How to Maximize Heat Pump Use in Cold Climates, A Comparative Assessment of Maine's Residential Heat Pump Programs

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ABSTRACT

Efficiency Maine ("EM") has offered residential heat pump incentives since 2009 to reduce heating costs and building-related greenhouse gas emissions. EM's legacy heat pump program ("Legacy"), offered from 2014 through 2023, helped accelerate statewide heat pump adoption. However, a 2022 Advanced Metering Infrastructure ("AMI") analysis and a 2024 field metering evaluation found that many rebated heat pumps displaced less fossil fuel than anticipated because homeowners continued to rely heavily on fossil fuel systems. In response, EM launched the Whole Home Heat Pump ("WHHP") program in September 2023. The program requires new and existing heat pumps to be sized to meet at least 80% of a home's peak heating load, with fossil fuel systems reserved for backup use.

This paper compares the Legacy and WHHP programs using prior Legacy evaluations and a 2026 assessment of WHHP homes. The WHHP assessment combined AMI analysis of 1,003 homes with field metering of all heat sources in 78 homes containing 160 heat pumps. Results indicate that WHHP increased heat pump utilization relative to the Legacy program. Across the evaluated WHHP population, heat pumps provided most household heating, while the highest-use homes relied almost entirely on heat pumps. The analysis also identifies remaining barriers to full heat pump utilization, including homeowner intent, zoning and heat distribution limitations, high-load homes, and interactions with backup heating systems. These findings suggest that cold-climate heat pump programs can increase fossil fuel displacement by requiring load-based sizing, improving contractor design practices, and supporting homeowner commitment to heat pump heating.

Introduction

The State of Maine has identified heat pumps as a key energy-efficiency solution for addressing energy affordability and residential greenhouse gas emissions. Nearly one-third of Maine's greenhouse gas emissions can be attributed to residential and commercial buildings (MCC 2020, 5), and approximately 80% of households in the state relied on fossil fuels as their primary heating fuel as of 2019 (Census Bureau 2019). Typical non-heat pump heat sources in Maine homes include boilers, furnaces, fossil-fuel stoves and space heaters, and wood and pellet stoves. In recent years, the State has taken major strides toward decarbonizing space heating. Between 2019 and 2023, 100,000 heat pumps were installed across homes, businesses, and public buildings (MCC 2025, 21), and, as of April 2026, Efficiency Maine ("EM") reports that more than 200,000 heat pumps had been installed statewide (EM 2026).

EM is the quasi-state agency and independent administrator responsible for planning and implementing energy efficiency programs in Maine. Since 2009, EM has offered rebate programs to encourage homeowners to transition from existing heating systems to high-efficiency cold-climate heat pump technology. The second generation of these heat pump incentives, referred to in this paper as the Legacy program, was offered from 2014 through 2023 and helped accelerate heat pump adoption across the state. Separate program studies performed by Ridgeline Energy Analytics ("REA") and Demand Side Analytics ("DSA") later suggested that many Legacy program heat pumps were performing efficiently but were underutilized relative to their full capacity (REA and Guidehouse 2024). Both studies determined that many homeowners continued to rely on their fossil-fuel systems for heating.

In response, EM launched a revised Whole Home Heat Pump ("WHHP") program in September 2023, which was designed to shift heat pumps from supplemental systems to the primary heating source, with fossil fuel systems reserved for emergency backup use. Recently, in 2026, REA and DSA worked together in the *Assessment of Heat Pumps in Maine Homes* to quantify the effects of this new WHHP program on heat pump utilization and the portion of the home heated by heat pumps (REA and DSA 2026). A timeline of EM's program changes and the respective evaluation, measurement, and verification (EM&V) work is highlighted in Figure 1. This paper compares the older Legacy program with the revised WHHP program using results from these three respective studies.

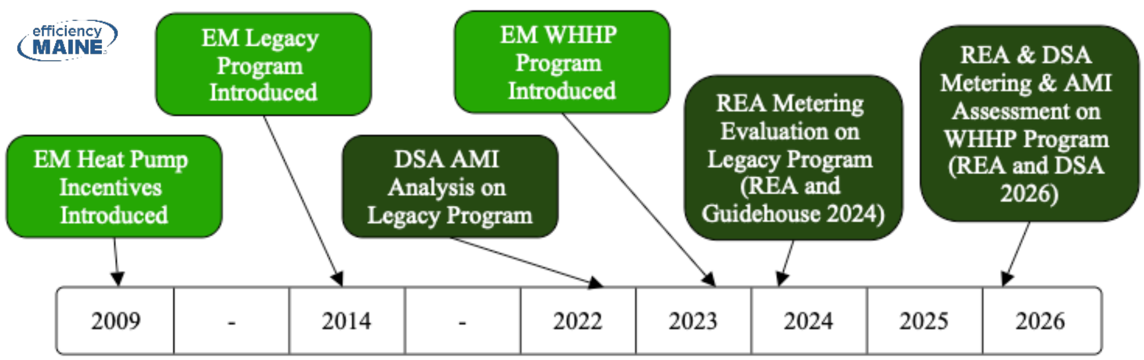

Figure 1. Timeline of EM's residential heat pump rebate programs and Evaluation, Measurement, and Verification (EM&V) work used as the basis for this comparative paper.

Comparison of Programs

The Legacy heat pump program offered rebates for heat pump installations that satisfied minimum high-efficiency and cold-weather performance standards as defined by the program. This program supported early heat pump adoption and contributed to reductions in fossil fuel heating, but it did not require that heat pumps serve a minimum portion of the home's heat load. In 2022, EM contracted DSA to perform a pre/post Advanced Metering Infrastructure ("AMI") analysis on thousands of Legacy rebate recipients. Although this AMI analysis was not published independently, it was later referenced in the 2026 WHHP report. Separately, EM contracted REA to conduct a field metering study of heat pumps installed through the Legacy program. The resulting report, *Efficiency Maine Residential Heat Pump Impact Evaluation,* was published in early 2024 (REA and Guidehouse 2024).

In 2023, EM redesigned its heat pump program by limiting rebate eligibility to a WHHP system intended to serve as a home's primary heating system. A WHHP system is defined as one in which the combined capacity of all heat pumps in a given home is designed and sized to meet at least 80% of the home's peak heating load at the ASHRAE 99.6% design temperature. If not met by heat pumps, the remaining 20% of the peak heating load may be met by other supplemental systems such as wood or pellet stoves, electric resistance elements like baseboards or space heaters, or non-central fossil-fuel wall furnaces or stoves. Under a program rule acknowledged by participating customers, existing primary fossil fuel heating systems may be retained for emergency backup, but their heating capacity cannot be counted toward the 100% requirement. To assess the impact of this requirement and several other key WHHP program changes, REA and DSA combined their respective AMI-based and metering-based analyses in the 2026 report *Assessment of Heat Pumps in Maine Homes* (REA and DSA 2026). Although the WHHP and Legacy programs shared several common elements, the WHHP program introduced minimum capacity criteria intended to increase the role of heat pumps in home heating. Table 1 summarizes these program similarities and differences.

