THE "TWO-WAY AC" OPPORTUNITY IN THE NORTHEAST

MARCH 2026

Acknowledgements

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About NEEP

NEEP was founded in 1996 as a non-profit whose mission is to serve the Northeast and Mid-Atlantic to accelerate regional collaboration to promote advanced energy efficiency and related solutions in home, buildings, industry, and communities. Our vision is that the region's homes, buildings, and communities are transformed into efficient, affordable, low-carbon, resilient places to live, work, and play.

Contents

Key Terms

Variable-Speed / Inverter-Driven Heat Pump: A heat pump (HP) equipped with an inverter-driven compressor that can modulate output continuously across a wide range. Variable-speed systems generally deliver higher efficiencies, especially at part-load conditions. Heat Pump Sized to Cooling variable-speed models (ccVS) are optimized for cold weather performance.

Single-Stage/Speed or Two-Stage/Speed Heat Pump: Heat pumps with compressors that operate at one (single-stage) or two (two-stage) discrete output levels. This can lead to more frequent cycling, less precise temperature control, and lower part-load efficiency. In most Northeastern climates, single- and two-stage systems require a backup heating source, whether fuel or electric resistance.

Cooling-Load-Sized Heat Pump: An HP that is sized to meet the home's entire cooling load. Because heating loads are higher than cooling loads in most of the Northeast, backup or supplemental heating, whether fuel or electric resistance, is required in most homes when the HP is sized to cooling.

Dual-Fuel System / Hybrid System / Partial Electrification: An HVAC system in which an existing or new furnace is retained to provide backup or supplemental heating, allowing heating to shift between electricity and fuel based on economics or other priorities. The HP in a dual-fuel system could be sized to meet the cooling load or upsized. Depending on home characteristics and HP size, dual-fuel systems avoid many electrical and distribution system (i.e., ductwork) upgrades, which can lower installation cost.

Coil-Only Heat Pump: A heat pump installed with an indoor coil and existing furnace blower, rather than a new AHRI-matched air handler, typically retaining the furnace for backup heat and with potential limitations on variable-speed performance and system integration.

Full Electrification / Heating-Load-Sized Heat Pump: An HVAC system in which the heat pump is sized to meet the home's entire heating load, enabling all-electric operation. A variable-speed HP is required for this type of home retrofit in most Northeastern climates.

Fuel Rate Economics / Spark Gap: The ratio between the cost per unit of energy for electricity versus fossil fuel. A large spark gap means electricity is significantly more expensive per unit of energy consumed, which affects the economic value of HP operation.

Cost-Parity COP / Seasonal Cost-Parity COP: The HP efficiency, or coefficient of performance (COP), at which the cost of delivering a unit of heat with the HP equals the cost of delivering that heat with the backup fuel. As HPs operate at efficiencies over 100 percent, cost-parity COPs can be reached in many scenarios. When the cost-parity COP is reached or exceeded, operating the HP at a given temperature is economical.

Capacity Switchover Temperature / Capacity Balance Point: The outdoor temperature below which a heat pump can no longer meet the home's full heating load and supplemental or backup heat is required.

Economic Switchover Temperature / Economic Balance Point: The outdoor temperature at which switching from the HP to the backup heating system minimizes annual heating cost. This can be calculated by consulting manufacturer specifications and identifying the temperature at which the HP begins operating above its cost-parity COP.

Executive Summary

Nearly 5 million single-family homes across the Northeast[1] region have central heating, ventilation, and air conditioning (HVAC) systems that include a forced air heating system paired with a one-way central air conditioner (AC). Each year, when aging AC units reach the end of their life, many households have to pick between a variety of equipment replacement options. When this happens, most simply replace their broken one-way AC with another one-way AC, missing the opportunity to install a "two-way AC": a heat pump (HP), which provides both high-efficiency cooling and heating for year-round comfort.

Every HVAC installation in the region is a critical decision point for equipment with a 10-to-20-year lifecycle. Cooling system installations are one of the region's most strategic points of leverage to improve home heating and cooling performance; reduce costly peak demands on electricity grids; lower overall energy consumption, air pollutants, and greenhouse gas (GHG) emissions; and improve energy costs for Northeast households, all while advancing state policy goals.

Methods and Results

This report evaluates the market potential of AC to HP retrofits; models the installation conditions and switchover controls under which a retrofit yields the greatest economic, energy, and environmental benefits; and discusses policies, programs, and market-based mechanisms that can overcome barriers to adoption. An "AC to HP retrofit" refers to a household opting to install an HP rather than a like-for-like AC replacement and could result in two HVAC setups in the retrofitted household:

- A dual-fuel central HVAC system in which the heat pump provides cooling and heating services and an existing fossil fuel (propane, oil, or gas) furnace covers part of the annual heating needs
- A fully electrified central HVAC system that relies solely on the heat pump system to meet all annual heating and cooling needs

The analysis models multiple retrofit scenarios of homes that install a two-way AC (i.e., heat pump) instead of a one-way AC system. In all scenarios, no matter the prior heating equipment, an HP reduces annual energy consumption and lifetime emissions. These benefits are greatest when the heat pump is sized and operated to cover the full heating load of the home—i.e., full electrification of the heating system.

Operational costs varied across scenarios. These were highly dependent on factors like existing heating system fuels, utility electricity rates, and switchover temperature settings. At one end of the range of savings, a home with an existing propane furnace installing a two-way AC to cover the full heating load—i.e., full electrification—returns up to $3,000 in annual savings. Modeling results returned annual operational cost savings in every state when converting an existing fuel oil or propane furnace to a cold climate variable-speed HP that meets

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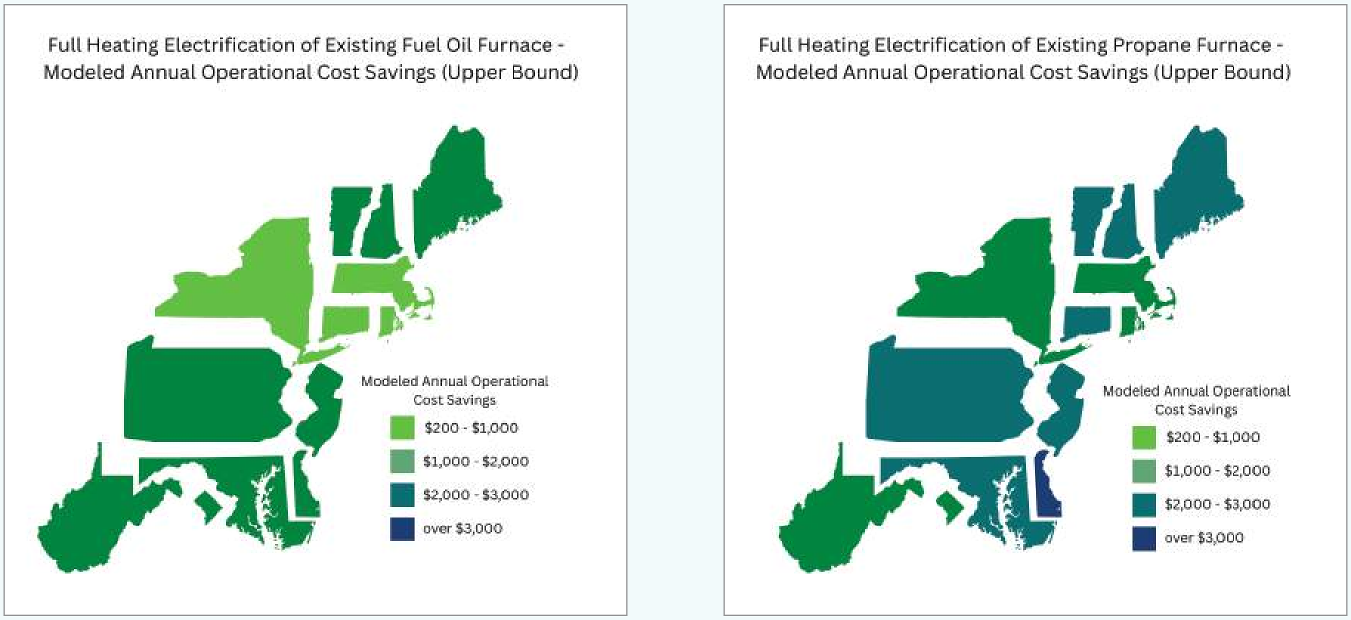
[1] In this report Northeast refers to the entire NEEP region, unless clearly stated. States and jurisdictions include Washington, D.C., West Virginia, Maryland, Delaware, Pennsylvania, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine.

all heating needs—i.e., full electrification. Figure ES-1 below displays the upper bound of annual operational cost savings in each Northeast state for these full electrification scenarios of homes with fuel oil and propane furnaces. The highest modeled annual savings for full electrification of propane furnaces resulted in more than $3,000, while full electrification models of existing fuel oil furnaces returned nearly $2,000 in annual savings at the upper bound.

Figure ES-1: ***Modeled upper-bound annual operational cost savings for full heating electrification of homes with existing fuel oil and propane furnaces***



Homes with existing gas furnaces realize a range of cost outcomes depending on type of heat pump, climate zone, utility rates, and switchover temperatures[2] (i.e., the temperature at which the HP switches to the backup heating system). Modeled homes realized operational cost savings during cooling seasons ranging from $100 to $200, reflecting the increased efficiency of the heat pump systems used to replace the like-for-like AC replacement baseline.

These estimated outcomes on operational costs are modeled from a household perspective—i.e., they do not consider benefits to the grid in the form of reduced summer peak capacity, environmental benefits, or potential costs savings from demand response programs or rate design reform. Estimates are also generalized by state, as the analysis relies on statewide average utility rates. Individual household impacts will vary based on the specific rates. Table ES-1 shows these summary outcomes on estimated operational cost impacts.

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[2] For more information on switchover temperatures, visit: https://goelectric.comed.com/wp-content/uploads/2024/08/001425_ComEd_SwitchoverGuide_WEB_ADA.pdf.

Table ES-1: ***Estimated household operational cost impact of an AC to HP retrofit in each state, for a ccVS HP sized to the cooling load and running down to capacity switchover***

State	BACKUP HEATING SYSTEM TYPE IN DUAL-FUEL SYSTEM		
	Propane Furnace	Fuel Oil Furnace	Gas Furnace
CT	Cost savings	Cost savings	Cost impact – interventions available to realize cost parity or savings
DC	Cost savings	Cost savings	Approximately break-even
DE	Cost savings	Cost savings	Cost savings
MA	Cost savings	Cost savings	Approximately break-even
MD	Cost savings	Cost savings	Cost savings
ME	Cost savings	Cost savings	Approximately break-even
NH	Cost savings	Cost savings	Approximately break-even
NJ	Cost savings	Cost savings	Cost impact – interventions available to realize cost parity or savings
NY	Cost savings	Cost savings	Cost impact – interventions available to realize cost parity or savings
PA	Cost savings	Cost savings	Approximately break-even
RI	Cost savings	Cost savings	Cost impact – interventions available to realize cost parity or savings
VT	Cost savings	Cost savings	Approximately break-even
WV	Cost savings	Cost savings	Approximately break-even

ES1 Notes:

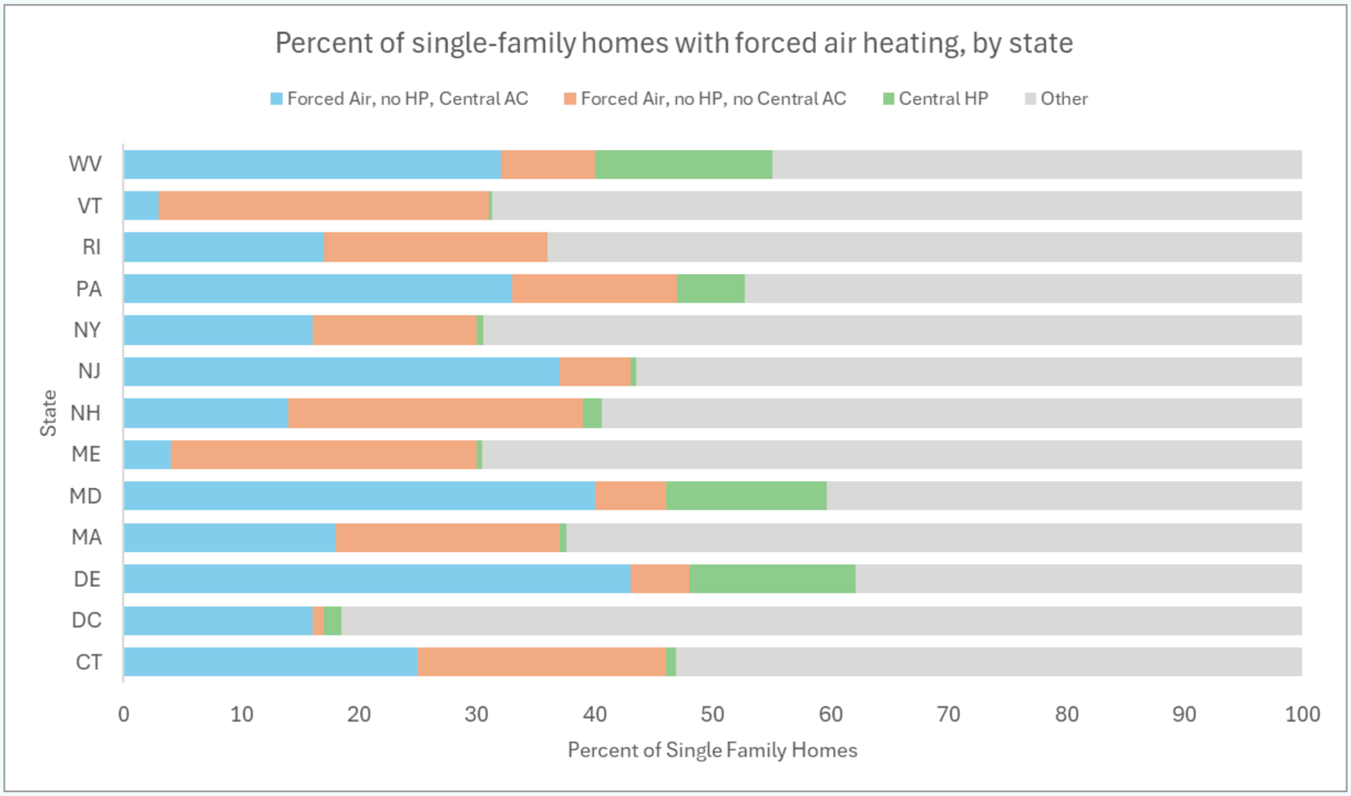
- *The operational cost savings modeled in the report are based on statewide average volumetric rates and provide helpful, directional awareness for the market. However, note that real-world operational cost impacts, especially for homes with gas furnaces, are best evaluated using jurisdictional, utility-specific rates—including any available modern rate designs like time-of-use or heat-pump technology rates and considering non-volumetric rate components—rather than statewide averages.*
- *"Interventions" alluded to in ES-1 refer to interventions on the operational side such as switchover settings, enrollment in modern rate design offerings, etc.*

Key Findings

Market Opportunity

The primary building typology for the type of retrofit modeled is a single-family home with an existing centrally ducted AC. There are 4.7 million such homes in the Northeast. Every year, an estimated 330,000 single-family homes in the region replace their central cooling equipment, and 14,000 install central AC for the first time. The percentage of homes with forced air heating per state, broken out into cooling system type, is shown in Figure ES-2 below.

Figure ES-2: *Percent of single-family homes with forced air heating, by state*



Upfront Cost Considerations

This analysis does not include upfront cost impacts because well-designed programs can match incentives and rebates to incremental costs. Incentives typically vary depending on the type of system, and the upfront cost impacts of those systems.

Single- and two-stage systems, which are typically sized to the cooling load as part of a dual-fuel system in most Northeastern climates, have an incremental installation cost of $200-$3,000 over a baseline single-stage central AC, with the most likely cost within this range falling at about $900. Costs are likely to compress towards the lower end of this range over time, as these units are not very technologically different than ACs. The modest incremental cost of these HP types presents a lower barrier to entry for HP adoption. Variable-speed HPs sized to the cooling load can cover more of a home's heating load but are more expensive, at $2,500-$6,000 more than a central AC.

In contrast, all-electric systems typically require a variable-speed HP in the Northeast and often face additional upfront costs, especially in colder climates, due to increased need for electrical and ductwork upgrades. These HPs typically cost $4,000-$10,000 more than an AC. However, an all-electric system may be at upfront cost parity with a new furnace and AC system in cases where a customer needs to replace both existing heating and cooling systems. Furthermore, the incremental upfront costs may compress further when considering higher efficiency but more expensive variable-speed central ACs.

Modeled Economic Impacts

AC to HP value propositions vary across heat pump types, utility rate structures, and climates. This study finds that opting for a heat pump over an AC replacement results in cost-savings or cost-parity in most scenarios across the region, when combined with strategic switchover settings.

Annual utility costs for modeled scenarios are shown in Figure ES-3 below, assuming the economic switchover temperature (as indicated above the relevant bars), various climate zones (indicated at the top), and existing or backup heating system (with each row representing a different system as shown on right).

Figure ES-3: ***Annual operational costs for baseline versus various heat pumps and sizing methods by climate zone and furnace fuel***

Figure ES-3 Notes:

- *Economic switchover temperatures are noted in the figure for sized-to-cooling scenarios. Cases in which the switchover temperature shown is the same temperature as the capacity balance point are shown in orange.*
- *zNY represents a colder version of climate zone 4, more reflective of conditions in New York City than the conditions experienced in Washington, D.C.*

As shown in the figure, the top two rows show the most potential for cost savings, indicated by the downward slope to the right for each grouping. The best value propositions for an HP retrofit under current electricity rates are in the over 2 million single-family homes with propane and fuel oil furnaces where the incremental cost of installing an all-electric HVAC system (i.e., a cold climate variable-speed system sized to heating), rather than just a new AC, would often pay back in six years or less even assuming high-end incremental installation cost estimates and absent upfront cost rebates that are common in the region.

In most modeled climate zones, homes with existing gas furnaces are expected to see modest annual operating cost savings when installing a variable-speed heat pump sized to cooling and operated with an economic switchover temperature. In warmer climate zones, operating cost savings or cost parity can be achieved when running the heat pump to the capacity balance point or in full electrification scenarios.

Due to the many variables that impact the economical switchover temperature for dual-fuel systems, especially those with gas furnace backups—climate zone, spark gap, heat pump type and sizing, enrolled rate structure, and more—quality system controls are vital. Proper system design for controls and operation principles should be incorporated into contractor training and utility and state program design.

Due to higher heating loads in colder climates, the magnitude of operational cost changes pre- versus post-retrofit is generally higher, even with the same spark gap between fuels. This leads to greater savings in scenarios with a favorable spark gap, and greater cost increases in scenarios with an unfavorable spark gap.

Modeled homes saw $100-$200 of cooling cost savings, with the higher end of these savings in warmer climates.

Modeled Energy Use, Emissions, and Grid Demand Impacts

All modeled heat pump installations saved energy (kWh and therms converted to BTU) and reduced lifetime equipment emissions when compared to the baseline equipment.

The magnitude of energy savings is higher in colder climates due to higher heating loads. In warmer climates, heating and cooling loads are closer in magnitude than in colder climates. Thus, in warmer climates, a greater proportion of a home's heating load can be covered by an HP sized to cooling.

All-electric systems deliver greater energy and emissions savings than dual-fuel systems. Higher switchover temperatures associated with dual-fuel systems correspond with higher energy use and emissions, presenting a trade-off between economics and energy and environmental priorities in certain scenarios.

Backup heating provided by the dual-fuel system's furnace on the coldest days (when heating loads are the highest) decreases peak winter grid demand, enabling greater flexibility in system planning. Time-of-use rates can benefit HP users and are most effective when paired with HVAC demand response controls that shift electricity consumption away from peak hours.

Overcoming Barriers to Adoption

Despite significant growth in HP sales and installations in the region, persistent barriers continue to hold back a more accelerated shift to HPs. These include incremental equipment and installation costs and lower levels of customer awareness, especially during emergency replacement scenarios. AC to HP replacements offer a promising entry point for HP technology and a pathway to realize more robust growth in the market. Modern cold climate heat pumps can reliably meet regional heating and cooling needs, and the installation process of an HP sized to cooling closely mirrors that of a central AC, enabling contractors to adopt the technology with minimal disruption and reducing perceived technological risk. Programs should continue to emphasize contractor training focused on the benefits and use cases of dual-fuel and all-electric systems, paired with targeted customer education and strategic incentives, to help overcome these barriers.

Meanwhile, policy tools like building energy codes, modern rate designs and reforms, long-term utility system planning processes, and emerging clean heat standards provide a strong suite of options for transforming routine AC replacements into opportunities for cost-effective heat pump adoption. In the near term, voluntary incentive programs and contractor training remain the region's most flexible and immediate mechanism to support consumer adoption of efficient technologies. Rebates structured to optimize adoption of AC to HP opportunities would align with incremental costs, expand eligibility beyond only the highest-efficiency HP systems, offer both partial- and whole-home electrification pathways, and incorporate operational guidelines or requirements like switchover temperatures when appropriate.

Program and Policy Recommendations

- **Promote public awareness** of heat pumps as "two-way ACs" to normalize adoption during replacements of central ACs, highlighting their ability to deliver year-round comfort.
- **Reexamine and recalibrate incentive programs** to spur HP market transformation via prioritization of AC to HP retrofits, which could include phasing out central AC rebates in favor of budgeting additional resources for HPs, allowing for flexibility in HP installation types, optimizing rebate amounts to cover incremental costs over central ACs, and more.
- **Support workforce development** and contractor training on heat pump sizing, heat pump selection, and heat pump controls in the context of regional economics.
- **Consider electric space heating rates** to improve full-electrification economics and lower economic switchover temperatures.
- **Align building codes and regulatory frameworks** with AC to HP opportunities, which may include electric-ready or heat pump prioritization code provisions, enhanced clean heat regulatory structures, and more.
- **Develop and implement multi-year program plans and policies** that consider and integrate the strategic role of fully electrified and dual-fuel HVAC systems in long-term energy-system planning and transitions that account for affordability, reliability, and decarbonization goals.

Introduction

Heating and cooling equipment decisions made today will shape household energy costs, comfort, and emissions for decades to come. When a central air conditioner (AC) is reaching the end of its useful life, households typically replace it with another one-way cooling system. Heat pumps should be considered as an upgrade at this time of replacement. Whether installed as a dual-fuel system that uses an existing or new furnace for backup or as a fully electric configuration, heat pumps are essentially air conditioners with a reversing valve, or "two-way ACs," which allow the equipment to provide high-efficiency heating as well as cooling for year-round comfort. They can also provide improved comfort and affordability.

Across the Northeast,[3] state and utility leaders are rising to the challenge of maintaining energy affordability and reliability while modernizing building systems for the future. Indeed, six Northeast states (Maine, Maryland, Massachusetts, New York, New Jersey, Rhode Island) and the District of Columbia have signed a memorandum of understanding with goals to advance clean buildings, including a goal of ensuring 65 percent of heating, cooling, and water heating equipment sales are highly efficient heat pumps by 2030.[4] Increasing energy demand[5] and an aging housing stock heighten the urgency of these efforts. Each new heating, ventilation, and air conditioning (HVAC) installation affects electric and gas utility system load profiles, peak demand, and long-term infrastructure needs, making these decisions important for grid reliability and resource planning as well as for individual homeowners and renters. States and electric utilities can benefit from dual-fuel HP systems, as they can contribute to more balanced year-round loads, as well as regional affordability, reliability, and market transformation goals.

When replacing an existing AC with a heat pump, households face important decisions about equipment size, configuration, and performance characteristics, each with upfront and operating cost implications. These trade-offs can be complex, and clearer frameworks are needed to guide contractors, program designers, and policymakers in supporting customers through these choices, as well as incorporating them effectively into energy-efficiency and electrification programs.

