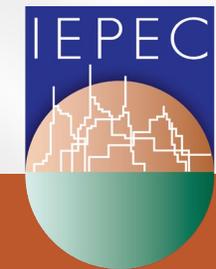


Cool Data. Hot Results.
**A Summary of a Comprehensive
Heat Pump Metering Study Across
185 Homes in Massachusetts
and Connecticut**

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Study Scope

1. **Investigate the performance, usage, and peak demands for heat pumps** incentivized through the Massachusetts & Connecticut residential programs.
2. **Investigate full and partial displacement heat pump usage patterns**, including portion of heating loads met by HPs, HVAC operational behavior and control usage
3. **Assess customer experience**, including overall satisfaction with HPs and their HP's ability to meet the heating needs of the home at low temperatures
4. **Update heat pump savings estimates** in the Massachusetts Technical Reference Manual and the Connecticut Program Savings document (electric consumption increase, fuel savings)

Both programs included two offerings:

Full Displacement: Heat pumps intended to fully displace pre-existing oil, propane, gas, or electric resistance baseboard heating systems. Customers agree to disconnect or remove backup heat.

Partial Displacement: Backup heating system is left in place, and customers are required to install an integrated control to modulate operation of HP and backup heating system based on outdoor air temperature.

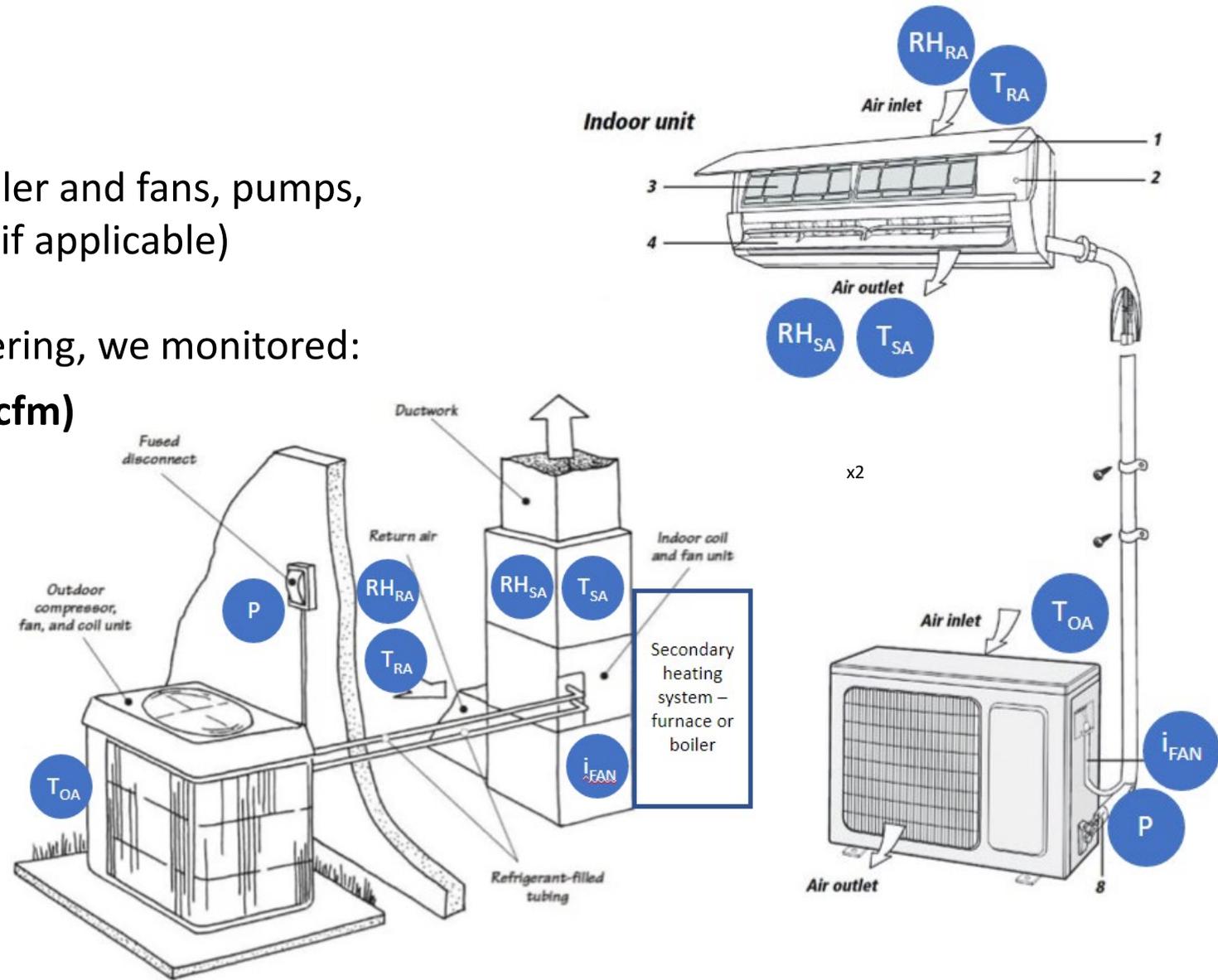
Metering Setup

At each home, we measured:

- **Power** - heat pump compressor, air handler and fans, pumps, and electric resistance auxiliary heating (if applicable)

For homes with additional performance metering, we monitored:

- **Fan amperage, correlated with airflow (cfm)**
- Indoor **supply** and **return** air temperatures and relative humidity
- **Outdoor air temperature**



Sample Sizes

185 total sites in the metering sample collecting heat pump usage data. 106 of the sites included additional metering for performance calculations.

50 sites installed in Fall 2022 with remaining in Spring/Summer 2023. Uninstalled in Spring 2024.

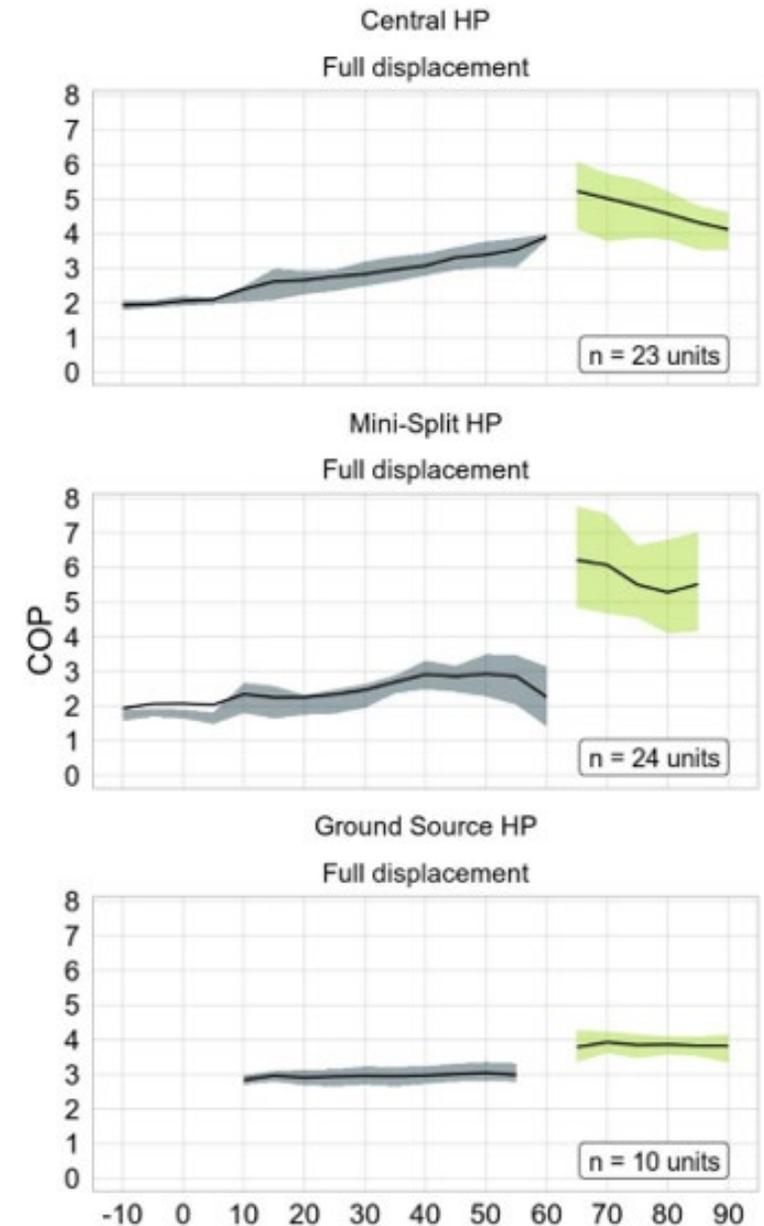
Study also included two customer surveys (preliminary – 1,456 responses, end of season – 136 responses).

