To: **Massachusetts Residential Program Administrators**

From: **Ryan Powanda and Steven Tobias, Guidehouse**

Date: **August 9, 2024**

Re: **Massachusetts Heat Pump Incremental Cost Research**

Executive Summary

This memo presents the results of the Massachusetts heat pump incremental costs analysis. This study supports the Massachusetts Program Administrators (PAs) in their Three-Year Planning efforts to accurately estimate costs and benefits for heat pump fuel displacement program offerings, which incentivize the installation of air and ground source heat pumps (HPs) to displace pre-existing fuel fired (natural gas, oil, propane) or electric resistance heating equipment.

This study leverages new HP cost research performed by NMR in 2023 and 2024 for the MA PAs. Recent NMR studies include an analysis of the MassCEC database and online webscraping data collection. These activities served to estimate recent HP installation costs and to understand the components of those costs, including equipment cost, installation, and labor costs.

The incremental cost study also leveraged data from Guidehouse's RES19 and RES23 studies. Cost and efficiency data from the studies were compiled and used to inform equipment costs or to cross-validate costs from other studies. Costs from the prior studies were updated for inflation to 2023 dollars and adjusted based on incremental efficiency differences between the prior study source and the incremental cost study equipment efficiencies for program rebated heat pumps, new equipment, and existing equipment.

Table ES-1 through Table ES-3 summarizes the key findings of this research for each of three baseline scenarios. The three baseline scenarios are as follows and are described in detail in Section 1.5.

- **Market Rate Program Data Designation Scenario**: This scenario summarizes costs for market rate heat pump program participants. This scenario includes the baseline equipment weights for all heating and cooling equipment types. Heat pump usage for the Full Displacement measure category is based on the full Heat Pump Metering Study metered sample, where the displacement categorizes are defined in the program tracking database.
- **Market Rate Alternative Scenario:** This scenario summarizes costs for market rate heat pump program participants. This scenario removes the baseline weights for baseline heat pump types and re-weights the remaining equipment types to 100%. Heat pump usage for the Full Displacement measure category is based on the subset of the

Heat Pump Metering Study metered sample where the customer either removed or disconnected their pre-existing heating equipment.

- **Income Eligible Scenario:** This scenario summarizes costs for income eligible heat pump program participants. The baseline equipment type is assumed to be the pre-existing system types per the measure name. Because this Incremental Cost study assumes zero cost for pre-existing equipment, this scenario results in an incremental cost identical to the new equipment cost.

For the market rate scenarios, the baseline equipment costs represent the blended average of costs for the equipment the customer would have installed if they did not install the HP they did, which could have been keeping their pre-existing HVAC system installed (assumed to be zero cost) or installing an alternative piece of equipment (noted as “New" equipment in this study). The HP installation costs are broken out for a new unit (at a base efficiency level), and for a higher efficiency HP unit representing a program-average installation. Results are provided for three incremental cost scenarios:

- Baseline equipment to new unit heat pump
- New unit heat pump to program rebated heat pump
- Baseline equipment to program rebated heat pump

These costs are summarized for each of the program measures, which vary based on installed HP type, displacement scenario (full or partial displacement), and the customer’s pre-existing heating fuel type. The costs are normalized by the rated cooling tonnage of the installed HP equipment.

Table ES-1: Heat Pump Fuel Displacement Incremental Costs - Market Rate Program Data Displacement Scenario

Measure Name	Displacement Type	Blended Baseline Equipment Cost ($/Ton)	HP - New Unit Cost ($/Ton)	HP - Program Rebated Cost ($/Ton)	Baseline to HP - New Unit Incremental Cost ($/Ton)	HP - New Unit to HP - Program Rebated Incremental Cost ($/Ton)	Baseline to HP - Program Rebated Incremental Cost ($/Ton)
Central HP Displacing Electric Resistance	Full	$2,884	$7,294	$7,781	$4,410	$486	$4,896
Central HP Displacing Oil	Partial	$2,688	$7,294	$7,781	$4,607	$486	$5,093
Central HP Displacing Propane	Partial	$2,725	$7,294	$7,781	$4,569	$486	$5,056
Central HP Displacing Natural Gas	Partial	$2,893	$7,294	$7,781	$4,401	$486	$4,887
Central HP Displacing Oil	Full	$2,688	$7,294	$7,781	$4,607	$486	$5,093
Central HP Displacing Propane	Full	$2,725	$7,294	$7,781	$4,569	$486	$5,056
Central HP Displacing Natural Gas	Full	$2,893	$7,294	$7,781	$4,401	$486	$4,887
GSHP Displacing Electric Resistance	Full	$3,292	$14,238	$14,876	$10,946	$638	$11,584
GSHP Displacing Oil	Full	$5,343	$14,238	$14,876	$8,894	$638	$9,532
GSHP Displacing Propane	Full	$5,343	$14,238	$14,876	$8,895	$638	$9,533
GSHP Displacing Natural Gas	Full	$5,350	$14,238	$14,876	$8,887	$638	$9,526
Minisplit HP Displacing Electric Resistance	Full	$1,046	$5,443	$6,029	$4,396	$586	$4,982
Minisplit HP Displacing Oil	Partial	$1,079	$5,443	$6,029	$4,363	$586	$4,949
Minisplit HP Displacing Propane	Partial	$1,162	$5,443	$6,029	$4,280	$586	$4,867
Minisplit HP Displacing Natural Gas	Partial	$1,156	$5,443	$6,029	$4,286	$586	$4,873
Minisplit HP Displacing Oil	Full	$1,079	$5,443	$6,029	$4,363	$586	$4,949
Minisplit HP Displacing Propane	Full	$1,162	$5,443	$6,029	$4,280	$586	$4,867
Minisplit HP Displacing Natural Gas	Full	$1,156	$5,443	$6,029	$4,286	$586	$4,873