Table 1. Comparison of EM heat pump program requirements

Program feature	Legacy Program (2014-2023)	WHHP Program (2023-Present)
Eligible building types	Single-family homes, mobile homes, two-unit duplexes, and condominiums	
Income eligibility	Low-Income, Moderate-Income and Any-Income[1]	
Minimum efficiency standards[2]	HSPF ≥12, HSPF2 ≥9.5	HSPF2 ≥9.5, COP @ 5°F ≥1.75
Contractor requirements	Must be installed by an EM Residential Registered Vendor	
Role of heat pump	Supplemental heating accepted; fossil fuel system may remain primary	Must serve as primary heating system throughout the season; fossil fuel reserved for emergency backup only
Capacity requirements	None specified	Heat pump(s) must be sized to meet ≥80% of home's peak heating load
Incentive amounts[3]	$813/project	$4,214/project
Multi-zone heat pump rebate eligibility	Rebated	Not rebated, but counts toward minimum capacity
EM&V studies	REA and Guidehouse 2024	REA and DSA 2026

Methods & Data

Field-Metering Methodology

This section primarily focuses on the methods implemented in the metering assessment performed by REA in the 2026 *Assessment of Heat Pumps in Maine Homes* study (REA and DSA 2026). In this study, REA metered all heat sources (not just heat pumps) in each home. In

[1] Low- and Moderate-Income participants must demonstrate income eligibility to be pre-qualified for enhanced rebates. See www.efficiencymaine.com/income-based-eligibility-verification/ for current eligibility criteria.
[2] Efficiency criteria changed over time in response to technology and testing improvements. Listed requirements are nominal for the program periods.
[3] Incentive levels varied over time, by income tier, and by project size (number of heat pumps installed). Values shown are average incentives per project across all program periods, income levels, and project sizes.

metering all heat sources, evaluators could better understand what portion of each home's heating load was being delivered by heat pumps. The methodology used in this study closely reflects the approach used in the earlier 2024 metering evaluation on the Legacy program, *Efficiency Maine Residential Heat Pump Impact Evaluation* (REA and Guidehouse 2024). However, the Legacy study only metered heat pumps and not every heating system in the home.

In both the 2024 and 2026 studies, REA measured the electric power consumed by each outdoor unit, the amperage drawn by each indoor unit (as a second power meter was not practical), and the temperatures of the air supplied and returned by each indoor unit at the minute-interval level. Metering also included outdoor air temperatures, room temperatures, and supply and return relative humidities. Additionally, the airflow of each indoor head was measured using a balometer (capture hood) to establish a relationship between indoor unit current readings (which are dominated by the indoor unit's fan) and airflows. Indoor unit amperages needed to be metered as airflows could not be continuously monitored throughout the entire field study period. Using the Heat Transfer Equation ($\dot{q} = \dot{m}c\Delta T$), these parameters allowed for the calculation of minute-level heat outputs since the airflow and difference in supply and return air temperatures are known. Furthermore, the efficiency of each heat pump could be calculated over any time interval by evaluating the ratio of measured heat output to power input for that heat pump. In the 2026 study, REA metered all heating forms from fall 2024 to summer 2025; the 2024 study metered heat pumps from fall 2021 through summer 2022.

Other sources of backup heating within the metered sample of 78 WHHP homes included boilers, furnaces, wood stoves, spot fossil heating, and electric resistance elements. The operating times of these backup heating systems were continuously metered at one-minute intervals using temperature sensors, and their rated output capacities were recorded. Metering non-heat pump systems in each house provided a more accurate and comprehensive picture of how homeowners were heating their homes across various temperatures and time frames. As mentioned, this was not performed in the earlier 2024 Legacy study.

In addition to metering heating outputs, REA calculated the heat loss of each sampled home using Amply, software that uses Light Detection and Ranging ("LiDAR") sensors to efficiently gather dimensions and construct 3D models of rooms and homes (Amply Energy 2026). The software contains an embedded Manual J model that calculates the heating and cooling requirements of living spaces at given design temperatures (ACCA 2016).[4] Understanding each home's heat loss allowed for comparison between the metered heat output of all heating forms and the expected heat loss from the given home. Again, this was not evaluated in the 2024 Legacy metering study. For this analysis, homes in both the WHHP and Legacy programs are assumed to be characteristically similar. While this assumption cannot fully account for unobserved differences between the cohorts, it provides a reasonable basis for comparison in the absence of more detailed household-level characterization data. This assumption is supported by the cohorts' similar program eligibility, predominantly single-family housing stock, broad geographic coverage across Maine, and reasonably similar average conditioned floor areas in the AMI populations.

Prior to metering installations, other qualitative measures including homeowner intentions and zoning issues were noted. REA discussed with homeowners how they were using their heat pump(s) and other heating systems. Homeowners described a variety of behaviors,

[4] Manual J is an ANSI-recognized Air Conditioning Contractors of America ("ACCA") standard that provides a detailed method for calculating the heating and cooling loads of residential buildings, considering factors like insulation, windows, local climate, and building envelope.

from "we don't heat with our heat pumps and prefer our pellet stove" to "we only heat with our heat pumps and have no other heating system." Homes that clearly showed intent to lightly use their heat pumps for heating were rated as "Low Intent" and homes that either had a clear plan to use the heat pump for most heating or had no alternative heat source were rated as "High Intent." All other homes were classified as "Moderate Intent" homes.

Moreover, homes where installed heat pumps may not have accessed a large share of the home's heating load were identified as having "zoning issues." Homes were classified as having potential zoning issues when the heat pump served a limited room or area, when airflow from the indoor head to adjacent spaces was restricted and heat distribution was impeded, or when an existing boiler or furnace served the same zone and could satisfy the thermostat before the heat pump carried much load. In these cases, low measured heat pump usage may reflect the interaction between the heat pump location and the home's existing heating zones, rather than only homeowner preference or equipment performance. Although the installed capacity satisfied program requirements, these heat pumps could not feasibly heat the entire home as intended.

Direct field metering is commonly used in heat pump literature to evaluate real-world heat pump operation and efficiency. In these studies, researchers typically monitor heat pump electric power and, in more detailed applications, estimate or directly measure thermal output using airside, hydronic, or refrigerant-side methods. These measurements support evaluation of operating patterns, seasonal energy use, delivered heat, and coefficient of performance ("COP") under field rather than laboratory conditions. Carroll, Chesser, and Lyons (2020) describe this broader literature in their systematic review of air-source heat pump ("ASHP") field studies, identifying field monitoring as a common method for evaluating heat pump performance, controls, defrost behavior, and demand-response applications. Residential field studies have similarly used detailed monitoring to assess cold-climate ASHP operation and efficiency. For example, Schoenbauer, Bohac, and Haynor (2018) monitored ducted and ductless cold-climate ASHPs in Minnesota homes, measuring system power, delivered energy, backup heat use, airflow, and temperature at high temporal resolution to evaluate annual energy use, operating behavior, and field performance. Together, these studies illustrate how device-level metering, paired with heat output measurements, can characterize heat pump utilization and efficiency.