System Type	Displacement Scenario	Sites Installed in Massachusetts	Sites Installed in Connecticut	Full Sample	Performance Sub-Sample
Mini-Split Heat Pump	Full	35	16	51	38
	Partial	23	8	31	7
Central Heat Pump	Full	30	10	40	34
	Partial	12	25	37	15
Ground Source Heat Pump	Full	1	25	26	12
		101	84	185	106

Performance Findings

Performance vs. Temperature

- These **COP values summarize average heat pump efficiencies during compressor 'on' periods** in heating or cooling mode (do not include defrost cycles, auxiliary electric usage, or fan-only operation).
- **COP decreased as outdoor air temperature (OAT) decreased, trending towards a COP of 1.5 to 2.0 at 0 to -10°F.**
- **Ground source heat pump COP relatively consistent at 3.0.**
- Heat pump COPs are higher in the cooling season, decreasing as temperature increases.



Seasonal Efficiency Values

- **Seasonal efficiency values include energy consumed by all modes of operation** (heating, cooling, fan only, defrost, standby, dehumidification, and aux electric heat).
- In Situ **Heating Season Performance Factor (HSPF)** values are comparable to rated **HSPF2** values for the metered units
- Cooling season **SEER** values were generally lower than rated.

Heat Pump Type	Average In Situ HSPF	Average Rated HSPF	Average Rated Region IV HSPF2*	Average Rated Region V HSPF2*	Systems Included (n)
Central HP	8.7	10.2	8.9	6.7	83
Mini-Split HP	9.5	11.1	10.1	7.8	113

*Region IV = coastal portion of CT and MA, western portion of CT

*Region V = western portion of MA and the Central/North region of CT

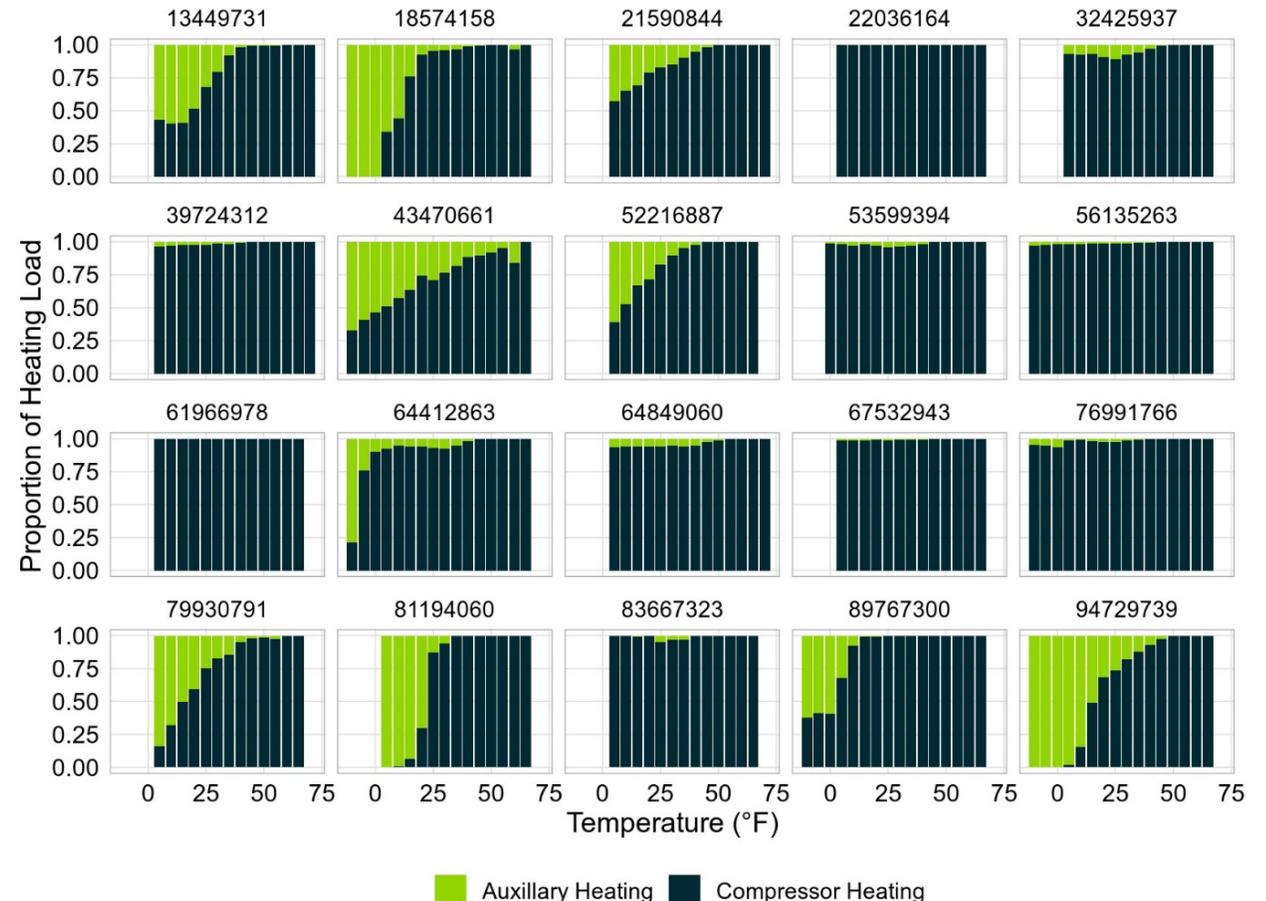
Portion of Heating Load Met by Heat Pumps