Source: Guidehouse analysis

Table ES-2: Heat Pump Fuel Displacement Incremental Costs - Market Rate Alternate Scenario

Measure Name	Displacement Type	Blended Baseline Equipment Cost ($/Ton)	HP - New Unit Cost ($/Ton)	HP - Program Rebated Cost ($/Ton)	Baseline to HP - New Unit Incremental Cost ($/Ton)	HP - New Unit to HP - Program Rebated Incremental Cost ($/Ton)	Baseline to HP - Program Rebated Incremental Cost ($/Ton)
Central HP Displacing Electric Resistance	Full	$1,917	$7,294	$7,781	$5,378	$486	$5,864
Central HP Displacing Oil	Partial	$1,899	$7,294	$7,781	$5,396	$486	$5,882
Central HP Displacing Propane	Partial	$1,947	$7,294	$7,781	$5,347	$486	$5,834
Central HP Displacing Natural Gas	Partial	$1,984	$7,294	$7,781	$5,311	$486	$5,797
Central HP Displacing Oil	Full	$1,899	$7,294	$7,781	$5,396	$486	$5,882
Central HP Displacing Propane	Full	$1,947	$7,294	$7,781	$5,347	$486	$5,834
Central HP Displacing Natural Gas	Full	$1,984	$7,294	$7,781	$5,311	$486	$5,797
GSHP Displacing Electric Resistance	Full	$1,769	$14,238	$14,876	$12,469	$638	$13,107
GSHP Displacing Oil	Full	$1,671	$14,238	$14,876	$12,567	$638	$13,205
GSHP Displacing Propane	Full	$1,670	$14,238	$14,876	$12,568	$638	$13,206
GSHP Displacing Natural Gas	Full	$1,683	$14,238	$14,876	$12,555	$638	$13,193
Minisplit HP Displacing Electric Resistance	Full	$803	$5,443	$6,029	$4,640	$586	$5,226
Minisplit HP Displacing Oil	Partial	$748	$5,443	$6,029	$4,694	$586	$5,280
Minisplit HP Displacing Propane	Partial	$939	$5,443	$6,029	$4,503	$586	$5,089
Minisplit HP Displacing Natural Gas	Partial	$834	$5,443	$6,029	$4,609	$586	$5,195
Minisplit HP Displacing Oil	Full	$748	$5,443	$6,029	$4,694	$586	$5,280
Minisplit HP Displacing Propane	Full	$939	$5,443	$6,029	$4,503	$586	$5,089
Minisplit HP Displacing Natural Gas	Full	$834	$5,443	$6,029	$4,609	$586	$5,195

Source: Guidehouse analysis

Table ES-3: Heat Pump Fuel Displacement Incremental Costs - Income Eligible Scenario

Measure Name	Displacement Type	Blended Baseline Equipment Cost ($/Ton)	HP - New Unit Cost ($/Ton)	HP - Program Rebated Cost ($/Ton)	Baseline to HP - New Unit Incremental Cost ($/Ton)	HP - New Unit to HP - Program Rebated Incremental Cost ($/Ton)	Baseline to HP - Program Rebated Incremental Cost ($/Ton)
Central HP Displacing Electric Resistance	Full	$0	$7,294	$7,781	$7,294	$486	$7,781
Central HP Displacing Oil	Partial	$0	$7,294	$7,781	$7,294	$486	$7,781
Central HP Displacing Propane	Partial	$0	$7,294	$7,781	$7,294	$486	$7,781
Central HP Displacing Natural Gas	Partial	$0	$7,294	$7,781	$7,294	$486	$7,781
Central HP Displacing Oil	Full	$0	$7,294	$7,781	$7,294	$486	$7,781
Central HP Displacing Propane	Full	$0	$7,294	$7,781	$7,294	$486	$7,781
Central HP Displacing Natural Gas	Full	$0	$7,294	$7,781	$7,294	$486	$7,781
GSHP Displacing Electric Resistance	Full	$0	$14,238	$14,876	$14,238	$638	$14,876
GSHP Displacing Oil	Full	$0	$14,238	$14,876	$14,238	$638	$14,876
GSHP Displacing Propane	Full	$0	$14,238	$14,876	$14,238	$638	$14,876
GSHP Displacing Natural Gas	Full	$0	$14,238	$14,876	$14,238	$638	$14,876
Minisplit HP Displacing Electric Resistance	Full	$0	$5,443	$6,029	$5,443	$586	$6,029
Minisplit HP Displacing Oil	Partial	$0	$5,443	$6,029	$5,443	$586	$6,029
Minisplit HP Displacing Propane	Partial	$0	$5,443	$6,029	$5,443	$586	$6,029
Minisplit HP Displacing Natural Gas	Partial	$0	$5,443	$6,029	$5,443	$586	$6,029
Minisplit HP Displacing Oil	Full	$0	$5,443	$6,029	$5,443	$586	$6,029
Minisplit HP Displacing Propane	Full	$0	$5,443	$6,029	$5,443	$586	$6,029
Minisplit HP Displacing Natural Gas	Full	$0	$5,443	$6,029	$5,443	$586	$6,029