Advanced Metering Infrastructure (AMI) Methodology

In parallel with REA's metering work, DSA conducted AMI analysis on thousands of Legacy participants in its 2022 assessment and on 1,003 WHHP homes in the 2026 report using premise-level interval electricity consumption data collected through utilities. These AMI samples were representative of their respective full Legacy and WHHP populations. DSA estimated heat pump usage by modeling each home's temperature-dependent electric load before and after heat pump installation. In general form, the regression estimated household electricity consumption as a function of outdoor temperature using heating and cooling degree terms, with separate pre- and post-installation relationships: $kWh = \alpha + \beta_1 HDD + \beta_2 CDD + \varepsilon$. The incremental post-installation cold-weather-dependent household electricity use, represented primarily by the increase in the heating degree day slope after installation, was interpreted as heat pump heating electricity use. Although not discussed in detail in this paper, the AMI results provide an important population-level comparison for the metering portion of the study.

The AMI analysis also supported the selection of homes for REA's WHHP field metering sample. Based on estimated heat pump electricity use from the initial AMI analysis, DSA divided WHHP participants with non-negative estimated use into thirds to define the low (0-3,250 kWh/year), medium (3,250-6,130 kWh/year), and high (≥ 6,130 kWh/year) use bins. REA then selected metering sites *only* from the negative, low, and medium use bins, intentionally focusing on homes suspected of lower heat pump utilization rather than a representative cross-section of all WHHP participants. Negative values were model outputs indicating that estimated cold-weather-dependent electricity use decreased as outdoor temperatures fell, rather than increasing as expected for heat pump heating. This can be primarily attributed to homes where heat pump operation was weakly or inconsistently related to outdoor temperature, producing counterintuitive regression results. The bins were initially developed using one post-installation winter of AMI data, and the analysis was later refreshed to incorporate a second winter. Because the metering sample excluded the high use bin, the metered results were extrapolated to the full WHHP population using the updated AMI-based usage distribution. This extrapolation was supported by a validation comparison showing that, across the same 78 metered homes, AMI-based estimates were equal to 99% of metered heat pump electricity use.

AMI and grid-meter-based analyses fall into a related but distinct literature that uses interval electricity consumption data to infer heat pump use, load profiles, or operational behavior when direct heat pump submetering or thermal-output measurement is not available. These studies treat electricity consumption, often in combination with outdoor temperature, as an empirical signal of heat pump operation or space-conditioning load. Brudermueller, Breer, and Staake (2023) disaggregated heat pump load profiles from commonly available smart-meter measurements, demonstrating that grid-meter data can be used to estimate heat pump electricity use and operational patterns. Program evaluations have similarly combined billing analysis with on-site EM&V to assess heat pump impacts. For example, DNV evaluated New York State Energy Research and Development Authority ("NYSERDA") heat pump programs using weather-normalized pre/post billing analysis and on-site monitoring of sampled heat pump systems to characterize seasonal usage, equipment-level operation, and evaluated energy impacts (DNV 2022). However, AMI alone is not a perfect proxy for heat pump usage or benefit because other large weather-dependent electric loads can also affect household electricity consumption. Compared with direct field metering, AMI-based methods are generally better suited to estimating heat pump electricity use, utilization, and grid impacts than to directly estimating delivered heat or COP, unless supplemented with additional assumptions or measurements.

Data

In *Assessment of Heat Pumps in Maine Homes*, REA metered 160 heat pumps in 78 WHHP participating homes (REA and DSA 2026). As mentioned, these 78 homes represented the lowest two-thirds of heat pump users in the greater WHHP population. On average, the sample had 2.1 heat pumps per home with an average capacity of 14.5 $\text{kBtu}^{\text{Rated}}{}_{47}$ per outdoor unit.[5] The average household heat pump capacity at 5°F was 34.1 $\text{kBtu}^{\text{Rated}}{}_{5}$. Single-zone ductless mini-split heat pump systems represented the vast majority of the studied heat pumps with only two homes having centrally ducted heat pump systems. Additionally, only three multi-zone heat pumps were metered. As of September 2025, approximately 98% of all rebated heat pumps in EM's WHHP program were ductless, with the remaining 2% ducted. Comparative counts for the other studies are presented in Table 2. It is important to note that the number of

[5] $\text{kBtu}^{\text{Rated}}{}_{47}$ indicates the Air-Conditioning, Heating, and Refrigeration Institute ("AHRI") rated capacities at outdoor temperatures of 47 °F.

heat pumps installed at each home within the metering samples increased from 1.4 heat pumps per home under the Legacy program to 2.1 heat pumps per home under the WHHP program.

Across the metered WHHP sample, 63% of the homes retained a central fossil fuel furnace or boiler, 15% had some form of non-central fossil fuel spot heating, 35% had a wood or pellet stove, and 13% had some form of electric resistance heating. These were stand-alone heating systems, separate from the heat pump equipment. Additionally, these statistics indicate the presence of these heating sources, not necessarily their use. Many supplemental systems were not used during the metering period, and many homes met their entire heating load with heat pumps alone, although few central systems were fully decommissioned.

Table 2. Comparison of EM heat pump EM&V study sample counts

<table>
<tr><td></td><td colspan="2">Legacy Program</td><td colspan="2">WHHP Program</td></tr>
<tr><td>Methodology</td><td>Metering</td><td>AMI</td><td>Metering</td><td>AMI</td></tr>
<tr><td>Homes</td><td>124</td><td>NA</td><td>78</td><td>1,003</td></tr>
<tr><td>Heat pumps (HPs)</td><td>170</td><td>NA</td><td>160</td><td>2,206</td></tr>
<tr><td>Single-zone ductless HPs</td><td>135</td><td>NA</td><td>155</td><td rowspan="2">2,162</td></tr>
<tr><td>Multi-zone ductless HPs</td><td>35</td><td>NA</td><td>3</td></tr>
<tr><td>Ducted HPs</td><td>NA</td><td>NA</td><td>2</td><td>44</td></tr>
<tr><td>Average HPs per home</td><td>1.4</td><td>1.2</td><td>2.1</td><td>2.2</td></tr>
<tr><td>Average $kBtu^{Rated}_{47}$ per HP</td><td>NA</td><td>NA</td><td>14.5</td><td>14.8</td></tr>
</table>

The average heat loss for a home in this metering sample was 25.7 kBtu/h at 5°F. The homes in this sample were relatively small at 1,337 ft^2, on average. This corresponds to an average heat loss per square foot of approximately 20.3 Btu/h/ft^2 at 5°F, based on an assumed indoor temperature of 65°F.[6]

Results & Discussion

Comparison of Legacy and Whole Home Heat Pump Program Outcomes

This section compares results from the Legacy and WHHP evaluations. The 2026 WHHP study found that the new program design–requiring heat pumps to serve as a home's primary heating system–significantly increased the use of heat pumps. Most importantly, REA observed that these WHHP systems were operating closer to their full capacity (instead of sitting idle) and were therefore displacing substantially more fossil fuel than the earlier program design.

