - A substantial portion of ICs are being installed in circumstances that don't require them, solely in order to receive the rebate
  - Many customers who installed them are either not using them, not using them as intended, overriding them, or have removed them entirely
    - The HP ME study estimated that, for ICs installed in 2021, by 2023 only 35% of them were in place and being used
  - Participant satisfaction with ICs is relatively low, even though satisfaction with HPs themselves is high
  - Some IC models have issues with connectivity and/or the app
  - Contractors tend to be skeptical of ICs, due in part to awareness of the above issues

RESIDENTIAL HEAT PUMP INTEGRATED CONTROLS STUDY: STUDY RECOMMENDATIONS

Ensure that the program clearly articulates the use case for partial displacement ICs, along with associated program requirements

Enhance contractor training on ICs

Provide more educational resources to customers

Keep current mix of IC products in the Qualified Products List

Beyond these study recommendations, are more basic changes to the programs' approach to promoting ICs needed?

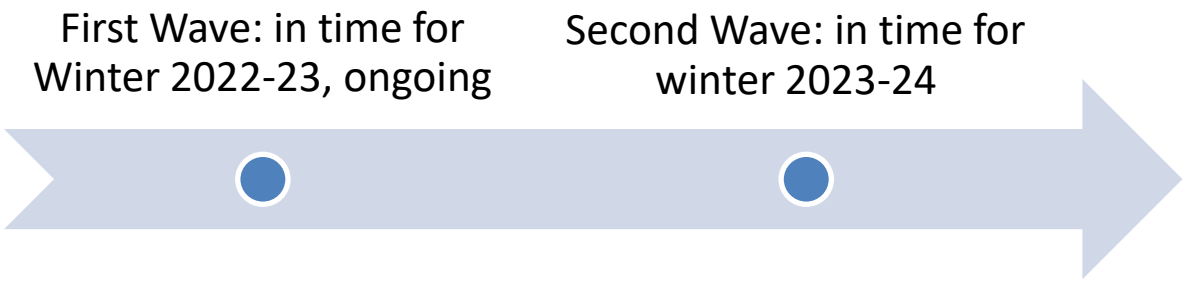
RESIDENTIAL HEAT PUMP METERING STUDY

- **Rigorous multi-state end-use metering study aimed at understanding:**
  - Usage patterns
  - Performance (particularly in cold weather)
  - Baselines

- **Features:**
  - End-use metering of wide range of HP systems (185 homes)
  - Additional dedicated LMI sample
  - Larger super-sample of participant interviews
  - Additional fast feedback surveys during cold snaps to understand occupant behavior and satisfaction
- **Results will be used to:**
  - Recommend changes to program design and implementation to enhance impacts
  - Make recommendations regarding prospective savings assumptions

HP METERING STUDY: STATUS

- **Two waves of metering installations**



- **Originally scheduled to run through Fall 2024, but accelerated in response to acceleration of 3YP planning process**
  - Draft final report in April, final in May, with a later supplement
  - Only partial draft results are available now
    - Participant survey and interview results
    - Metering results for a portion of first wave cases, for the first year of operation only (excluding winter 2023-2024)
  - While it is important not to over-interpret these limited results, they do suggest some potentially important insights

HP METERING STUDY: EARLY RESULTS

- **Limited results to date suggest some shortfalls in ex-post MMBtu savings relative to ex-ante savings forecasts**
  - Full Displacement (FD) CHPs: 15% shortfall
  - Partial Displacement (PD) minisplits: 36% shortfall
  - Full Displacement (PD) minisplits: no shortfall
- **Primary driver of these shortfalls appears to be lower displacement of fossil fuel heating than had been forecast**
  - In turn, likely causes of lower-than-forecasted displacement include:
    - For minisplits:
      - Some units being used for cooling only
      - Some units with higher heating switchover temperatures than forecasted, due in part to the issues with integrated controls discussed earlier
    - For central heat pumps:
      - Some units reported as FD that were actually PD
      - The latter issue may already have been addressed by the recent change to require disconnection of old equipment for FD projects

HP METERING STUDY: EARLY RESULTS, CONTINUED

- **Equipment performance and occupant comfort during coldest weather**
  - Too early to reach many conclusions, but little indication to date of any major problems
  - 2nd fast-feedback survey currently in field to assess participant comfort and satisfaction during relative cold-snap in January 2024
- **Many participants continue to be motivated largely by a desire to add or improve cooling**
  - Because heating load is so much higher than cooling load in MA, this is a relatively small factor from an MMBtu impact perspective
  - Under NEI study completed earlier in 2023, improvement of cooling now receives substantial NEI credit – so even less impact on BCR
  - However, participants who are motivated by cooling may need to be persuaded to use the HP for heating

HP METERING STUDY: WHAT SHOULD WE MAKE OF THESE EARLY RESULTS?

- **Caution is called for**
  - Only a small portion of the full dataset reflected so far
  - HP offerings have been evolving
  - Some of the specific issues observed in 2022 cases may already have been addressed by program changes
- **Nonetheless, the results are a reminder that for us to get the MMBtu impacts we want from heat pumps, several things have to go right**
  - The equipment needs to be used extensively for heating
  - Integrated controls need to work as intended
  - Equipment needs to perform in the coldest weather
  - Savings forecasts need to recognize that HPs are a great way for customers to improve their cooling in a time of climate change
- **Much more extensive results expected in April**

C&I ENERGY OPTIMIZATION TOOL UPDATE STUDY

- **C&I EO Tool drives savings assumptions for most prescriptive commercial HP measures**
- **Previous version of tool was quite limited**
  - Developed in an era when heat pumps were more of a niche measure
- **This study made major improvements**
  - Engineering simulations informed by analysis of program tracking data, secondary data, and a participant survey
- **Results**
  - Savings assumptions revised downward for most delivered fuel measures
  - Drivers are better underlying data and more rigorous engineering methods
  - Results have been applied for PY24
  - Savings estimates for commercial electrification in 2025-2027 will be on more solid ground

C&I CUSTOM RETROFIT ELECTRIFICATION IMPACT EVALUATION

- **Purpose of study was to develop more defensible realization rate (RR) for custom retrofit electrification projects**
- **For custom measures, initial ex-ante savings estimates need to be developed with limited information**
  - Limited information means actual savings can differ significantly from predictions
  - Impact evaluations of custom programs focus on how actual savings relate to ex-ante predictions
  - RR quantifies that relationship
  - RR gets applied to future projects in order to improve accuracy of reported savings
- **Results**
  - RR in the neighborhood of 80%
  - Results have been applied for PY24

CONCLUSIONS

- **EM&V results suggest that overall progress with heat pump markets to date is encouraging**
- **However, there have been a few bumps in the road**
  - Some issues with promotion of integrated controls
  - Some initial (inadvertent) overstatement of gross MMBtu impacts
  - Slower traction in commercial sector than for residential
- **This is not surprising**
  - Heat pumps are a complex technology, and heat pump markets are also complex
  - Electrification via HPs has ramped up quickly in MA
- **There is an opportunity to take satisfaction in market progress to date, while focusing on fixing the bumps in the road**

AND COMING SOON…

Heat pump results

- Full results on residential HP metering study
- Dedicated study on trends in HP pricing

Selected other final EM&V reports

- Minority and Women-Owned Business Enterprise (MWBE) study
- C&I Custom Program Process study
- C&I Existing Building Baseline Study

Thanks!

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February 14, 2024