Source: Guidehouse analysis

1. Methodology

Guidehouse estimated heat pump equipment and installation costs using the results of a 2023 NMR draft memo[1] which evaluated invoices from the Massachusetts Clean Energy Center (MassCEC) public database, along with results from a subsequent NMR Webscraping effort.

Guidehouse estimated baseline equipment costs using studies developed in 2018, including the MA Water Heating, Boiler, and Furnace Cost Study (RES19)[2], and MA Cost Study of Heat Pump Installations for Dual Fuel Operation (RES23)[3].

Once primary data sources were identified for each piece of equipment, Guidehouse used inflation and price index values to update all costs to 2023 dollars. The team also estimated costs at varying efficiency levels, leveraging regression analysis performed in the various studies to correlate installed equipment prices with various equipment characteristics, such as size and efficiency.

For the market rate scenarios, Guidehouse applied a series of baseline equipment cost weights using the counterfactual condition: what equipment the customer would have installed if they did not install the heat pump they did, which could have been install no unit (for cooling), keep the existing cooling or heating units installed, installing an alternative piece of equipment (assumed to be a new unit efficiency), or indicating that the installed heat pump was the only unit type considered. For the income eligible scenario, the baseline equipment type is assumed to be the pre-existing equipment type(s).

Incremental cost was defined as the difference between a baseline equipment cost and a more-efficient equipment cost, inclusive of equipment labor, materials, taxes, and other install-related costs. Incremental cost was calculated for several points, including the blended baseline cost to the program-rebated efficient heat pump, blended baseline costs to new unit heat pump, and new unit heat pump to program-rebated heat pump.

1.1 Heat Pump Cost Assumptions

The following section provides a detailed overview of data sources used and the underlying analysis methodology within each source.

NMR MassCEC Heat Pump Invoice Analysis

In November 2023, NMR shared a draft memo with Guidehouse which included heat pump project cost results as sourced from the MassCEC database.[4] The review was conducted for Ground Source Heat Pumps (GSHP), Central Heat Pumps (CHP), and Mini-Split Heat Pumps (MSHP), and focused on publicly available MassCEC datasets. The study pulled data from residential-scale projects within the commercial ASHP program and records from the residential ASHP and whole home pilot programs. The final sample included 206 GSHP

[1] 2023 NMR MassCEC Invoice Analysis Memo Draft is not publicly available as of May 2024.
[2] https://ma-eeac.org/wp-content/uploads/RES19_Assembled_Report_2018-09-27.pdf
[3] https://ma-eeac.org/wp-content/uploads/RES23_Task2_AC-HP_Cost_Study_Results_Memo_v3_clean.pdf
[4] https://www.masscec.com/public-records-requests

projects, 2,217 MSHP projects, and 11 CHP projects installed between 2019 and 2021. All cost values were adjusted to December 2022 dollars.

Guidehouse used the study's mean project cost per ton of installed HP cooling capacity for each system type as a starting point to estimate typical heat pump equipment and installation costs. The study also included regression coefficients for GSHP and MSHP unit types (the CHP sample was too small to develop a coefficient), which Guidehouse used to validate unit cost results and to estimate equipment costs based on variations in rated equipment efficiency.

NMR Webscraping Data (January 2024)

Following the NMR MassCEC Heat Pump Invoice Analysis memo, NMR conducted an online webscraping effort to collect cost data across multiple heat pump unit types and retailer webpages. The webscraping task sourced cost information from thousands of online records for GSHP, MSHP (ductless and ducted), and CHP units. NMR's webscraping also collected rated efficiency values and unit capacities. Guidehouse used this data for developing and validating equipment efficiency cost regressions.

1.2 Baseline Equipment Cost Assumptions

The following studies were used to inform the baseline equipment costs. The costs from each study were adjusted for 2023 dollars using Consumer Price Index (CPI) data.[5]

MA Water Heating, Boiler, and Furnace Cost Study – RES19 (2018)

This study evaluated the costs for single family installations of water heaters, boilers, and furnaces rebated through the Massachusetts Residential Heating and Cooling program. It assessed consumer costs for purchase and installation of these HVAC equipment types and analyzed the relationship between cost and equipment efficiency.