First, looking at the program-level AMI analyses, the green distribution in Figure 2 represents the AMI-predicted electricity use of Legacy program participants, while the translucent distribution represents the AMI-predicted electricity use of WHHP participants. Both distributions are normalized to a Typical Meteorological Year 3 ("TMY3") weather year (Wilcox and Marion 2008).[7] Temperature-dependent electricity use is clearly greater among WHHP

[6] The normalized design heat losses ranged from 11 to 32 Btu/h/ft^2 at 5°F, reflecting substantial variation in building efficiency, air leakage, geometry, and insulation across the sample of 78 metered homes. These heat loss estimates were developed using an assumed interior temperature of 65°F.

[7] Hourly dry-bulb temperatures were obtained from National Renewable Energy Laboratory ("NREL") TMY3 files for the Maine weather station nearest each study home. TMY3 data represent a typical weather year constructed

participants than among Legacy participants, although the left half of the WHHP distribution suggests that some participants may still be underutilizing their heat pumps since their estimated use is near zero. This initial AMI analysis was used to select the field metering sample; the AMI analysis was subsequently refreshed to incorporate a second post-installation winter. For a small subset of homes, electricity use decreases as outdoor air temperature declines, resulting in predicted cold-weather-dependent electricity use characterized as "negative." Negative heating electricity use is not physically meaningful—it indicates that the relationship between electricity use and outdoor air temperature is opposite the pattern expected in a home relying on heat pumps for space heating. Although annual kWh is not a complete measure of heat pump adoption or homeowner behavior, it provides a reasonable proxy for operational heat pump usage when interpreted alongside weather, installed capacity, and other site-specific context.

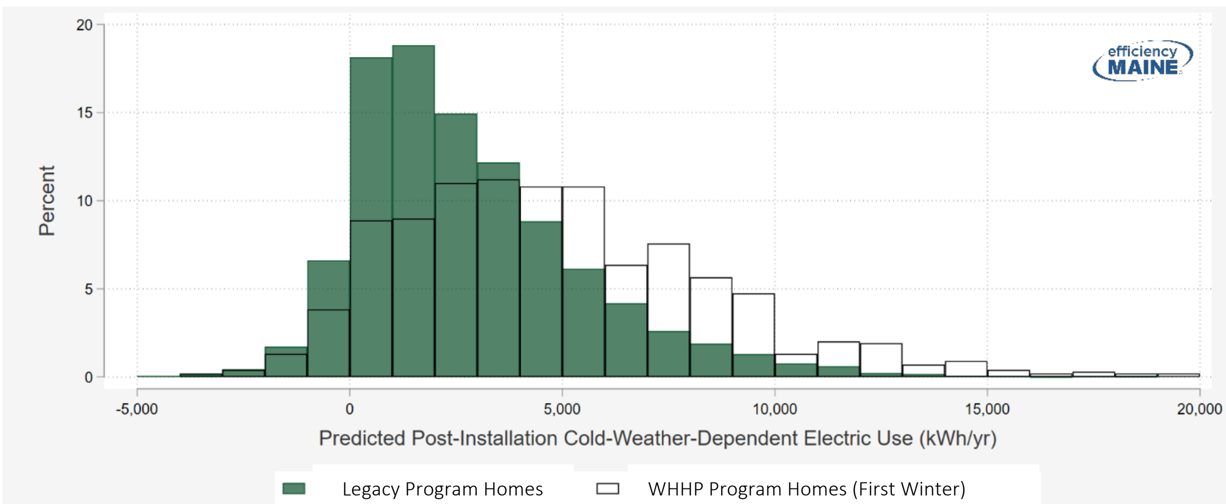

Figure 2. Distribution of predicted annual heat pump electricity consumption (kWh) for Legacy and WHHP program participants, based on Advanced Metering Infrastructure (AMI) analysis. *Source*: REA and DSA 2026.

Figure 3 shows the annual metered heat pump heating electricity consumption for WHHP homes (green bars), with the metered-sample average shown by the solid black reference line. As discussed, the WHHP metering evaluation sampled homes with negative, low, and medium heating impacts as identified through DSA's AMI analysis; therefore, the metered sample represents approximately the lowest two-thirds of the WHHP population by heat pump electricity use. Among these metered households, heat pump electricity consumption averaged 3,849 kWh per year (solid black line). When the results are extrapolated to the full WHHP program population including the high use category not directly represented in the metering sample, the average increases to 4,904 kWh per household per year (dashed blue line). This population-level extrapolation was developed by comparing metered results with AMI-based estimates for the same 78 metered homes, as discussed in the Methodology section of this paper. The metering and AMI analyses yielded very similar average annual heat pump heating electricity use for the 78 metered homes: 3,849 kWh (solid black line) and 3,815 kWh (dashed red line), respectively. In comparison, the Legacy program metering sample, which was representative of the full

from representative months selected from each station's long-term historical weather record, typically spanning 1991-2005. Data were downloaded from OneBuilding.org (Lawrie and Crawley 2026).

Legacy program population, averaged 2,642 kWh per home (dashed orange line), substantially below the WHHP program. As mentioned, this closely reflects the average AMI-based heat pump usage estimate of 2,817 kWh per Legacy program home (dashed gray line).

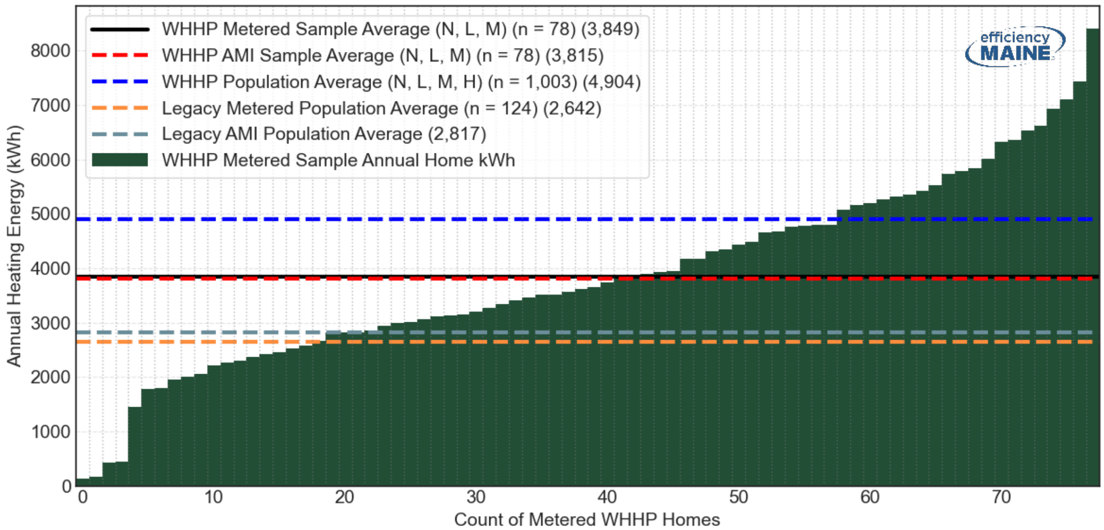

Figure 3. Annual heat pump heating electricity consumption (kWh) per household in ascending order for the 78 home WHHP metering sample (bars), with reference lines for: the WHHP metering sample mean, the WHHP AMI mean for the same 78 metered homes, the extrapolated WHHP population mean including high use homes, the Legacy program metering mean, and the Legacy program AMI mean. N, L, M, and H denote the negative, low, medium, and high use AMI-based bins included in each grouping.