This analysis focuses on the following objectives:

- Quantify the economic potential for residential HPs to replace central ACs in the Northeast
- Identify the conditions under which the AC to HP switch yields the greatest benefits in energy usage, customer economics, grid impact, and greenhouse gas (GHG) emissions
- Assess the benefits, barriers, and stakeholder considerations relevant to customers, utilities, implementers, manufacturers, distributors, and contractors in the region
- Explore policies, programs, and market-based mechanisms that can accelerate this transition within existing state and utility frameworks

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[3] In this paper, the Northeast region refers to 12 states and Washington, D.C., in the New England and Mid-Atlantic regions (see Figure 1).

[4] Booth, K., Honegger, S., Fosberg, C., Miziolek, C., & Chapman, G. (2024, October 30). *Heat Pumps in the Northeast and Mid-Atlantic: Costs and Market Trends.* Northeast States for Coordinated Air Use Management (NESCAUM), Ozone Transport Commission (OTC), & Energy Solutions. https://www.nescaum.org/documents/Heat-Pumps-in-the-Northeast-and-Mid-Atlantic---Costs-and-Market-Trends.pdf

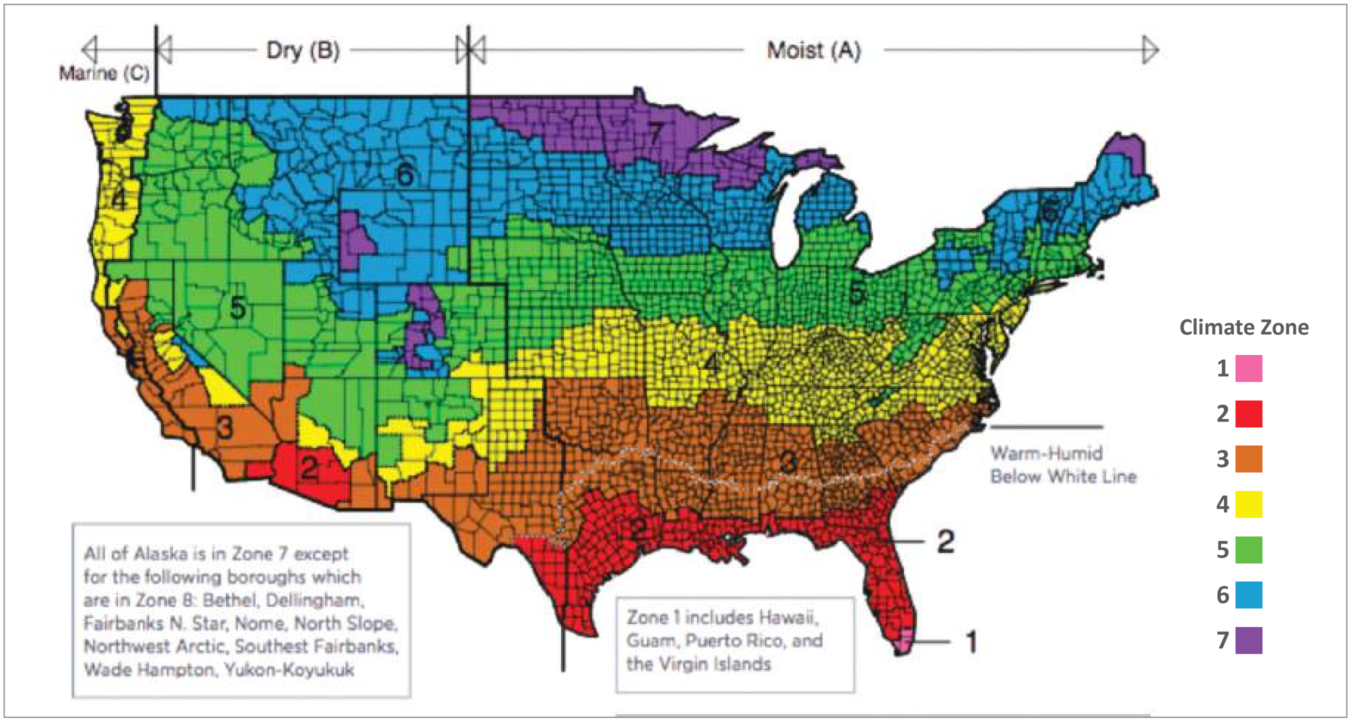
[5] U.S. Energy Information Administration (EIA). (2025, May 13). "After More Than a Decade of Little Change, U.S. Electricity Consumption Is Rising Again." Today in Energy. https://www.eia.gov/todayinenergy/detail.php?id=65264

This study aims to inform practical strategies for states and utilities to capture the full value of cooling system retrofits, turning a routine decision into a regional efficiency and affordability opportunity that benefits residents and utilities into the future.

Scope

The analysis and report focus on the opportunity to replace existing air conditioners with air source heat pumps in single-family homes across the Northeast states in the NEEP region, which includes Connecticut, Washington, D.C., Delaware, Massachusetts, Maryland, Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia. Analyses focus on climate zones 4, 5, and 6, which together represent the majority of the region's households (Figure 1). While some jurisdictions extend into climate zone 7, the limited geographic area and market size make them outside of the primary scope of this study.

Figure 1: *ASHRAE climate zones*



All of Alaska is in Zone 7 except for the following boroughs which are in Zone 8: Bethel, Dellingham, Fairbanks N. Star, Nome, North Slope, Northwest Arctic, Southest Fairbanks, Wade Hampton, Yukon-Koyukuk

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands

The research focuses on the opportunity for households with centrally ducted systems that are currently equipped with central ACs and fuel-fired furnaces (gas, fuel oil, or propane). As an AC replacement often occurs at a different time than furnace replacement, this research highlights opportunities for dual-fuel systems that retain the existing functional furnace. Scenarios involving an older or faulty existing furnace are provided when relevant.

The analysis also notes implications for ducted homes installing central cooling for the first time. As the Northeast experiences more extreme summer temperatures, many households without existing AC systems are installing cooling equipment where it did not previously exist.

The modeling and discussion consider both dual-fuel systems and all-electric centrally ducted air source HPs. Ductless, window, packaged terminal, ground source, and air-to-water heat pumps are excluded from this study's scope but pose similar opportunities.

Research Methods

To assess the regional market opportunity and potential impacts of replacing central AC systems with HPs, the research team conducted a literature review, a program and policy review, a market data analysis, and modeling of economic, environmental, and grid impacts. The research team engaged an Advisory Committee composed of subject matter experts to provide guidance and input throughout the effort.

Advisory Committee

To ensure the research and recommendations in this report were well-informed and actionable, the research team formed an Advisory Committee to guide the project. The Advisory Committee consisted of 31 stakeholders with wide-ranging areas of expertise. Stakeholder types include manufacturers, contractors, non-profit organizations, regional energy-efficiency organizations, consultants and service providers, program implementers, utilities, academics, and think tanks.

The Advisory Committee met three times throughout the project:

- **Advisory Committee Meeting #1:** The research team presented the research scope and plan, including research goals, key research questions, research methods, and the anticipated outline of the report. Advisory Committee members offered feedback to confirm and guide the direction of the research and suggest resources, areas of emphasis, etc.
- **Advisory Committee Meeting #2:** The research team shared initial findings and facilitated discussion focused on results from the market opportunity and modeling analysis. The Advisory Committee provided feedback on the research findings and provided suggestions for the next phase of research and drafting.
- **Advisory Committee Meeting #3:** The research team shared final market opportunity and modeling findings, AC to heat pump retrofit benefits and barriers, and strategies to increase market adoption. The Advisory Committee provided feedback on the findings and recommendations to inform the final report.

Market Data Analysis

The research team conducted a market opportunity analysis to assess market conditions throughout the Northeast and quantify the opportunity for installing a heat pump at the time of replacing a central AC. In this section, we estimate the prevalence of relevant building stock characteristics, provide a summary of fuel rate economics, outline local and general upfront cost considerations for these technologies, and discuss additional customer benefits. The results of this section provide population-level statistics that are used in the modeling section to contextualize modeled case studies at scale.

One important finding from the market opportunity analysis is the number of single-family homes in each state that have centrally ducted HVAC systems, allowing for a potential central HP installation. In analyzing the Northeast building stock to quantify this market potential, we drew from two primary data sources. Firstly, 2020

Energy Information Administration (EIA) Residential Energy Consumption Survey (RECS) microdata was used to determine the proportion of the single-family building stock in each state that would be a good fit for a central heat pump installation, and the proportion of each state heated by each fuel type.[6] Data from the 2023 U.S. Census American Community Survey was then used to update these proportions to more recent estimates of the total number of homes in each state.[7]

The section puts this overall market opportunity into context by looking at the rate at which new cooling equipment is installed in homes, and therefore an estimated number of homes that could install a central HP per year. To estimate this cooling equipment turnover, historical sales data were gathered from the Air-Conditioning, Heating, and Refrigeration Institute (AHRI).[8]

The section then analyzes energy costs across the region to understand fuel rate economics in each state. Assumed electricity costs in this section and throughout the report reflect a volumetric charge (i.e., the cost per unit of energy, not including monthly lump utility service charges) pulled from Genability. This is given for the standard residential rate within the largest utility in each state and averaged over the course of 2023. Fuel costs are pulled from EIA databases and are averaged from September 2023 to September 2025. These statewide average volumetric rates provide helpful, directional awareness for the market. However, note that real-world operational cost impacts, especially for homes with gas furnaces, are better evaluated using jurisdictional, utility-specific rates—including any available modern rate designs like time-of-use or heat-pump-technology rates and considering non-volumetric rate components—rather than statewide averages.

The incremental installation cost of an HP compared to a central AC is a barrier to central HP installation, even in locations where fuel rates are favorable operationally. Thus, we discuss the upfront costs of equipment next. This section provides a range of prices for various HP systems sized to homes' cooling or heating loads. It also outlines additional factors (e.g., duct and electrical upgrades) that contribute to a higher price tag when sizing an HP for full heating displacement. We gathered installation costs from a literature review of recent cost and market trend reports in the Northeast, as well as Texas, Colorado, the Midwest, and Canada. These reports use a variety of research methods, including direct aggregation of invoices, adjustments to out-of-state gathered data using RSMeans cost adjustments, and consultation with contractors.

Lastly, we discuss additional customer benefits from partial and full electrification, drawing from literature review sources and Advisory Committee input.

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[6] U.S. EIA. (2020). 2020 RECS Survey Data. Residential Energy Consumption Survey (RECS). https://www.eia.gov/consumption/residential/data/2020/

[7] U.S. Census Bureau. American Community Survey (ACS). https://www.census.gov/programs-surveys/acs.html

[8] Air Conditioning, Heating, and Refrigeration Institute (AHRI). Statistics: Historical Data, Monthly Shipments, and Member Reports. https://www.ahrinet.org/analytics/statistics

Modeling

The research team then modeled the impacts that AC to HP retrofits would have on equipment loads, operational cost, energy consumption, grid demand, and long-term operational emissions. These results provide outcomes for one home across climates, furnace fuels, and heat pump types.

Climate: We modeled scenarios in Washington, D.C., New York City, New York, Boston, Massachusetts, and Essex Junction, Vermont, to incorporate a range of climate zones and grid operators that represent the Northeast region. TMY3 weather files were used for each location.

Furnace Fuels: We ran scenarios with a propane furnace, a fuel oil furnace, and a gas furnace. We did not model electric furnace retrofits because these retrofits will always result in cost and energy savings due to increased HP efficiency. We assumed an annual fuel utilization efficiency (AFUE—i.e., furnace efficiency) factor of 80 percent, which is representative of the existing Northeastern building stock.

Heat Pump Types: We modeled scenarios with each furnace combined with a single-stage, two-stage, variable-speed, and cold climate variable-speed HP. Modeled heat pump capacities and efficiencies decreased with outdoor temperature according to manufacturer specifications. When compared to the other HP types, the cold climate heat pump operates the most efficiently, and at the highest capacity, at lower temperatures. The modeled baseline AC unit had a Sustainable Energy Expense Reduction and Refrigeration (SEER2) of 15, leading to cooling efficiency gains post-retrofit.