Guidehouse used the RES19 study's average itemized costs by category for each equipment type and efficiency level to develop cost estimates for baseline gas-fired equipment.

MA Cost Study of Heat Pump Installations for Dual Fuel Operation – RES23 (2018)

This study provides itemized install costs for residential central A/C and heat pump products installed in Massachusetts. The authors analyzed 7,948 Mass Save rebate records submitted between November 2016 and July 2017, and used a set of 200 total invoice records to supplement the analysis.

Guidehouse used the RES23 study to source cost information for existing central AC equipment.

[5] https://data.bls.gov/timeseries/CUUR0000SA0L1E

1.3 Baseline and Program Rebated Equipment Efficiency Assumptions

Table 1 shows efficiency assumptions for existing, new, and program rebated (EE) HVAC equipment. These values are used in the incremental cost analysis to scale the equipment costs based on the rated efficiency of the equipment. Several of the cost data sources include regressions to adjust equipment costs based on efficiency, or lookup tables for equipment costs based on different efficiency levels.

The following data sources and assumptions were used to inform these baseline and post-retrofit equipment efficiency assumptions:

- **Existing unit efficiency** values are sourced from the most recent Massachusetts Residential Building Use and Equipment Characterization Study (RBUECS), updated in 2023.[6] The existing unit efficiencies are the median unit efficiencies for all HVAC units installed in the 2023 onsite metering sample (n=269 sites in onsite sample). The existing unit efficiency values are used for customers who indicate that they would have left their existing HVAC system in place if they did not install the heat pump they did.
- **New unit efficiency** values are sourced from the MA RBUECS survey data collection and subsequent characterization analysis and are the median efficiency values for all units installed from 2020-2023. These efficiency values are used for customers who indicate that they would have installed an alternative HVAC system if they did not install the heat pump they did. Based on discussions with the MA PAs and EEAC consultants, the team assumes new unit efficiencies of 15 SEER and 8.8 HSPF for central heat pump based on current code minimum values, and 17 SEER and 9.5 HSPF for mini-split heat pumps to estimate typical standard efficiencies for mini-split heat pumps available on the market.
- **Program rebated (EE) unit efficiency** values are sourced from 2022 Mass Save Fuel Displacement program tracking dataset, delivered by DNV. The program average efficiency values represent the median unit efficiency values for all units installed in 2022.

[6] The Phase 7 RBUECS for Massachusetts has not been made publicly available at this time of this report submission. The Phase 6 report is available on the MA Energy Efficiency Advisory Council webpage: https://ma-eeac.org/wp-content/uploads/Residential-Building-Use-and-Equipment-Characterization-Study-Comprehensive-Report-2022-03-01.pdf

Table 1: Heat Pump and Baseline Equipment Rated Efficiency Assumptions

HVAC Type	Existing Unit Efficiency	New Unit Efficiency	Program Rebated Unit Efficiency
Central AC	13.0 SEER 12.4 SEER2	15.0 SEER 14.3 SEER2	N/A
Central Heat Pump	13.0 SEER 12.4 SEER2 7.1 HSPF 6.1 HSPF2	15.0 SEER 14.3 SEER2 8.8 HSPF 7.5 HSPF2	18.0 SEER 17.1 SEER2 10.0 HSPF 8.5 HSPF2
Mini-Split Heat Pump	20.0 SEER 19.0 SEER2 11.0 HSPF 9.4 HSPF2	17.0 SEER 16.2 SEER2 9.5 HSPF 8.1 HSPF2	13.6 SEER 13.0 SEER2 7.6 HSPF 6.5 HSPF2
Window AC	11.0 CEER	11.3 CEER	N/A
Gas Furnace	91.0%	96.0%	N/A
Propane Furnace	91.0%	96.0%	N/A
Oil Furnace	85.0%	86.2%	N/A
Gas Boiler	83.1%	95.0%	N/A
Propane Boiler	83.1%	95.0%	N/A
Oil Boiler	85.0%	86.2%	N/A
Electric Resistance	3.41 HSPF	3.41 HSPF	N/A

*SEER2 estimated as SEER/1.05, HSPF2 estimated as HSPF/1.17

Source: MA Residential Building Use and Equipment Characterization Study (2023), Evaluation Team Analysis

1.4 Equipment Cost Normalization and Aggregation

Guidehouse used the NMR MassCEC memo to source post-retrofit equipment costs and used the RES19 and RES23 studies to source baseline equipment costs, and then made updates based on unit efficiency levels. The cost adjustment methodology is shown below:

Incremental Efficiency Cost Factor

The team applied an adjustment factor to scale the efficiency and related equipment costs between the source dataset and the efficiency value assumptions used for this analysis. The NMR webscraping data was used to develop adjustment factors for baseline existing and new units as well as the program rebated heat pump equipment. The RES19 study was used to develop adjustment factors for baseline existing and new unit fossil fuel equipment. Incremental efficiency cost factor between two pieces of equipment (unit “a” and unit “b”), expressed in dollars per ton per unit efficiency, is defined in Equation 1:

Equation 1. Incremental Efficiency Cost Factor (IECF)

$$IECF = \frac{CostPerTon_a - CostPerTon_b}{(CoolEff_a - CoolEff_b)/3.412 + (HeatEff_a - HeatEff_b)}$$

Where:

- $CostPerTon_a$ and $CostPerTon_b$ are install costs per ton of installed unit cooling capacity for new and program rebated heat pumps. For heating-only baseline and new fossil fuel equipment, heating capacity was converted to ton-equivalent installed capacity (MBH/12).
- $CoolEff_a$ and $CoolEff_b$ are equipment cooling efficiencies (EER, SEER, or SEER2), which are converted from btu/watt to btu/btu (dimensionless) to be comparable to heating efficiencies. Where possible, part-load efficiencies were used (SEER / SEER2)
- $HeatEff_a$ and $HeatEff_b$ are equipment heating efficiencies, expressed as COP, HSPF, or HSPF2 (dimensionless). Where possible, part-load efficiencies were used (HSPF / HSPF2)

Because this methodology relies on two pieces of similar equipment at different efficiency levels and costs and interpolates between the two, it will be less accurate for large changes in efficiency – especially for efficiency values outside the range of the two equipment values. Table 2 shows source and adjusted equipment cost per ton, including the inflation adjustment factor for each source vintage, and the efficiency adjustment factor based on heating and cooling efficiency differences.

Table 2: Equipment Cost Per Ton Adjustment for Inflation and Efficiency

Source	Efficiency Category	Equipment Type	Source Cost Per Ton [a]	Cooling Efficiency			Heating Efficiency			Inflation Adjustment Factor [b]	Efficiency Adjustment Factor [c]	Adjusted Cost Per Ton [a*b*c]
				Source Efficiency	Modified Efficiency	Metric	Source Efficiency	Modified Efficiency	Metric			
Baseline (Existing/New Unit)												
RES23	New Unit	Central AC	$4,156	16.0	15.0	SEER	-	-		1.21	0.98	$4,918
NMR MassCEC Analysis	New Unit	CHP	$7,678	19.0	15.0	SEER	10.6	8.8	HSPF	1.04	0.91	$7,294
RES19	New Unit	Electric Radiant	$357	-	-		1.0	-	COP	1.24	1.00	$444
NMR MassCEC Analysis	New Unit	GSHP	$14,290	24.5	11.1	EER	4.3	3.6	COP	1.04	0.96	$14,238
NMR MassCEC Analysis	New Unit	MSHP	$5,947	21.4	17.0	SEER	11.4	9.5	HSPF	1.04	0.88	$5,443
RES19	New Unit	Natural Gas Boiler	$659	-	-		0.82	0.95	AFUE	1.24	1.47	$1,201
RES19	New Unit	Natural Gas Furnace	$595	-	-		0.80	0.96	AFUE	1.24	1.44	$1,064
RES19	New Unit	Oil Boiler	$692	-	-		0.84	0.86	AFUE	1.24	1.07	$920
RES19	New Unit	Oil Furnace	$667	-	-		0.83	0.86	AFUE	1.24	1.13	$934
RES19	New Unit	Propane Boiler	$720	-	-		0.82	0.95	AFUE	1.24	1.49	$1,331
RES19	New Unit	Propane Furnace	$538	-	-		0.80	0.96	AFUE	1.24	1.38	$924
RES23	New Unit	Room AC Unit	$450	10.0	12.0	EER	-	-		1.21	1.46	$795
RES19	New Unit	Wood Stove	$357	-	-		-	-		1.24	1.00	$444
Program Rebated Heat Pump												
NMR MassCEC Analysis	Post Retrofit	MSHP	$5,947	21.4	20.4	SEER2	11.40	11.00	HSPF	1.04	0.97	$6,029
NMR MassCEC Analysis	Post Retrofit	CHP	$7,678	19.0	18.0	SEER	10.60	10.00	HSPF	1.04	0.97	$7,781
NMR MassCEC Analysis	Post Retrofit	GSHP	$14,290	24.5	24.5	EER	4.30	4.30	COP	1.04	1.00	$14,876

Source: Guidehouse analysis

Table 3 shows the total install cost per ton for each HVAC equipment type used in the analysis, adjusted for heating and cooling efficiency levels as well as updated for inflation to 2023 dollars. For this incremental cost study, existing equipment was assumed to have a cost of zero dollars and is not included in this table.