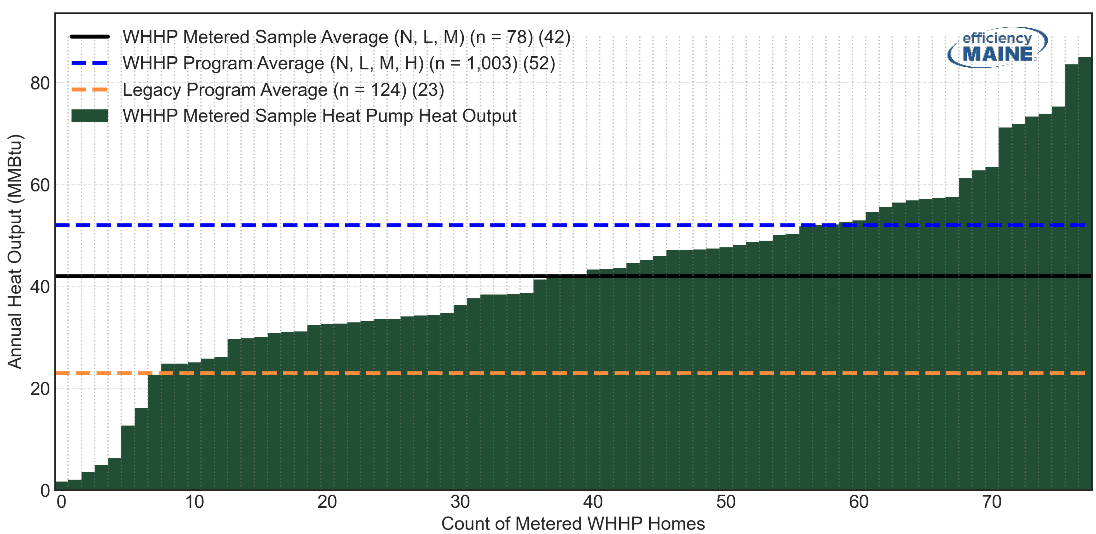

Figure 4. Annual heat pump heating output (MMBtu) per household in ascending order for the 78 home WHHP metering sample (bars).

Turning to heating output, Figure 4 shows the heat provided by heat pumps to the 78 metered WHHP homes. The mean metered value was 42 MMBtu delivered per home per year from heat pumps alone. Extrapolating this value to include homes originally categorized as high users that were omitted from the metering sample, the average heating delivered by heat pumps rises to 52 MMBtu per home per year. For this extrapolation, the 4,904 kWh WHHP program-level average was multiplied by the average field-metered seasonal COP. By comparison, the average metered Legacy program heat pump heating output was 23 MMBtu.

Figure 5 shows the proportion of total heat output (MMBtu) provided across all homes by five heating-source categories: heat pumps, central fossil fuel systems, spot fossil fuel systems, wood and pellet stoves, and other electric heating systems. Across the full WHHP population, including homes that use their heat pumps infrequently, heat pumps provide about 71% of total household heat, while central fossil fuel systems, including boilers and furnaces, provide 18%. The average annual heat load among the metered WHHP homes was 68.5 MMBtu per home. When extrapolated to include the omitted high use homes, the estimated population-level average heating load increases to approximately 73 MMBtu per home. Using this same average heating-load basis, heat pumps provided approximately 32% of household heat in the Legacy program. Heating output from other systems in Legacy homes could not be directly determined because of the key methodological differences described in the Methodology section.

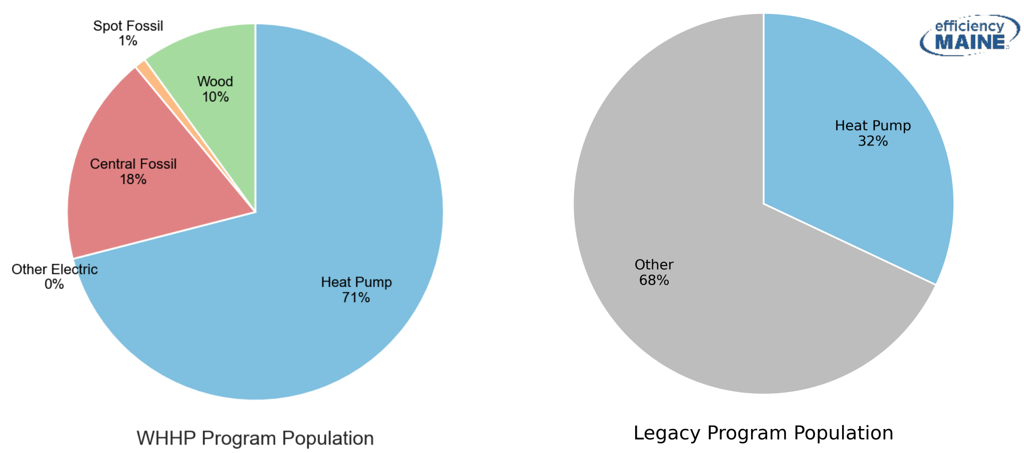

Figure 5. Share of total annual heating (MMBtu) by source for the WHHP population (left) and Legacy population (right).