The team completed this modeling using Slipstream's heat pump model, which takes weather, home, and HVAC system attributes and runs heat transfer and energy use calculations for each hour of the year. We calibrated the model for this project by referencing data from Northeast homes in the 2018 ResStock dataset and drawing from Advisory Committee input.

A detailed breakdown of modeling defaults, archetypes, and assumptions, including equipment sizes and HVAC loads for each climate zone, can be found in Appendix A.

The first modeling subsection provides economic impacts for the modeled home in each climate and with each HVAC system. These are reported annually and broken into heating and cooling outcomes. After sharing modeled results, the section projects these results across the rest of the region to understand operational economic impacts of AC to HP retrofits at scale. The utility rates used in each location are the same as shown in the market data analysis.

The next subsection details energy savings in each scenario. The numbers provided are site energy savings, and do not incorporate utility grid or power plant efficiencies. Energy savings use standard conversion factors to equate HP energy consumption in kWh to furnace fuel energy consumption in therms or equivalent.

The team then used the modeled load shapes to calculate the lifetime emissions of each HVAC system based on each location's grid utility operator. We calculated emissions in conjunction with the National Renewable Energy Laboratory's (NREL) 2024 Cambium workbook, which provides average hourly long-run marginal emissions rates for electricity assuming grid update projections over time. We used projected grid emissions for the "mid-case," or most likely, renewable adoption scenario, over an assumed 15-year equipment lifetime.

Lastly, the grid demand analysis provides average daily peak demand throughout the year by calculating the average hourly load shape of each HVAC system in each climate per season. We then model the impact of time-of-use pricing using several Northeastern time-of-use rates.

For dual-fuel systems, we give results for various switchover temperatures. A capacity switchover point is indicated in scenarios for which a dual-fuel system runs down to the temperature at which the HP can no longer cover the heating load. An economic switchover temperature is indicated in scenarios for which the cost-minimizing switchover temperature setting is shown. For modeling, we determined this setting by running each HVAC system in each climate with switchover temperatures of 47°F, 30°F, and the capacity switchover temperature, and pulling the lowest cost outcome.

Literature Review

The research team conducted a targeted literature review to identify and synthesize existing studies, reports, and policy and programs related to AC to HP retrofits. The research team identified sources through database searches, professional recommendations from peer organizations, and Advisory Committee members. Each source was reviewed for relevance, geographic applicability, and methodological rigor. Sources outside of the Northeast region were included when relevant because of cold climate similarities (e.g., in the Midwest and Canada) and/or pertaining to common barriers and opportunities across all regions.

While reviewing sources, the research team identified common implementation strategies, opportunities, outcomes, and barriers. The findings were synthesized to highlight key themes and inform strategic and actionable recommendations.

Program and Policy Review

The program and policy review situates the research within the current policy and program landscape in the Northeast, identifying enabling and constraining conditions and highlighting opportunities to align emerging research findings with policy and program development.

The research team assessed the existing program landscape by collecting and compiling incentive data from major utility and state programs across the Northeast states and using publicly available program websites and documentation. Incentive offerings were categorized and analyzed to identify trends in program design and to compare levels of support for air source heat pumps versus central air conditioners. Only residential programs for air source heat pumps and air conditioners were analyzed. The largest program in each state was assessed, so not all programs are captured in this report (i.e., municipal utilities). The analysis focused on only rebate-based incentives and did not include financing programs.

Market Opportunity

This section provides an analysis of market conditions throughout the Northeast that illustrates the opportunity for installing a heat pump instead of a central AC. First, to identify the total market opportunity, we estimate the prevalence of relevant building stock characteristics and the rate of equipment turnover. Second, to address the economic market opportunity, we provide a summary of fuel rate economics and outline local and general upfront cost considerations for these technologies. Finally, we discuss additional customer benefits from the adoption of a heat pump instead of a central AC.

Northeastern Building Stock

Key Insights

- Over 4.7 million single-family homes in the Northeast have centrally ducted AC but no heat pump.
- An estimated 330,000 single-family homes in the region install central cooling equipment per year, 14,000 of those for the first time.

We quantified the portion of the Northeast single-family building stock that could install a central heat pump instead of a central air conditioner to understand the maximum impact that interventions and programs can have within each state in the region. The primary requirement of a central heat pump installation is central ductwork in the home. Figure 2 below shows the percentage of each state's building stock with central ductwork, broken out by current AC type. Delaware, Maryland, West Virginia, and Pennsylvania have the greatest proportion of forced air heating systems, all exceeding 50 percent. These states also have the largest portion of the building stock transitioned to heat pumps already, ranging from five to 15 percent.

Figure 2: ***Percent of single-family homes with forced air heating, by state***

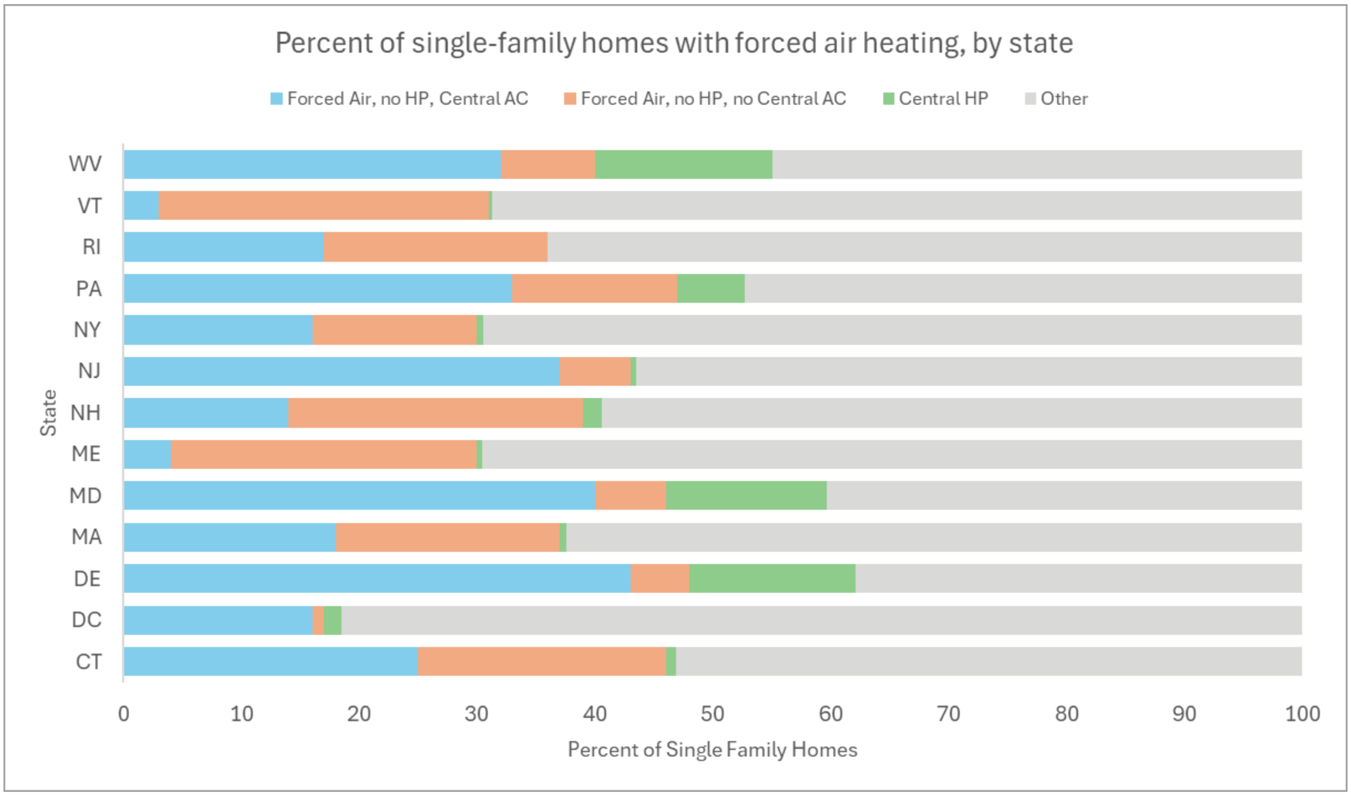
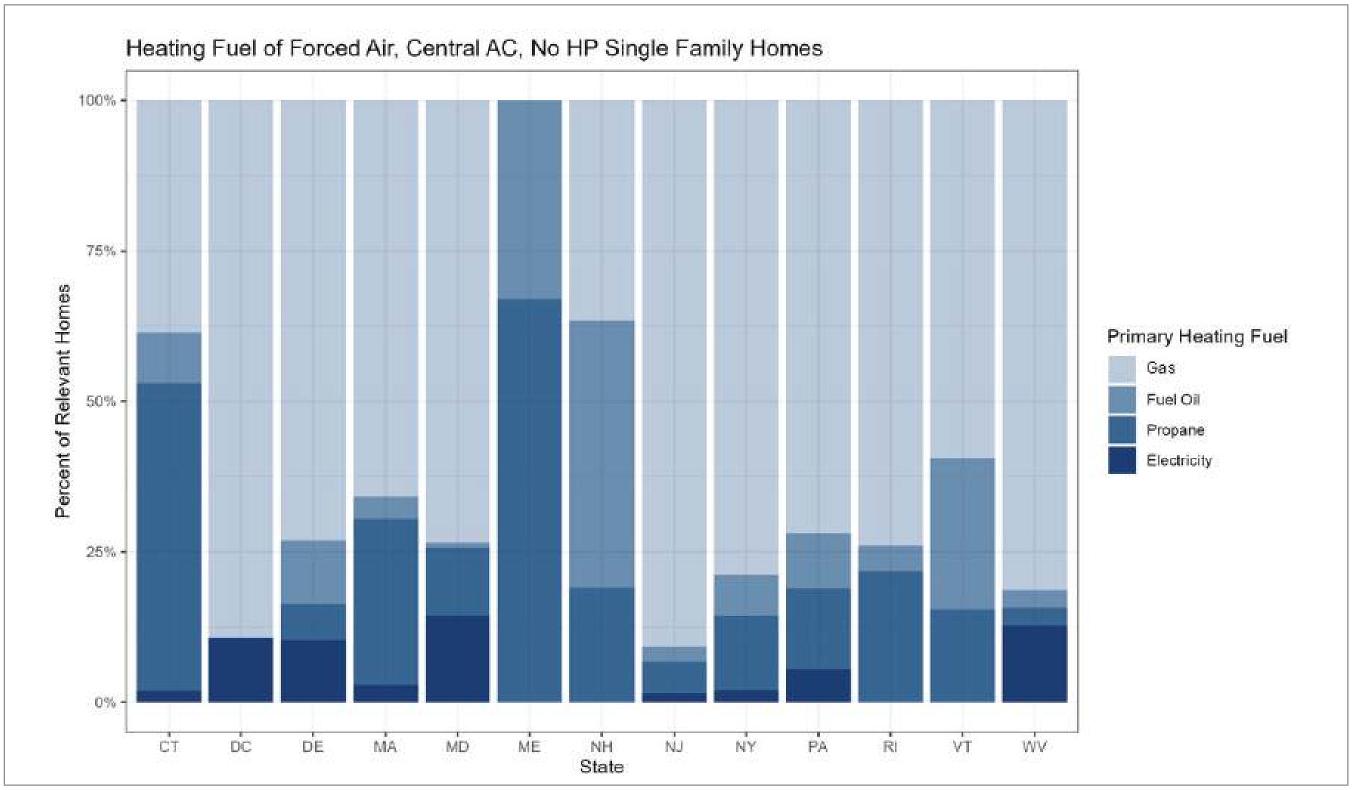


Figure 3 below looks at just the “forced air, no HP, central AC” equipment type, illustrating the percentage of AC to HP candidates that are currently heated with each fuel type.