Table 3: Equipment Cost Per Ton Summary

Initial Cost Source	Equipment Type	Cooling Efficiency		Heating Efficiency		Total Cost Per Ton (Inflation Adjusted)
		Value	Metric	Value	Metric	
Baseline (Existing / New Unit)						
RES23	Central AC	16	SEER	-	-	$4,918
NMR MassCEC Analysis	CHP	19	SEER	10.60	HSPF	$7,294
RES19	Electric Radiant	-	-	1.00	COP	$444
NMR MassCEC Analysis	GSHP	25	EER	4.30	COP	$14,238
NMR MassCEC Analysis	MSHP	21	SEER	11.40	HSPF	$5,443
RES19	Natural Gas Boiler	-	-	0.82	AFUE	$1,201
RES19	Natural Gas Furnace	-	-	0.80	AFUE	$1,064
RES19	Oil Boiler	-	-	0.84	AFUE	$920
RES19	Oil Furnace	-	-	0.83	AFUE	$934
RES19	Propane Boiler	-	-	0.82	AFUE	$1,331
RES19	Propane Furnace	-	-	0.80	AFUE	$924
RES23	Room AC Unit	10	EER	-	-	$795
RES19	Wood Stove	-	-	-	-	$444
Program Rebated Heat Pump						
NMR MassCEC Analysis	MSHP	21	SEER2	11.40	HSPF	$6,029
NMR MassCEC Analysis	CHP	19	SEER	10.60	HSPF	$7,781
NMR MassCEC Analysis	GSHP	25	EER	4.30	COP	$14,876

*Cost Per Ton includes updates for 2023 dollars, and cost per unit efficiency regressions.

Source: Guidehouse analysis

1.5 Baseline Equipment Weights and Strata Mapping

This section provides the baseline heating and cooling weights for the Market Rate Prospective and Alternative scenarios, as well as the Income Eligible scenario. Table 4, Table 5, and Table 6 show the baseline heating weights for the Market Rate Prospective, Market Rate Alternative, and Income Eligible scenarios, respectively. Table 7, Table 8, and Table 9 show the respective cooling weights.

Table 4: Heating Equipment Types and Weights by Heat Pump Type and Pre-Existing Fuel Type - Market Rate Program Data Designation Scenario

		Central Heat Pump				Mini-Split Heat Pump				Ground Source Heat Pump			
Unit Type	**Baseline Heating Equipment Type**	**Electric (n=34)**	**Gas (n=96)**	**Oil (n=139)**	**Propane (n=28)**	**Electric (n=79)**	**Gas (n=53)**	**Oil (n=89)**	**Propane (n=13)**	**Electric***	**Gas***	**Oil (n=19)**	**Propane***
Existing Unit	CHP	21%	1%	0%	0%	1%	0%	0%	0%	21%	0%	0%	0%
	MSHP	0%	0%	0%	0%	3%	0%	0%	6%	0%	0%	0%	0%
	GSHP	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Electric baseboard	21%	0%	0%	0%	58%	2%	0%	3%	21%	0%	0%	0%
	Electric furnace	3%	0%	0%	0%	1%	2%	0%	3%	3%	0%	0%	0%
	Natural gas boiler	3%	17%	1%	0%	0%	49%	0%	0%	3%	5%	0%	0%
	Natural gas furnace	0%	49%	1%	7%	3%	26%	0%	3%	0%	47%	0%	0%
	Oil boiler	12%	0%	25%	0%	4%	2%	42%	0%	12%	0%	16%	0%
	Oil furnace	12%	1%	48%	4%	3%	0%	44%	3%	12%	0%	37%	0%
	Propane/LPG boiler	3%	0%	0%	7%	0%	0%	1%	23%	3%	0%	0%	11%
	Propane/LPG furnace	0%	0%	1%	54%	3%	0%	0%	26%	0%	0%	0%	42%
	Wood stove/fireplace	3%	1%	1%	0%	9%	0%	1%	9%	3%	0%	0%	0%
New Unit	CHP	6%	5%	3%	7%	1%	2%	3%	0%	6%	32%	32%	32%
	MSHP	6%	5%	6%	0%	1%	2%	0%	3%	6%	11%	11%	11%
	GSHP	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Electric baseboard	0%	0%	0%	0%	4%	2%	0%	0%	0%	0%	0%	0%
	Natural gas boiler	0%	0%	1%	0%	1%	6%	0%	3%	0%	0%	0%	0%
	Natural gas furnace	3%	21%	2%	0%	1%	8%	2%	3%	3%	5%	0%	0%
	Oil boiler	0%	0%	3%	0%	0%	0%	2%	0%	0%	0%	0%	0%
	Oil furnace	3%	0%	6%	0%	5%	0%	2%	0%	3%	0%	5%	0%
	Propane/LPG boiler	3%	0%	1%	0%	1%	0%	0%	6%	3%	0%	0%	0%
	Propane/LPG furnace	3%	0%	2%	21%	1%	0%	0%	11%	3%	0%	0%	5%
	Wood stove/fireplace	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%
	Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

*Due to low sample, baseline weights for GSHPs with pre-existing oil were assigned to the gas and propane groups, adjusted for proportions of boilers/furnaces. Baseline weights for GSHP with pre-existing electric resistance are assumed to be the same as those for central HPs with pre-existing electric resistance.