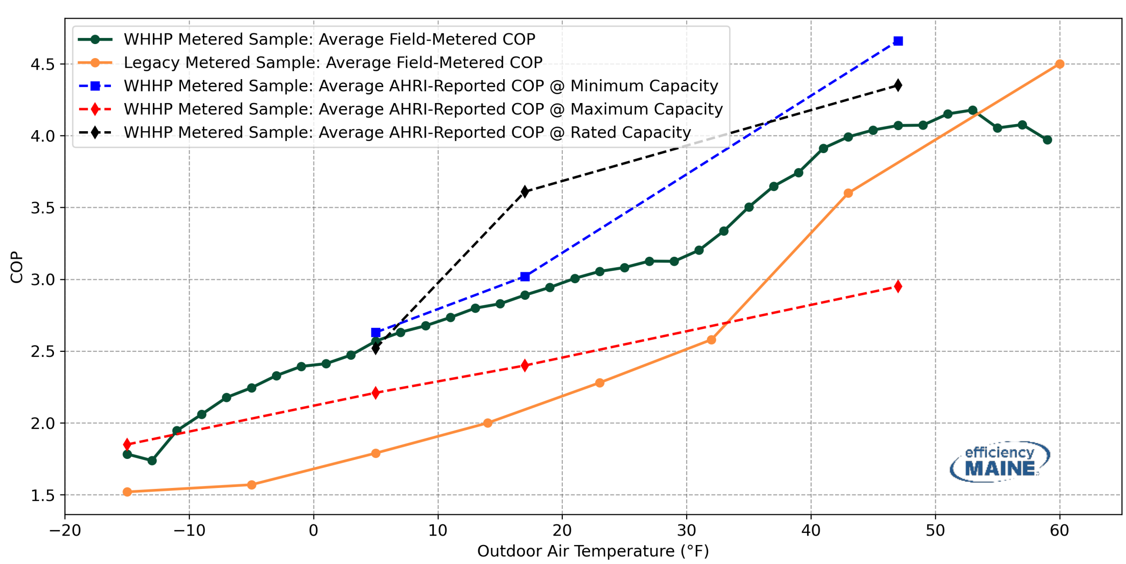

Figure 6. Average field-metered WHHP COP (green) and AHRI-reported COPs (blue, red, and black) versus outdoor air temperature, with average field-metered Legacy COP (orange).

Efficiency, expressed as the COP, was calculated for the 160 heat pumps in the WHHP study using the metered data and methods previously discussed. Figure 6 shows the observed relationship between COP and outdoor air temperature. The field-metered COP (green) falls between the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) rated COPs claimed by manufacturers for maximum and minimum capacities across a range of outdoor temperatures (AHRI 2026). AHRI reports three primary COPs across various outdoor temperatures: COP at maximum capacity (red), COP at rated capacity (black), and COP at minimum capacity (blue). The metered COPs from the WHHP assessment are higher than those reported in the previous Legacy study (orange), which evaluated heat pumps installed prior to 2021. The average AHRI-rated HSPF2 for the metered WHHP sample was 11.4, an increase of 12% from the average Legacy sample rated HSPF2 of 10.2. The average operational, field-metered seasonal COP integrated across all observed temperatures for the WHHP sample increased to 3.15, up 22% from 2.57 in the Legacy study.

Insights from Whole Home Heat Pump Metering Evaluation

This section takes a deeper look at the WHHP metering evaluation and presents areas in which heat pump usage could be increased. Figure 7 shows the average measured heat output from the five previously noted heating sources across a range of temperatures for the metered 78 homes. As expected, the average heat provided to balance a home's heat loss is roughly linear from nearly no heat needed at 62°F to maximum heat needed at -14°F. Heat output from the heat pumps increases linearly until approximately 6°F, after which it begins to level off. As previously discussed, the metered sample shown is representative of the bottom two-thirds of the general WHHP population in terms of cold-weather-dependent electric use (since the top-performing one-third of users were excluded from the metering study). As a consequence, this figure represents the average home in the lowest two-thirds of the WHHP population. Since outdoor temperatures ranging from 10°F to 40°F are the most frequent in Maine winters, increased fossil fuel use at temperatures below 10°F (less frequent) has a modest annual impact.

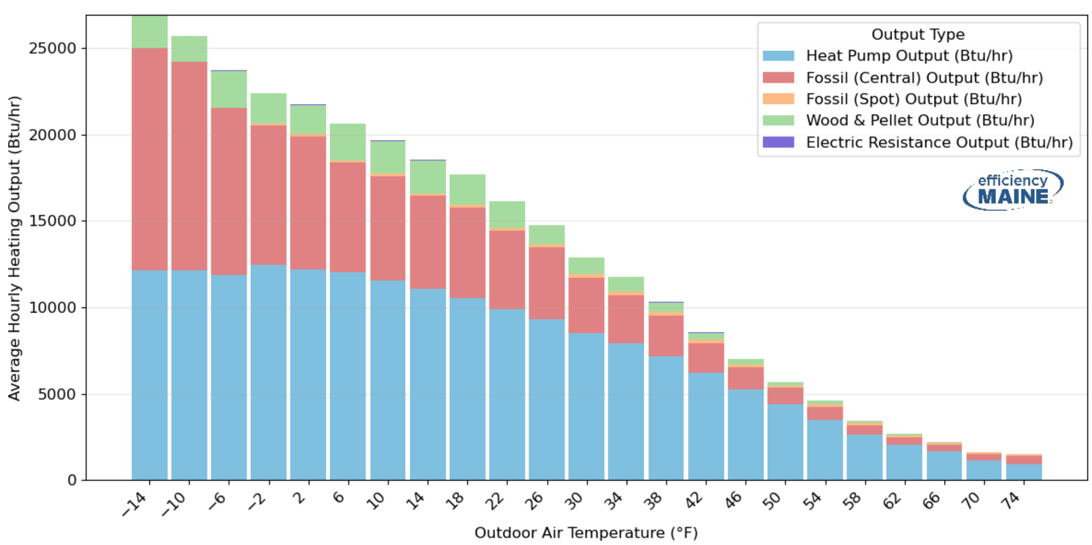

Figure 7. Average heat (Btu/hr) contributed by heat source in the WHHP metering sample versus outdoor air temperatures. *Source*: REA and DSA 2026.

To examine the correlation between homeowners' intentions to use heat pumps for heating and actual heat pump utilization, the portion of heat provided by heat pumps at each home was plotted in Figure 8 with the associated homeowner intent categorization shown by color. As discussed in the Methodology section, homeowner intent was determined through initial homeowner interviews. Homeowner interviews were also conducted during metering removals, but these were not factored into initial homeowner intention categorizations. The figure shows that intent is important, with most of the high-intent users on the right side of the graph, where heat pump utilization rates are high, and with all but one of the low-intent users on the far left of the graph, where utilization rates are low.

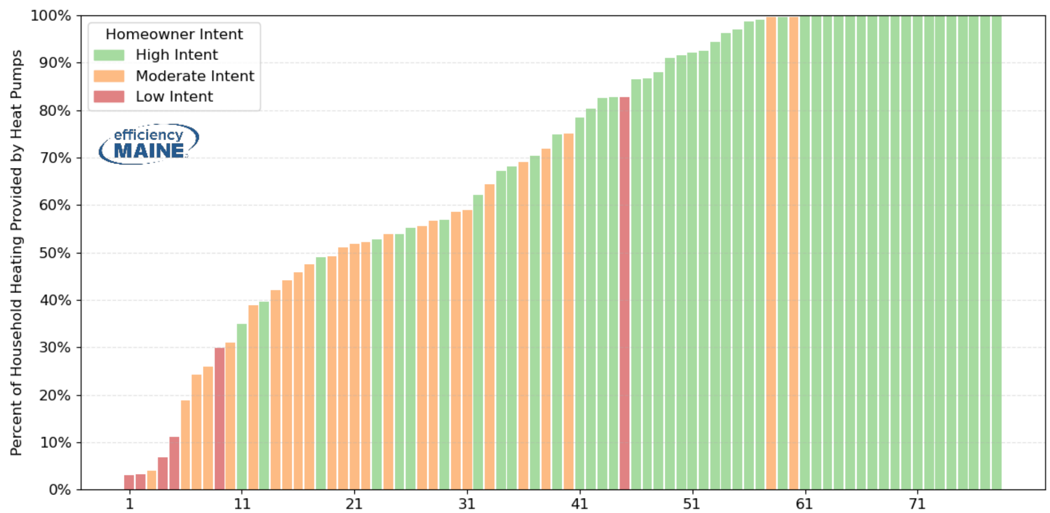

Figure 8. Share of total home heating provided by heat pumps for each of the 78 metered WHHP homes, sorted by percent heat pump heating and color-coded by homeowner intent (high/medium/low, determined through pre-metering structured interviews). The x-axis indicates a count of the metered homes. *Source*: REA and DSA 2026.