- **Heat pumps met a large majority of the heating load** in full displacement applications (86-99%) and partial displacement applications (65-79%)
- **Variability in usage** driven primarily through **manual operations of the heat pumps** (such as turning the units on and off), use of customer’s **backup heating systems**, even for homes that were intended to be ‘Full Displacement’, and use of installed **integrated controls (ICs)** with varied switchover temperatures.

		Portion of Heating Load Met		
Heat Pump Type	Displacement Scenario	Heat Pump	Auxiliary Electric Heat	Backup Heating Systems
Central HP	Full	86%	4%	10%
Central HP	Partial	65%	0%	34%
Mini-Split HP	Full	91%	0%	9%
Mini-Split HP	Partial	79%	0%	21%
Ground Source HP	Full	99%	0%	1%

Auxiliary Electric Heating – Full Displacement Installs

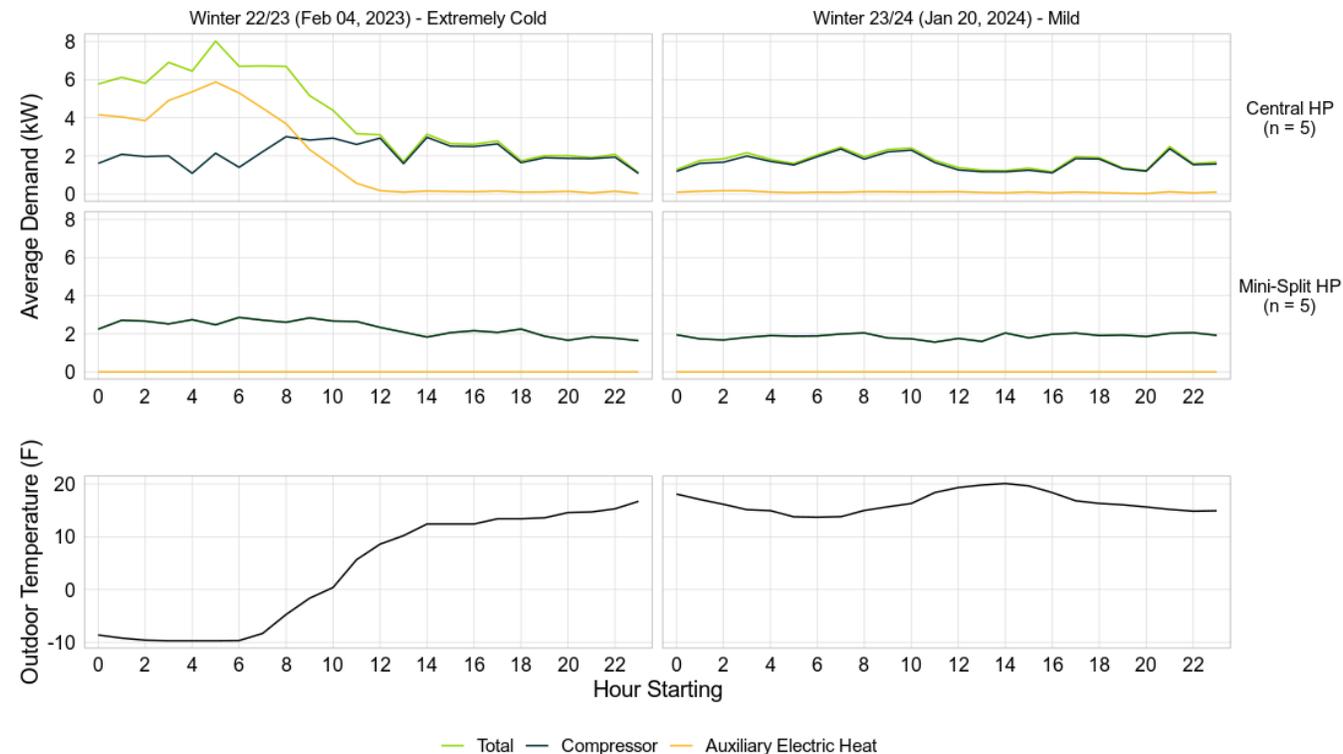
- **Central air source HP is the only unit type that showed any significant usage of aux heat.**
- Mini-split HP do not have aux heat usage, and of the 18 ground source HP sites, only one saw minimal aux heat usage
- About a third of central HP sites had aux heat installed (n=20, shown on the right). About 75% of these homes used it.
- Some sites saw aux heat usage fully take over around 0°F. Most sites saw little aux heat usage, or the aux heat was used to boost heat output.