Source: Evaluation team analysis

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Table 5: Heating Equipment Types and Weights by Heat Pump Type and Pre-Existing Fuel Type - Market Rate Alternate Scenario

		Central Heat Pump				Mini-Split Heat Pump				Ground Source Heat Pump			
Unit Type	**Baseline Heating Equipment Type**	**Electric (n=34)**	**Gas (n=96)**	**Oil (n=139)**	**Propane (n=28)**	**Electric (n=79)**	**Gas (n=53)**	**Oil (n=89)**	**Propane (n=13)**	**Electric***	**Gas***	**Oil (n=19)**	**Propane***
Existing Unit	CHP	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	MSHP	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	GSHP	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Electric baseboard	30%	0%	0%	0%	62%	2%	0%	3%	30%	0%	0%	0%
	Electric furnace	4%	0%	0%	0%	1%	2%	0%	3%	4%	0%	0%	0%
	Natural gas boiler	4%	19%	1%	0%	0%	51%	0%	0%	4%	9%	0%	0%
	Natural gas furnace	0%	55%	1%	8%	3%	28%	0%	3%	0%	82%	0%	0%
	Oil boiler	17%	0%	28%	0%	4%	2%	43%	0%	17%	0%	27%	0%
	Oil furnace	17%	1%	53%	4%	3%	0%	45%	3%	17%	0%	64%	0%
	Propane/LPG boiler	4%	0%	0%	8%	0%	0%	1%	25%	4%	0%	0%	18%
	Propane/LPG furnace	0%	0%	1%	58%	3%	0%	0%	28%	0%	0%	0%	73%
	Woodstove, pellet stove, or fireplace	4%	1%	1%	0%	10%	0%	1%	9%	4%	0%	0%	0%
New Unit	CHP	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	MSHP	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	GSHP	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Electric baseboard	0%	0%	0%	0%	4%	2%	0%	0%	0%	0%	0%	0%
	Natural gas boiler	0%	0%	2%	0%	1%	6%	0%	3%	0%	0%	0%	0%
	Natural gas furnace	4%	24%	2%	0%	1%	8%	2%	3%	4%	9%	0%	0%
	Oil boiler	0%	0%	3%	0%	0%	0%	2%	0%	0%	0%	0%	0%
	Oil furnace	4%	0%	6%	0%	5%	0%	2%	0%	4%	0%	9%	0%
	Propane/LPG boiler	4%	0%	1%	0%	1%	0%	0%	6%	4%	0%	0%	0%
	Propane/LPG furnace	4%	0%	2%	23%	1%	0%	0%	13%	4%	0%	0%	9%
	Woodstove, pellet stove, or fireplace	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%
	Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

*Due to low sample, baseline weights for GSHPs with pre-existing oil were assigned to the gas and propane groups, adjusted for proportions of boilers/furnaces. Baseline weights for GSHP with pre-existing electric resistance are assumed to be the same as those for central HPs with pre-existing electric resistance.

Source: Evaluation team analysis

Table 6: Heating Equipment Types and Weights by Heat Pump Type and Pre-Existing Fuel Type – Income Eligible Scenario

		Central Heat Pump				Mini-Split Heat Pump				Ground Source Heat Pump			
Unit Type	**Baseline Heating Equipment Type**	**Electric (n=34)**	**Gas (n=96)**	**Oil (n=139)**	**Propane (n=28)**	**Electric (n=79)**	**Gas (n=53)**	**Oil (n=89)**	**Propane (n=13)**	**Electric (n=40)**	**Gas* **	**Oil (n=19)**	**Propane***
Existing Unit	CHP												
	MSHP												
	GSHP												
	Electric baseboard	100%				100%				100%			
	Electric furnace												
	Natural gas boiler						100%						
	Natural gas furnace		100%								100%		
	Oil boiler							100%					
	Oil furnace			100%								100%	
	Propane/LPG boiler								100%				
	Propane/LPG furnace				100%								100%
	Woodstove, pellet stove, or fireplace												
New Unit	CHP												
	MSHP												
	GSHP												
	Electric baseboard												
	Natural gas boiler												
	Natural gas furnace												
	Oil boiler												
	Oil furnace												
	Propane/LPG boiler												
	Propane/LPG furnace												
	Woodstove, pellet stove, or fireplace												
	Total												

Source: Evaluation team analysis

Table 7: Cooling Equipment Types and Weights by Heat Pump Type - Market Rate Program Data Designation Scenario

Existing or New Unit	Baseline Cooling Equipment Type	Central Heat Pump (n=300)	Mini-Split Heat Pump (n=246)	Ground Source Heat Pump (n=62)
Existing Unit	None	16%	52%	8%
	Central air conditioning	37%	8%	31%
	Central heat pump	2%	0%	2%
	Mini-split heat pump	0%	2%	0%
	Room, window, or through the wall air conditioning	1%	13%	2%
	Ground-source heat pump	0%	0%	11%
New Unit	Central air conditioning	30%	10%	19%
	Central heat pump	2%	0%	15%
	Mini-split heat pump	6%	3%	7%
	Room, window, or through the wall air conditioning	6%	13%	7%
Total		100%	100%	100%

Source: Evaluation team analysis

Table 8: Cooling Equipment Types and Weights by Heat Pump Type - Market Rate Alternate Scenario