In Figure 9, the 78 metered homes are ordered by the percentage of total heating load served by heat pumps. Homes with the highest total heating consumption, particularly those exceeding 70 MMBtu per year across all heat sources, generally show some of the lowest heat pump shares. Moderate consumers of heat (all sources) were more successful than high consumers in fully heating their homes with heat pumps, and homes that consumed the least heat overall were more likely to achieve the highest share of their home's heating needs from their heat pumps. Examining the graph sorted by percentage of heat pump heating, the left side, which indicates low percentage of heat pump use, also correlates with moderate and high total heating use. In the characteristics grid below the graph, low heat pump percentage correlates strongly with homes with larger conditioned square footages (see "SQFT") and homeowner intention (see "Homeowner Intent"), and it correlates weakly or moderately with zoning issues (see "Zoning Issues"). As discussed in the Methodology section, REA labeled a home as having zoning issues if there were portions of the home not heated unless non-heat pump systems were used. An extreme case of this is where homes had no heat pumps on their second floor. The AMI groupings shown in Figure 9 reflect the initial WHHP AMI analysis, which used only one winter of post-installation data and served as the basis for selecting the metering sample.

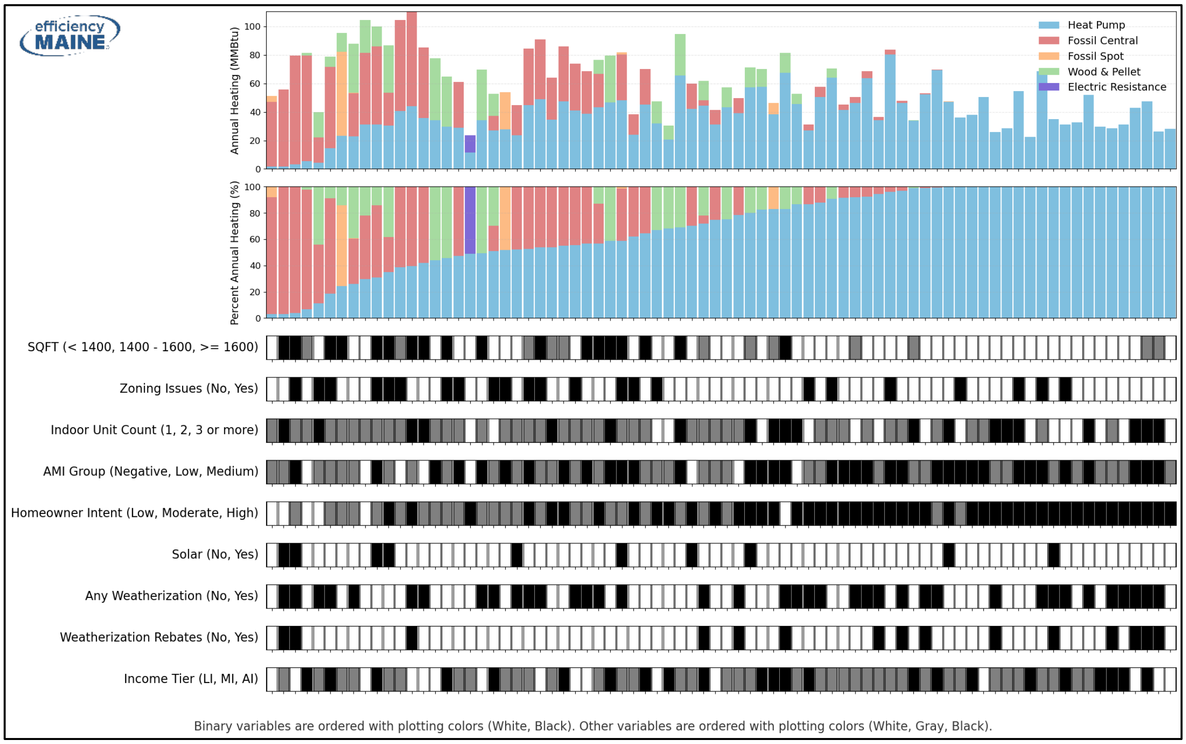

Figure 9. Total annual heat output (MMBtu) by source for each of the 78 metered WHHP homes, ordered from left to right by increasing heat pump share. The characteristics grid below each home shows key factors correlated with heat pump utilization. For the income tier, LI indicates low income, MI indicates middle income, and AI indicates any income. *Source*: REA and DSA 2026.

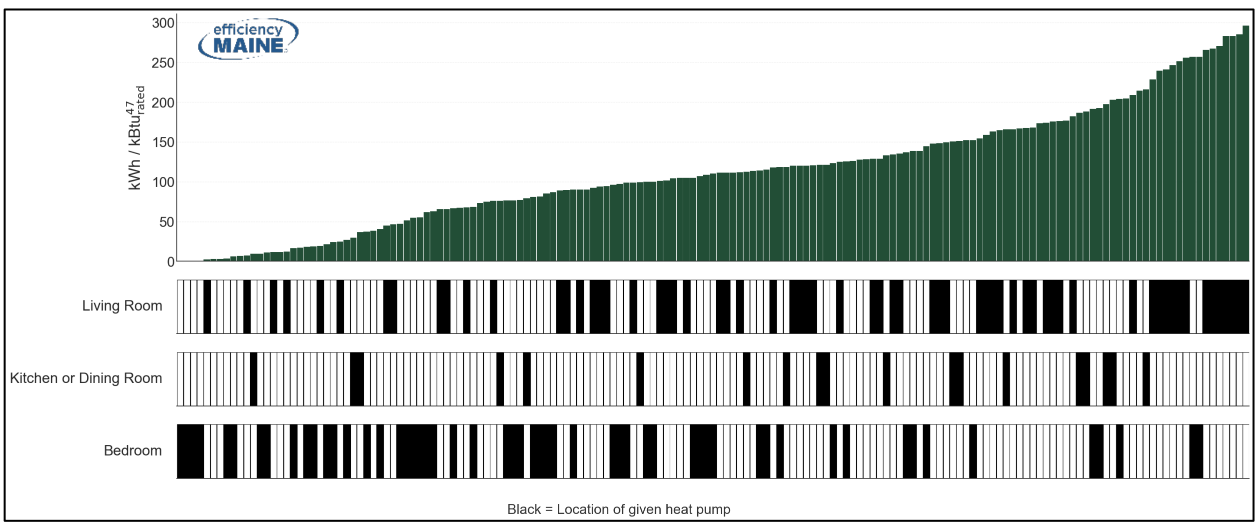

Figure 10. Normalized metered heat pump kWh by kBtu$_{rated}^{47}$ for the 160 metered WHHP heat pumps versus room location. The x-axis denotes the count of heat pumps. *Source*: REA and DSA 2026.