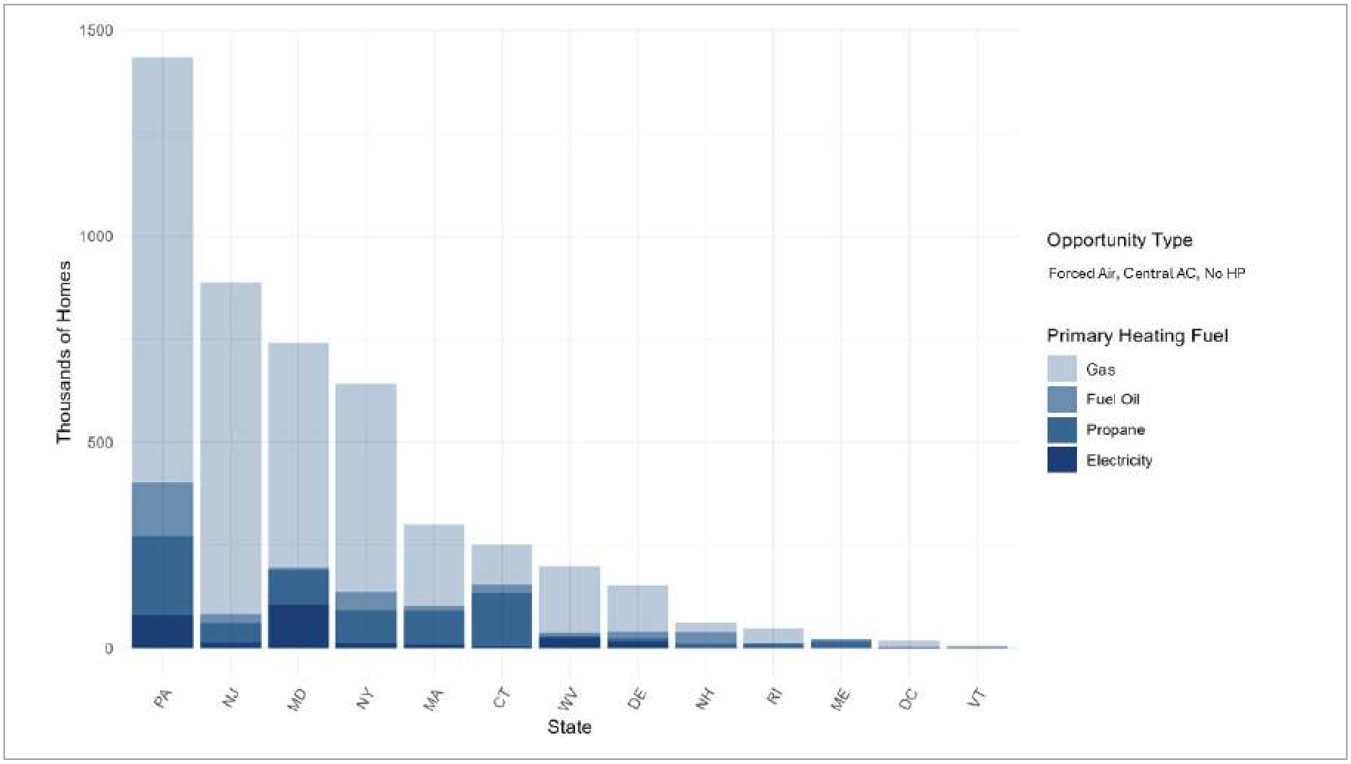
Gas is by far the most common heating fuel for these homes in almost all states, as shown by the lightest blue color in Figure 3. Connecticut and Maine have a greater than 50 percent share of AC to HP candidate buildings with propane heating. Note that Maine and Vermont AC to HP candidates are only a limited portion of the stock, as shown above, with most homes being non-ducted or ducted without a central AC.

Figure 3: ***Percent of single-family homes with central AC (no HP), by heating fuel***



Using census data, Figure 4 illustrates the total number of AC to HP candidates in each state, shaded by fuel type. We identified 4.7 million homes in the region as primary candidates for AC to HP conversion. Within these homes, there are a total of 3.5 million homes heated with gas with a central AC, 650,000 propane-heated homes with a central AC, 270,000 fuel-oil-heated homes with a central AC, and 250,000 homes with a central AC and an electric furnace in the Northeast region.

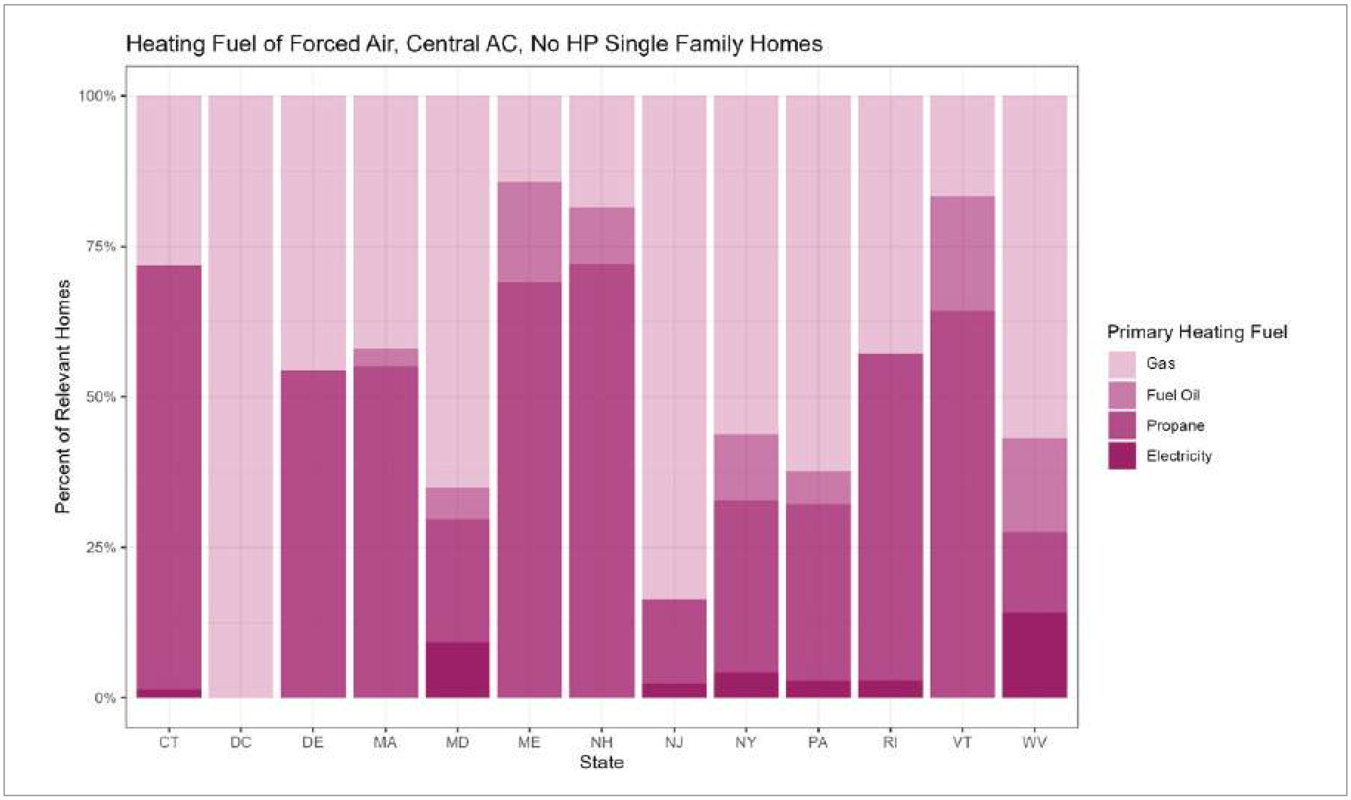
Figure 4: ***Number of single-family homes with forced air, central AC no HP, by heating fuel***



Although this paper focuses on transitioning homes with existing central ACs to heat pumps, some homes are looking to install AC for the first time. In some of these cases, a dual-fuel central HP system could be installed for similar installation and operational cost outcomes to a central AC. This secondary market opportunity is shown in Figure 5 below, which quantifies the percentage of single-family homes in each state that have ducted heating systems and no AC. These bars, like those above, are colored by heating fuel.

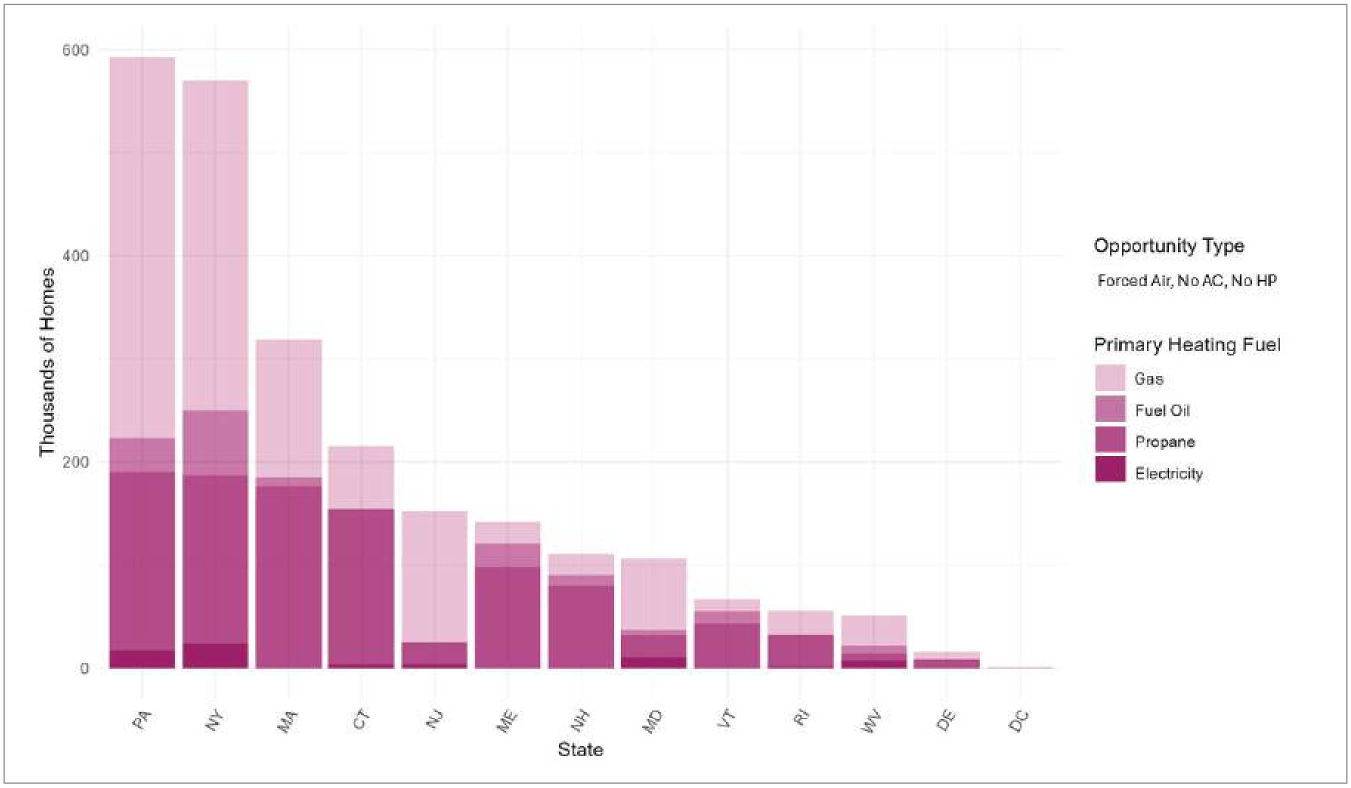
There is a greater prevalence of propane heating in these homes than in homes with a central AC; propane-heated forced air homes make up more than 50 percent of ducted households with no AC in Connecticut, Delaware, Massachusetts, Maine, New Hampshire, Rhode Island, and Vermont.

Figure 5: ***Percent of single-family homes with forced air heating (no AC and no HP), by heating fuel***



Using census data, Figure 6 illustrates the total number of forced air homes without a central AC per state, shaded by fuel type. Comparing the primary and secondary market sizes, we find more residences with a central AC than with forced air heating and no central AC in almost all states, with the exception of the northernmost states (Maine, New Hampshire, and Vermont).