Existing or New Unit	Baseline Cooling Equipment Type	Central Heat Pump (n=300)	Mini-Split Heat Pump (n=246)	Ground Source Heat Pump (n=62)
Existing Unit	None	16%	52%	8%
	Central air conditioning	42%	9%	49%
	Central heat pump	0%	0%	0%
	Mini-split heat pump	0%	0%	0%
	Room, window, or through the wall air conditioning	2%	14%	3%
	Ground-source heat pump	0%	0%	0%
New Unit	Central air conditioning	34%	11%	31%
	Central heat pump	0%	0%	0%
	Mini-split heat pump	0%	0%	0%
	Room, window, or through the wall air conditioning	7%	15%	10%
Total		100%	100%	100%

Source: Evaluation team analysis

Table 9: Cooling Equipment Types and Weights by Heat Pump Type - Income Eligible Scenario

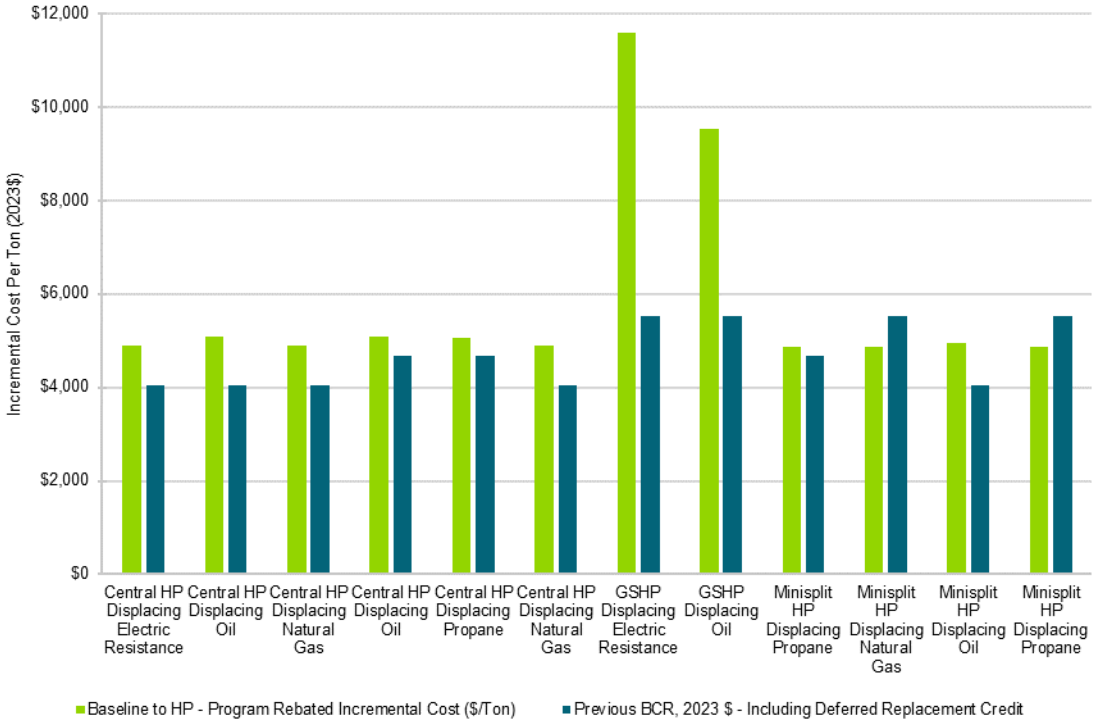
Existing or New Unit	Baseline Cooling Equipment Type	Central Heat Pump (n=300)	Mini-Split Heat Pump (n=246)	Ground Source Heat Pump (n=62)
Existing Unit	None			
	Central air conditioning	20%	20%	20%
	Central heat pump			
	Mini-split heat pump			
	Room, window, or through the wall air conditioning	80%	80%	80%
	Ground-source heat pump			
New Unit	Central air conditioning			
	Central heat pump			
	Mini-split heat pump			
	Room, window, or through the wall air conditioning			
Total				

Source: Evaluation team analysis

1.6 Incremental Cost Comparison

Guidehouse compared incremental costs for "Blended Baseline to Heat Pump – Program Rebated" against the MA 2022-2024 Plan BCR Model measure inputs.[7] Table 10 shows the results of this comparison, using the Market Rate Program Data Designation Scenario. GSHP measure incremental cost is significantly higher in comparison to the 2022-2024 BCR model, likely due to the prior assumption not accounting for the full installation costs of GSHPs. Most of the remaining measures have similar incremental costs compared to the previous BCR assumption, likely because the previous BCR Model includes a deferred replacement credit which accounts for existing equipment being replaced before end of useful life.

Table 10: Incremental Cost Comparison to Previous BCR Study – Market Rate Program Data Designation Scenario



Source: Guidehouse analysis

[7] https://ma-eeac.org/wp-content/uploads/Exh-5-2022-2024-Plan-BC-Model-NG-Electric-4-1-22.xlsx