Furthermore, Figure 10 shows the metered electricity used by a heat pump (kWh) divided by its AHRI rated capacity at 47°F (kBtu$_{rated}^{47}$). This ratio normalizes a given heat pump's kWh usage by its size or capacity. Below the column chart, colored boxes show the locations of the heat pumps. Living room units tend to have the highest normalized use, while bedroom units tend to have lower normalized use. Where a heat pump serves a room with heat loss much lower than its capacity, the heat pump's usage will be limited. Consider a heat pump in a small bedroom (e.g., 120 ft^2). Some manufacturers offer indoor units with capacities as low as 7,000 Btu/h, meaning that the bedroom heat pump is providing 58 Btu/h/ft^2. For a well-insulated room, this could be three to four times the capacity needed for even the coldest temperatures, and 8:1 during moderate temperatures. This will cause the heat pump to be used at a relatively low rate and could cause it to cycle often during warmer temperatures.

Conclusions

The Legacy program played a crucial role in rapidly scaling heat pump installations. Building on that success, EM launched the WHHP program in September 2023 to replace, rather than merely supplement, fossil fuel heating systems. The 2026 *Assessment of Heat Pumps in Maine Homes* described in this paper provides strong evidence that the program succeeded in substantially increasing heat pump utilization relative to the Legacy program.

In the 2026 study, REA and DSA found that, on average, homes participating in EM's WHHP program used 4,904 kWh for heating with heat pumps annually, delivering approximately 52 MMBtu of heat. Compared with earlier generations of EM's Legacy heat pump rebate program, which did not establish minimum design-load capacity requirements, annual heat pump electricity consumption nearly doubled under the WHHP program (Figure 11). Under the WHHP program, electricity consumed per unit of rated heat pump capacity rose from approximately 109 to 143 kWh per kBtu$^{Rated}{}_{47}$ when compared to the Legacy program. Combined with increased COPs, this indicates higher usage of the heat pumps and, therefore, higher fossil fuel displacement. This increase in heat pump kWh is associated with an increased percentage of household heating by heat pumps from 32% under the Legacy program to 71% under the WHHP program. The Legacy metering evaluation and Legacy AMI study are presented separately in Figure 11 because they were conducted under separate contracts, whereas the WHHP Program Assessment was completed as a joint effort by REA and DSA.

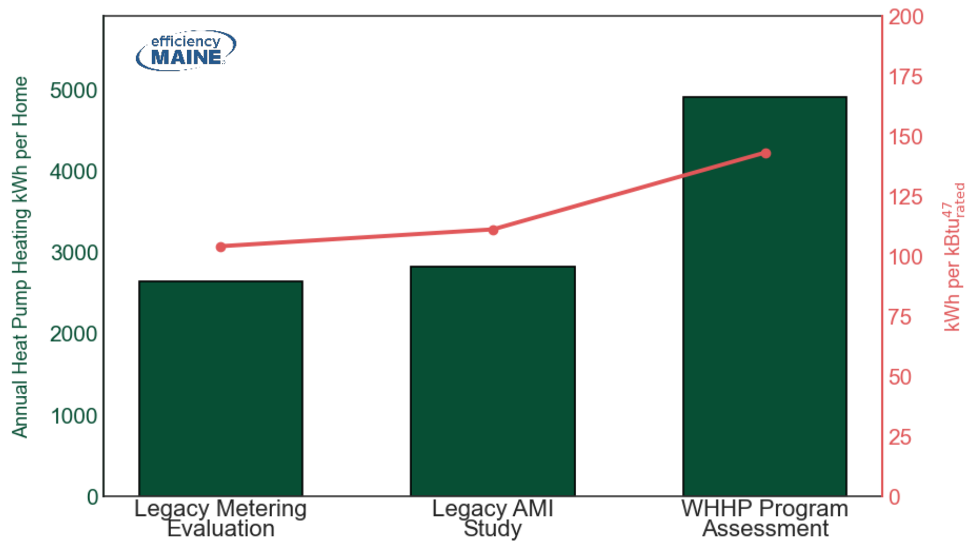

Figure 11. Heat pump consumption (kWh) across multiple Maine EM&V studies.

Key findings regarding the revised WHHP program relative to the Legacy program and their implications are summarized below.

- Substantially higher utilization. Average heat pump electricity consumption nearly doubled under the WHHP program (4,904 kWh/home/yr) compared with the Legacy program (2,642 kWh/home/yr). Heat pumps provided 71% of total home heating across the WHHP population versus approximately 32% under the Legacy program.
- Improved equipment efficiency. Average seasonal COP rose from 2.57 (Legacy) to 3.15 (WHHP), and the average AHRI-rated HSPF2 improved from 10.2 to 11.4, reflecting the newer equipment installed under the revised WHHP program requirements.
- More heat pumps per home. The average number of installed heat pump systems rose from 1.4 per home under the Legacy program to 2.1 under the WHHP program, reflecting the load-based sizing requirements and the program's emphasis on whole-home coverage.
- Strong homeowner engagement. Program requirements attracted participants with a high intent to use heat pumps as their primary heating source. Homeowners engaged during the study generally reported an intention to rely heavily on their heat pumps for heating.

Despite overall program success, the 2026 *Assessment of Heat Pumps in Maine Homes* identified three primary remaining barriers to full heat pump utilization:

- Homeowner intent. Low-intent homeowners—those who preferred wood heat, had concerns about operating costs, or were not committed to heat pump heating—were strongly correlated with low heat pump utilization. Intent was the single strongest predictor of utilization in the metered sample.
- Zoning and heat distribution. Homes where heat pumps covered only a portion of the conditioned area—particularly larger homes with second floors unserved by heat pumps—saw continued fossil fuel use. Comfort gaps in unserved zones drove backup system operation even when the total installed heat pump capacity met the total design load.
- High-load homes. Homes with the greatest total heating needs (above ~70 MMBtu/yr) were least likely to achieve high proportions of heat pump heating.

EM continues to refine its program requirements and contractor coaching in response to evaluation findings. The results from Maine offer a replicable model for cold-climate states seeking to move beyond supplemental heat pump adoption toward full residential electrification.

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