Figure 6: ***Number of single-family homes with forced air, no central AC and no HP, by heating fuel***



Only a portion of the potential market detailed above replaces or installs cooling equipment each year. AHRI has recorded shipment data of primary cooling equipment sales, including both ACs and air source heat pumps[9] in the United States over the past two decades. Installations of primary cooling equipment have totaled around 9 million units per year in recent years.[10] This equates to 7 percent of the 124 million U.S. homes.[11] Multiplying this percentage by the total number of Northeastern single-family homes with forced air HVAC results in an estimated 330,000 homes from Figure 6 installing central AC or heat pump equipment per year. The majority of these installations likely come from the "forced air, central AC, no HP" category, as households replace their current central AC equipment at the time of the equipment's failure.

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[9] AHRI. Central Air Conditioners and Air-Source Heat Pumps. https://www.ahrinet.org/analytics/statistics/historical-data/central-air-conditioners-and-air-source-heat-pumps

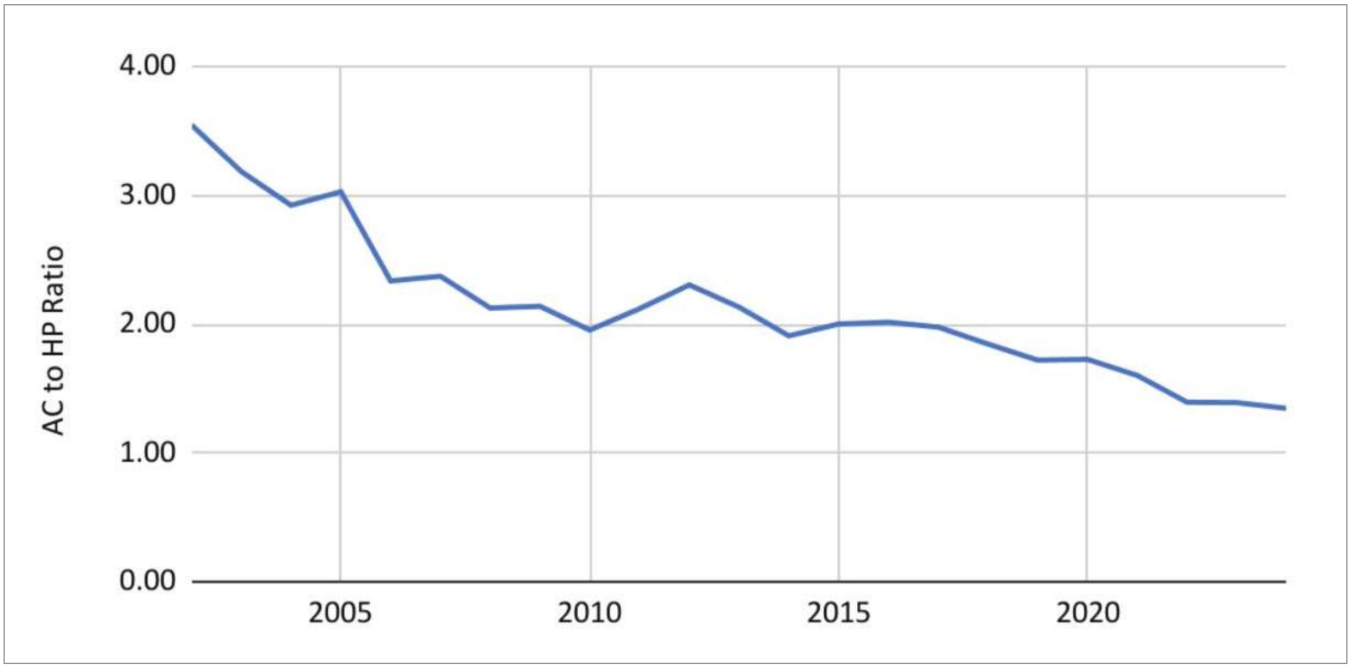
[10] This includes both ducted and ductless models, but not window or wall room ACs.

[11] U.S. EIA. (2023, May). Consumption: Residential Data, Space Heating in U.S. Homes. https://www.eia.gov/consumption/residential/data/2020/hc/pdf/HC%206.1.pdf

Total sales of cooling HVAC technologies have increased by about 4 million shipments since 2005. Assuming that the rate of equipment replacement has remained constant, this means that cooling technologies are being installed for the first time in 200,000, or 0.2 percent of, U.S. homes per year. Adjusting for the number of Northeast single-family homes with forced air HVAC, this results in an estimate of 14,000 homes from the "forced air, no AC, no HP" category above (i.e., this study's secondary market opportunity) installing central cooling equipment per year. Note that adoption patterns likely vary by region, with a greater increase in adoption in cool and/or dry climates where AC has historically not been installed as often.

The U.S. is already seeing a transition from AC installations to heat pump installations. Figure 7 below shows the ratio of ACs to heat pumps sold over the past 20 years. For each central air source heat pump sold in 2024, around 1.4 central ACs were sold, compared to 3.5 central ACs in 2000. This paper provides insights on the trends in policies and system controls contributing to this trend and offers recommendations to further the trendline in this direction.

Figure 7: ***Ratio of AC to heat pump sales over time, from AHRI shipment data***



Courtesy of Nate Adams and Shawn LeMons

Northeastern Energy Rates

Key Insights

- The best value propositions under current Northeastern average rate structures are in households with propane and fuel oil furnaces.
- Strategic rate design can unlock broader savings for homes with existing gas heating, especially in states with a high spark gap, like New York, New Jersey, Connecticut, and Rhode Island.

To understand the economic value proposition of an AC to heat pump retrofit, it is important to consider the relative costs of the baseline furnace fuel and electricity, as this determines the impact of a retrofit on a customer's energy bills. These costs vary widely across the Northeast region and fluctuate regularly.

The cost-parity coefficient of performance (COP) indicates the heat pump efficiency at which a home would start experiencing operational cost savings when heating with a heat pump as opposed to the baseline furnace. This is calculated by dividing the electricity cost per BTU by the fuel cost per BTU and multiplying by an assumed furnace efficiency.12 Table 1 below lists costs and cost-parity heating COPs for each fuel type in each state.

Table 1: ***Fuel prices and heating cost-parity COPs per state, 80 AFUE furnace***

State	Volumetric Electricity Price ($/kWh)	Volumetric Propane Price ($/gallon)	Volumetric Fuel Oil Price ($/gallon)	Volumetric Gas Price ($/therm)	Heating Cost-Parity COP Elec vs. Propane	Heating Cost-Parity COP Elec vs. Fuel Oil	Heating Cost-Parity COP Elec vs. Gas
CT	$0.30	$4.00	$3.60	$1.40	1.6	2.7	4.7
DC*	$0.21	$3.60	$3.80	$1.40	1.2	2.7	3.3
DE	$0.14	$3.80	$4.00	$1.30	0.8	1.1	2.4
MA*	$0.33	$3.60	$3.80	$2.20	2.0	2.9	3.4
MD	$0.18	$3.60	$3.60	$1.50	1.0	2.5	2.6
ME	$0.21	$3.30	$3.80	$1.50	1.4	1.5	3.2
NH	$0.21	$3.70	$3.90	$1.70	1.2	1.9	2.9
NJ	$0.21	$3.70	$3.90	$1.20	1.2	1.8	3.9
NY*	$0.31	$3.50	$4.00	$1.50	1.9	2.5	4.7
PA	$0.19	$3.00	$3.40	$1.30	1.3	1.8	3.3
RI	$0.21	$3.70	$3.70	$1.70	1.7	2.5	3.8
VT*	$0.21	$3.70	$3.70	$1.60	1.2	1.9	3.1
WV	$0.16	$3.00	$3.40	$1.20	1.2	1.5	3.1

* These rates were included in the next section as the modeled scenarios for each zone.

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[12] These calculations assume an AFUE of 80 percent for all furnaces, which is representative of the existing Northeastern ResStock building stock, though furnaces currently sold on the market are generally higher efficiency.

Note that because an electric furnace uses electricity at the same cost as an HP and operates at an assumed COP of 1.0, the cost-parity COP when retrofitting an electric furnace is 1.0. This results in energy savings in all electric resistance-to-HP retrofits.

Upfront Cost Considerations

Key Insights

- Adding heating functionality to AC equipment has a low incremental manufacturing cost, but market immaturity drives variation. HPs are not very technologically different from CACs to install, indicating the potential for future cost compression.
- Single- and two-stage systems, which are typically sized to the cooling load as part of a dual-fuel system in most Northeastern climates, have an incremental installation cost $200-$3,000 over a central AC, with the most likely cost within this range falling at about $900. The modest incremental cost of these HP types presents a lower barrier to entry for HP adoption. Variable-speed HPs sized to the cooling load can cover more of a home's heating load but are more expensive, at $2,500-$6,000 more than a central AC. In the case that the furnace fails in the future, the homeowner's options include weatherization to lower the home's heating load, furnace replacement, a ductless mini-split, or a variable-speed HP sized to heating.
- All-electric systems typically require a variable-speed HP in the Northeast and can have the largest incremental cost of systems evaluated, especially in colder climates, due to the potential need for electrical and distribution system upgrades. These systems typically cost $4,000-$10,000 more than a central AC. However, if a customer must replace both heating and cooling systems, an all-electric system may be at upfront cost parity with a new furnace plus CAC system.

Upfront cost is a critical consideration when promoting the adoption of any efficient technology. In an ideal scenario, a more expensive but more efficient technology will pay off its incremental installation cost within its lifetime.

Fundamentally, adding heating capability to a given air conditioner, thereby converting it to a heat pump, requires minimal adjustments to manufacturing. Heat pumps include a reversing valve, defrost board, and controls requirements that an AC does not, but the cost increase of these additions should be small, absent any market considerations. However, the current low level of heat pump market maturity introduces a significant variation in cost. Because contractors are not yet able to deploy these systems at a large scale, customers see a markup on HP units. Market interventions, such as those described in the "Policy and Programs" section, can decrease this markup in the short term while providing experience to market actors that can prompt the lowering of this markup in the long term as well.

Changing codes and regulations also influence product pricing. For example, the American Innovation and Manufacturing Act restricted the manufacturing of products using R-410A starting in January 2025, which will result in more environmentally friendly refrigerants across the board, but also has led to an adjustment period for both AC and HP market actors.

Upfront cost information presented here has been condensed from several sources. The two most relevant sources are a recent Northeast States for Coordinated Air Use Management (NESCAUM) cost and market trend report for heat pumps in the Northeast[13] and NEEP's prior report on high-performance HVAC in the region.[14] Additional sources of data include reports from Massachusetts,[15],[16] Texas, Colorado,[17] the Midwest,[18] and Canada.[19] Taken together, these sources outline a consistent picture of the upfront costs of heat pump installations across scenarios.

In most of the Northeast, homes require more heating than cooling energy. In these cases, because an air conditioner's capacity is sized to meet the smaller cooling load, a one-to-one replacement with a heat pump would result in a system that meets the entire cooling need and only a portion of the heating need. This system would rely on backup heat (e.g., the furnace) during colder periods. For cooling-sized scenarios, the full range of HP types are applicable, including single-stage, two-stage, and variable-speed models. Variable-speed installations are typically more expensive but can cover more of the home's heating load.

Alternatively, the HP could be sized to meet the home's entire heating load. The increased capacity of the resulting system typically translates to a more expensive variable-speed HP in most Northeastern climates. Installation costs could increase further in this scenario: The heat pump would need to have higher capacity, which might also trigger electrical, duct, and HVAC system upgrades.

Table 2 below summarizes cost data for three HP installation scenarios compared to a baseline single-stage one-way central AC: a single- or two-stage HP sized for cooling, a variable-speed HP sized for cooling, and a variable-speed HP sized for heating. There are many installation types not included in the table, such as sizing an HP to as much of the heating load as possible without needing upgrades, which would likely fall near the high end of the first or second rows' incremental costs. Furthermore, the incremental upfront costs may compress further when compared to a baseline of a higher efficiency but more expensive variable-speed central AC.