Auxiliary Electric Usage for Central HP Sites with Aux Heat Installed

Peak Demand for Sites that Removed Pre-Existing Heating

- Metered period included a winter with “cold snap” down to **-13°F** (2023), while 2024 was milder at **12°F**.
- For subset of homes with data collection in both winters, **mini-split HPs had relatively consistent peak demand, while central HPs had 3x the peak demand due to aux electric heat usage on the colder day.**



Metered Peak Day Load Shape for Full Displacement Sites that Removed Pre-Existing Heating

Heat Pump Controls Findings

- For Partial Displacement (PD) installations, most customers indicate an **integrated control (IC) was installed**. Most also report **not knowing their IC switchover temperature**.
- **About half of PD installations reported still using their IC** to auto-switch operation.
- **70% of PD sites with CHPs and 20% of PD sites with MSHPs had a consistent switchover temperature** throughout the metered period.
- Switchover temps were between **15–40°F** (average 25°F) for those with oil backup heat, **20–40°F** (average 30°F) for natural gas backup.
- Customers that do not use a switchover report **manual operation** of their systems or using the **droop method** on their thermostats.

Customer Feedback

- **Overall Heat Pump Experience** - 95% of respondents said they would install a heat pump again if they were to go back in time.
- **Comfort** - Most customers are satisfied with the ability of their heat pumps to keep them comfortable in the winter (about 93% of Full Displacement installations). Guidehouse noted some potential system under-sizing at a few sites. Some customers wished they had installed cold climate models.
- **Costs** – some customers were satisfied with reduced costs, while others noted their higher electric costs as a downside.
- **Issues** – A few sites reported refrigerant leaks or other miscellaneous issues.

Conclusions and Considerations

- **Customers are largely satisfied** with their heat pumps. They are **performing well down to lower outdoor air temperatures** and are **offsetting a sizable portion of heating loads**. These areas can continue to be studied under evolving program rules or for latest generation heat pump and control models.
- Some central HP installations saw **large electric aux heat demands at low temperatures**. Utilities should consider implications of additional winter electric peak from heat pumps. Programs could consider additional guidance on design temperatures and sizing thresholds for heat pump installations. Future studies could investigate contractor sizing practices.
- Some customers noted frustration that they did not understand how much a heat pump could impact their electrical bill. Programs can consider providing education and tools to **help customers understand how switching to a heat pump could impact their electric and overall energy bills**.

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Study Report Links:

https://ma-eeac.org/wp-content/uploads/MA-HPMS-CT-R2246-Heat-Pump-Metering-Study-Final-Report_April_2025.pdf

https://www.energizect.com/sites/default/files/documents/MA%20HPMS%20CT%20R2246%20-%20Heat%20Pump%20Metering%20Study%20Final%20Report_August_2024.pdf