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[13] Booth, Honegger, Fosberg, Miziolek & Chapman. *Heat Pumps in the Northeast and Mid-Atlantic.*

[14] Northeast Energy Efficiency Partnerships, Inc. (NEEP) & Slipstream. (2025, May). *Northeast High-Performance HVAC Market Assessment Report.* https://neep.org/sites/default/files/media-files/neep_ne_high_performance_hvac_market_assessment_final_.pdf

[15] NMR Group, Inc. (2024, October 18). *Residential Heat Pump Invoice Cost Analysis (MA23X14-B-RHPINV).* Massachusetts Program Administrators & EEAC. https://ma-eeac.org/wp-content/uploads/MA23X14-B-RHPINV-Residential-Heat-Pump-Invoice-Cost-Study-Web.pdf

[16] Guidehouse. (2024, August 9). *Massachusetts Heat Pump Incremental Cost Research.* Massachusetts Residential Program Administrators. https://ma-eeac.org/wp-content/uploads/Massachusetts-Heat-Pump-Incremental-Cost-Research-Memo_Final_2024-08-09.pdf

[17] Colorado Energy Office / State of Colorado. (2025, June). Accelerated Adoption of Heat Pump Technology: Analysis of a Potential Point-of-Sale Standard for Residential Air Conditioners in Colorado. Manuscript available upon request.

[18] Midwest Heating and Cooling Collaborative. (2025, May). *Moving Toward High-Performance HVAC: Applications for Dual Fuel Heat Pumps in the Midwest.* https://mwcollab.org/sites/mwcollab/files/2025-06/Moving%20Toward%20High-Performance%20HVAC%20-%20Applications%20for%20Dual%20Fuel%20Heat%20Pumps%20in%20the%20Midwest.pdf

[19] Gard-Murray, A., Haley, B., Miller, S., & Poirier, M. (2023). *The Cool Way to Heat Homes: Installing Heat Pumps Instead of Central Air Conditioners in Canada.* Building Decarbonization Alliance, Canadian Climate Institute, Efficiency Canada, & Greenhouse Institute. https://buildingdecarbonization.ca/report/the-cool-way-to-heat-homesinstalling-heat-pumps-instead-of-central-air-conditioners-in-canada/

Table 2: *Incremental installation cost of heat pump retrofits over AC installation*

Baseline	Retrofit Scenario	Incremental Cost (Low)	Incremental Cost (High)
Single-stage AC sized for cooling	Single- or two-stage HP sized for **cooling**	$200	$3,000
Single-stage AC sized for cooling	Variable-speed HP sized for **cooling**	$2,500	$6,000
Single-stage AC sized for cooling	Variable-speed HP sized for **heating**	$4,000	$10,000[20]

One of the key advantages of dual-fuel systems with the heat pump sized to cooling, and a major reason for their growing popularity, is affordability. In the absence of sufficient incentive programs to cover full project cost or incremental equipment costs, full electrification of heating systems can be cost prohibitive, especially for cost-sensitive ratepayers. This could be further complicated in a full electrification project that requires duct or electrical upgrades for an all-electric system. Dual-fuel systems can provide a lower-cost entry point, especially in an AC to HP scenario where the customer maintains the existing furnace.

Note that in partial electrification scenarios, future full electrification of the residence remains an option through weatherization measures to reduce the heating load, ductless mini-splits to provide additional heating capacity, and/or future system upgrades, with the cost of those measures being spread over time. This future full electrification is more feasible with a variable-speed HP.

Several pathways for replacing an AC with an HP are outlined below. The ideal pathway depends on the specifics of the home, the homeowner's finances, and available incentives. Note that these scenarios assume that home heating loads are greater than home cooling loads. In the southernmost portions of the Northeast, heating and cooling loads may be close to equivalent, meaning that an all-electric system could likely be installed at a "sized to cooling" cost.

Working Furnace and New HP Sized to Cooling

If the furnace is in working order (less than 12 years old and in good condition) and the homeowner is looking for the minimum upfront cost, a single- or two-stage HP sized for cooling could be installed for **$200-$3,000** more than a single-stage AC, as shown in Table 2, with the most common incremental cost within that range falling at about **$900**. In that case, the furnace would pick up heating load over a wide band of low temperatures.

Alternatively, a variable-speed HP system could be installed sized to the home's cooling load. This HP type has higher capacity maintenance and efficiencies at lower temperatures and could pick up more of the home's heating load. However, variable-speed inverters add complexity to the installation process, and are thus more expensive. Sized to the cooling load, these HPs are installed at an incremental cost of **$2,500-$6,000**.

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[20] This incremental cost incorporates some of the most common necessary electrical and ductwork upgrades needed to size an HP to heating but excludes the most expensive outlier retrofits, which can be thousands of dollars higher.

Note that if a variable-speed system was sized toward the cooling load, but as high as possible without incurring home upgrades, this could minimize future upgrade needs while incurring an incremental cost still within the variable-speed sized-to-cooling range. Additionally, Advisory Committee members suggest that because heating loads and system sizing needs are often overestimated, a variable-speed heat pump sized to the cooling load or slightly higher may cover most or all of a home's heating load in some scenarios.

If the furnace gives out before the end of the HP's life (a risk minimized by installing cooling-sized HPs only on furnaces still under warranty, or less than 10-12 years old), a cooling-sized heat pump may not be able to meet the heating load at the coldest temperatures, in which case the homeowner must once again pay for an HVAC retrofit. They could choose to replace their furnace with a new one for $4,000-$8,000, they could add a single-head ductless mini-split to provide supplemental heating, which would cost an additional $5,000-$10,000, or they could replace the heat pump with a larger one (with potential home modifications required) for $15,000-$20,000. Note that weatherizing the home after installing the heat pump sized to cooling could decrease or eliminate the need for these retrofits, especially if the HP is variable-speed.

Faulty Furnace, Potentially Replace With All-Electric System

In the case that a furnace is not in working order and needs replacement around the same time as the AC, sizing a heat pump to the heating load could incur no incremental installation cost, depending on the scope of electrical and ductwork and distribution system upgrades needed. However, many such retrofits do not consider an all-electric replacement, instead defaulting to either a new furnace and AC combination or a new dual-fuel system (i.e., new furnace and smaller-sized HP). This can be a missed opportunity and underscores the importance of exploring both dual-fuel and all-electric scenarios at the time of AC replacement.

Working Furnace, Replace With All-Electric System

A variable-speed heat pump sized for the heating load provides a long-term solution that would meet the homeowner's needs after the furnace reaches end-of-life, avoiding the need for future HVAC system modifications. That system is likely to cost **$4,000-$10,000** more than a single-stage AC, with cost typically increasing with efficiency and home load.

The final cost of an all-electric system installation is very home-specific, dependent on load and necessary home modifications. Depending on regional rate economics, detailed in the "Modeling AC to HP Retrofits" section, a homeowner could see operational cost savings that pay that incremental cost back over time.

The following factors may impact the final all-electric installed cost:

- **Ductwork and distribution system modifications:** Heat pumps require about double the target airflow of furnaces (e.g., 400 CFM/ton versus 180 CFM/ton), meaning that many duct systems cannot handle the airflow of systems larger than four tons, and require modifications. Simply widening the supply and return ducts could be sufficient, or it is possible that entire duct systems would need to be replaced, which could cost thousands of dollars.
- **Electrical system upgrades:** While electrical modifications, such as running new electrical lines or

installing a subpanel, can be relatively inexpensive, many homes have limited electrical panel capacity and could require panel upgrades. This can cost thousands of dollars depending on project complexity. In general, systems serving a higher load require a higher power draw and more panel space, and thus in regions with a larger difference between heating and cooling loads (i.e., colder climates), more upgrades will be required.

- **Weatherization at time of install:** Projects to improve the insulation and decrease the leakiness of a home also vary widely in cost. An important factor here is that weatherization can end up decreasing total home load, which can decrease the necessary HP size, and thus also the need for the electrical or distribution system upgrades.

Additional Customer Benefits

In addition to the evaluated energy, emissions, and potential economic benefits, replacing a one-way AC with a two-way heat pump offers several other customer benefits. These benefits are often particularly salient to low- and middle-income households. The first two subsections refer to both partial and full electrification scenarios, while the second two subsections discuss benefits of dual-fuel systems, in particular.

Health and Safety Benefits of Heat Pumps

The most significant health and safety benefits associated with fuel switching for individual homes are realized in full electrification scenarios (where combustion appliances are removed), but benefits may be observed in dual-fuel setups as well. For example, fewer run-time hours of combustion appliances may lead to reduced indoor exposure to combustion-related pollutants, especially in homes with aging infrastructure or sub-optimal ventilation.

Additionally, from a community, state, and regional perspective, combustion of fossil fuels in home appliances is a significant contributor to outdoor air pollution, especially nitrogen oxides.21 Outdoor air pollution contributes to lung22 and heart disease,23 as well as the broader economic impacts of those health issues like missed school or workdays. An AC to HP project decreases these impacts in the larger community.

Comfort Improvements Due to Heat Pumps

The responsiveness and flexibility of heat pump controls in both dual-fuel and all-electric systems can offer opportunities for improved comfort inside the home year-round. Inverter-driven heat pumps provide more stable indoor temperatures, since they ramp their heating capacity up and down to match the heating demand to the needs of the home.[24] Longer run-times at lower capacity compared both to single-speed HPs and non-

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[21] Gruenwald, T., Dennison, J., & Louis-Prescott, L. (2021). *How Air Agencies Can Help End Fossil Fuel Pollution From Buildings*. RMI. https://rmi.org/insight/out-door-air-quality-brief/

[22] American Lung Association. Who Is Most Affected by Outdoor Air Pollution? https://www.lung.org/clean-air/outdoors/who-is-at-risk

[23] American Heart Association. Air Pollution, Heart Disease and Stroke. https://www.heart.org/en/health-topics/consumer-healthcare/what-is-cardiovascular-disease/air-pollution-and-heart-disease-stroke

[24] U.S. Department of Energy (DOE). Heat Pump Systems. https://www.energy.gov/energysaver/heat-pump-systems

modulating furnaces also enable inverter heat pumps to provide gentler and more continuous airflow, to be quieter for much of the year, and to extract more moisture and provide better dehumidification.

Reliability and Resilience of Dual-Fuel Systems

Dual-fuel systems combine efficient heat pump technology with existing backup fuel infrastructure. This offers residents a more robust HVAC system with greater resilience during cold-weather events, as well as the flexibility to minimize operational costs as electricity and fuel prices change over the course of the equipment's useful life. This provides peace of mind for customers, especially within populations who may have to wait for funds to become available if one component of their HVAC system fails.

Improved Accessibility of Electrification Technologies Due to Dual-Fuel Systems

Low- to moderate-income households often face the greatest barriers to building electrification due to high upfront equipment costs, insufficient access to financing, older housing stock, and other factors.[25] Partial electrification through dual-fuel systems is often a more affordable retrofit than an all-electric system, and once installed, controls can be set to benefit from a lower operational cost. Even in scenarios where full-home electrification is a goal, dual-fuel systems provide a realistic and achievable first step towards this end.

Note that amid increasing building electrification and an aging gas distribution system, customers who retain gas furnaces, whether paired with a central AC or a heat pump, are at risk of shouldering a disproportionate share of rising gas infrastructure costs. These households are often lower-income, making the resulting rate burden especially concerning.[26] Coordinated long-term planning across gas and electric systems, including targeted whole-home electrification and strategic gas pipeline decommissioning, is important to prevent vulnerable customers from being locked into paying for costly gas system replacements.[27]

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[25] Fadali, L., Waite, M., & Mooney, P. (2024, May). *The Value of Prioritizing Equitable, Efficient, Building Electrification.* ACEEE. https://www.aceee.org/sites/default/files/pdfs/b2405.pdf

[26] A recently published study entitled "Effects of Uncoordinated Electrification on Energy Burdens for Natural Gas Customers" models how vulnerable communities face disproportionate affordability risks during heating electrification transitions, and found that Massachusetts households that do not electrify may bear an increase in their gas bills of 60 percent on average over the next 15 years with building electrification and planned gas pipeline replacements. Garibay-Rodriguez, R., Edwards, M. R., Fink, A., & Magavi, Z. (2025). "Effects of Uncoordinated Electrification on Energy Burdens for Natural Gas Customers." *Nature: Scientific Reports* 15. https://www.nature.com/articles/s41598-025-09543-5

[27] This solution includes challenges described in the 2024 ACEEE Summer Study paper by E3 and in Switchbox's 2025 research: Landman, J., Smillie, S., Alberga, D., Bertolacini, M., Sontag, M., Levine, M., Aas, D., & Price, S. (2024). "Debunking the Myths of Hybrid Heat Pumps." ACEEE. https://www.aceee.org/sites/default/files/proceedings/ssb24/assets/attachments/20240722163133624_dbffa54e-2033-4535-bbcc-ffa2bbbaa7cb.pdf; and Smith, A., Palta, R., Shron, M., & Velez, J-P. (2025, March 7). "Targeted Electrification in New York State." Switchbox. https://www.switch.box/lpp

Modeling AC to HP Retrofits

We modeled the impact that replacing a central AC unit with a heat pump would have on equipment loads, operational cost, energy consumption, peak kW utility grid demand, and long-term operational emissions. Results are a snapshot of “typical” outcomes that enhance understanding of trends in these variables across climates, rate structures, furnace fuel types, and heat pump types. Here, we will cover operational cost outcomes, as well as economic switchover temperatures. The next subsection will speak to energy savings from different retrofits. The final two subsections show modeled emissions and grid impacts of each scenario. For an outline of modeling methods and archetypes, see the “Methods” section and Appendix A.

Economic Impacts

Key Insights

- AC to HP value propositions for homes with central forced air systems vary across climates, utility rate structures, and heat pump types.
- Colder climates experience higher heating loads, which magnify the operational cost differences before and after a retrofit. Under these conditions, a given spark gap produces larger savings when fuel prices are favorable and larger cost increases when they are unfavorable.
- Annual modeled operational cost savings in propane-heated households varied depending on rate structure, climate, and HP type, and ranged from $500 to $3,000 per year, with a payback period of less than six years for all HPs. Fuel-oil-heated homes saved up to $1,000 per year, with payback periods of eight years and higher.
- Sized to the cooling load with the most economic switchover temperature, modeled gas retrofits sized to cooling broke about even, underscoring the benefits of dual-fuel controls. Running down to the capacity balance point temperature or as an all-electric system, costs increased in many scenarios, with more dramatic increases for the single-stage HP.
- Modeled homes saw $100-$200 of cooling savings, with the higher end of these savings in warmer climates.

This section details the operational cost impacts of switching an AC to a heat pump. The numbers given include both cooling and heating season cost impacts to illustrate the annual cost change experienced by a consumer. The end of the section projects modeled results across the rest of the Northeastern building stock using information from the “Market Opportunity” section.

Figure 8 below shows the modeled annual operational costs of various equipment combinations in each region. Heat pump operational costs are given for both single-stage and cold climate variable-speed (ccVS) models sized to cooling, assuming the economic switchover temperature setting for each scenario, with the lowest possible switchover being the capacity balance point. The economic switchover temperature is indicated above the relevant bars. Cases in which the switchover temperature is the same temperature as the capacity balance point are shown in orange. Operational costs are also given for the ccVS heat pump when the heat pump was sized to cover 100 percent of the heating load as an all-electric system. Cooling versus heating costs are broken out by color. Rates used to calculate the operating costs for the zones are starred in Table 1.

Figure 8: ***Annual operational costs for baseline versus various heat pumps and sizing methods by zone and furnace fuel, economic switchover temperatures noted for sized-to-cooling scenarios***

With higher heating loads in colder climates, the magnitude of operational cost impacts of an AC to HP retrofit are amplified. Even with similar spark gaps, favorable fuel economics produce larger savings, while unfavorable spark gaps result in larger cost increases. One example of this can be seen when comparing the propane results in z4 (D.C.) with z6 (Vermont). Both locations have a cost-parity COP of 1.2 between electricity and propane, but there are larger savings in z6 (though a greater percentage decrease in z4).

Variable-speed heat pumps offer higher efficiency than single- or two-stage units, often translating into lower energy costs. In rate environments where the economic switchover temperature aligns with the system's capacity balance point, the increased incremental installation cost of a variable-speed system can pay back over its lifetime. In scenarios where the economic switchover is higher, there are less economic benefits to variable-speed systems.

Within the four rate structures modeled, transitioning from a propane furnace saved $500 to $3,000 per year. Using the higher end of incremental installation costs enumerated in the “Upfront Cost Considerations” section (~$3,000 for single-speed sized to cooling, ~$6,000 for VS sized to cooling, and ~$10,000 for VS sized to heating), this would result in short payback periods of less than six years for all installations. Homes switching from a propane furnace experienced the most savings when allowing the heat pumps to run down to their capacity switchover temperature. Since savings increased with the amount of load the heat pump took on, the greatest savings were seen switching to an all-electric system.

Switching from a fuel oil furnace saved up to $1,000 annually running down to capacity switchover in Vermont and Washington, D.C., where fuel oil prices are higher. Incremental installation costs in these scenarios would pay back in less than eight years for modeled installations in these locations. In Massachusetts and New York, slight cost savings were also observed switching to a heat pump, but payback periods were greater than 10 years. The single-stage heat pump had a higher, 47°F, economic switchover in these locations, with a longer payback period.

Because of the relatively low gas prices and relatively high electricity prices in the region, gas furnaces were the most economic at a 47°F switchover in almost all scenarios, at which point operating costs broke about even (i.e., incremental installation costs would not be paid back with savings). In a full displacement scenario, where a ccVS heat pump is sized to heating, the greatest modeled increase in annual cost, switching from a gas furnace in New York and using the state average rates, is $400. Note that the New York model is grounded in climate zone 4, with a relatively low heating load. If this rate structure were modeled in colder climates, such as northern New York, costs would increase by up to $1,500 per year.

For ccVS switches, modeling estimates $200 in yearly cooling savings in Washington, D.C., and New York, $150 in Massachusetts, and $100 in Vermont, due to increases in cooling efficiency (i.e., the higher SEER2 of the ccVS system), with cooling gains more marginal in the cooler regions.

The capacity switchover temperatures for single-speed and ccVS heat pumps in each climate zone, as well as the operational cost differences for other modeled gas switchover temperatures, are shown in Table 3. Post-retrofit annual operational costs, including both heating and cooling, are shown in green when less than pre-retrofit operational costs, and the economic switchover temperature is bolded.

Table 3: ***Capacity switchover points per location and equipment type, and operational costs at other switchover temperatures for a gas furnace backup***

State	Heat Pump Type	Pre-Retrofit Annual Operational Costs	Approximate Capacity Switchover Point Sized to Cooling	Post-Retrofit Annual Operational Costs (Gas Furnace, HP Sized to Cooling)
VT	Cold climate variable-speed	$3,000	15°F	Cap switchover: $2,900 30°F: $2,800 47°F: $2,850
VT	Single-stage	$3,000	35°F	Cap switchover: $3,100 30°F: $3,100 **47°F: $2,950**
MA	Cold climate variable-speed	$3,550	15°F	Cap switchover: $3,550 30°F: $3,400 **47°F: $3,300**
MA	Single-stage	$3,550	35°F	Cap switchover: $3,900 30°F: $3,850 **47°F: $3,500**
NY	Cold climate variable-speed	$2,700	15°F	Cap switchover: $3,150 30°F: $2,950 **47°F: $2,550**
NY	Single-stage	$2,700	30°F	Cap switchover: $3,550 30°F: $3,500 **47°F: $2,750**
DC	Cold climate variable-speed	$2,300	15°F	Cap switchover: $2,150 30°F: $2,100 **47°F: $2,050**
DC	Single-stage	$2,300	30°F	Cap switchover: $2,500 30°F: $2,500 **47°F: $2,250**

Results demonstrate a variation in sensitivity to switchover depending on both climate and rate structure. The economic switchover for gas retrofits is 47°F in all scenarios except one: In Vermont, where gas prices are the most expensive, the economic switchover is 30°F for a ccVS system. In Washington, D.C., and Massachusetts, the ccVS system does save money at a capacity switchover but less than at a higher switchover. In all locations, the less efficient single-speed heat pump raises costs without a switchover, from $100 more per year in Vermont to $850 more per year in New York, where gas is cheaper.

Note that an indoor droop temperature setting could enable the heat pumps above to run at temperatures lower than the capacity switchover point, with the furnace only jumping in when needed to maintain indoor comfort. This would result in a higher portion of the heating load being covered by the heat pump overall, with higher savings for households with propane furnaces and households with fuel oil furnaces installing a ccVS HP, break-even price points for households with a fuel oil furnace installing a single-stage HP, and a variety of cost outcomes for households with gas furnaces depending on heat pump type and the gas to electric spark gap.

We modeled baseline furnaces at 80 percent AFUE, illustrating a switch from an average existing furnace. An important consideration is that ENERGY STAR standards for furnaces sold today are higher than this (requiring 95 percent AFUE for gas and propane and 85 percent AFUE for fuel oil in the northern U.S.), and that with a newer and more efficient furnace as the baseline, pre-retrofit energy consumption would be lower, as well as post-retrofit energy and cost savings. This is the most pertinent for gas switches, where annual cost increases would be slightly higher. As an example, in D.C., a modeled switch from a 95 percent AFUE gas furnace at a 47°F switchover leads to a $50 cost increase for the single-speed heat pump, versus the $50 savings shown in the table above. Switches from a newer propane furnace would still result in substantial savings. And as the ENERGY STAR requirement for a fuel oil furnace is only 85 percent AFUE, the impact on the calculations above would be marginal for this type of switch.

Market-Wide Impacts

To understand the operational cost outcomes in un-modeled locations, we estimated the annual operational cost impact of an AC to HP retrofit for each state's assumed rate structure using the modeled load from the relevant climate zone. Outcomes for each fuel in each state are shown in Table 4 below. Annual cost increases or savings of less than $200 are considered about break-even. Appendix B can be referenced for contour plots showing more detailed cost outcomes.

These results assume a ccVS HP sized to the cooling load. Note that single- and two-stage heat pump systems perform at lower winter COPs, so with those heat pump types, less savings would be seen.

Additionally, these outcomes assume that the HP is operating down to its capacity balance point. In cases where savings are likely, an indoor temperature droop setting could lead to greater savings. In cases where cost increases are likely, a higher switchover temperature could bring annual costs closer to cost parity.

Table 4: *Estimated operational cost impact of an AC to HP retrofit in each state, for a ccVS HP sized to the cooling load and running down to capacity switchover*

State	Backup Heating System Type in Dual-Fuel System		
	Propane Furnace	Fuel Oil Furnace	Gas Furnace
CT	Cost savings	Cost savings	Cost impact – interventions available to realize cost parity or savings
DC*	Cost savings	Cost savings	Approximately break-even
DE	Cost savings	Cost savings	Cost savings
MA*	Cost savings	Cost savings	Approximately break-even
MD	Cost savings	Cost savings	Cost savings
ME	Cost savings	Cost savings	Approximately break-even
NH	Cost savings	Cost savings	Approximately break-even
NJ	Cost savings	Cost savings	Cost impact – interventions available to realize cost parity or savings
NY*	Cost savings	Cost savings	Cost impact – interventions available to realize cost parity or savings
PA	Cost savings	Cost savings	Approximately break-even
RI	Cost savings	Cost savings	Cost impact – interventions available to realize cost parity or savings
VT*	Cost savings	Cost savings	Approximately break-even
WV	Cost savings	Cost savings	Approximately break-even

*These rates were included as the modeled scenarios for each zone.

The best value propositions in the table above come from propane and fuel oil baselines; transitioning from a propane or fuel oil furnace to a variable-speed heat pump leads to savings in all states.28 Using current state average rates, the study finds the following with regard to gas retrofits:

- Delaware and Maryland have the best value propositions for customers switching from a gas furnace.
- Customers in D.C., New Hampshire, West Virginia, Massachusetts, Maine, Vermont, and Pennsylvania would break about even switching from gas with a capacity switchover temperature. These customers could likely see slight savings if they set a higher switchover temperature.
- Customers in New York, New Jersey, Connecticut, and Rhode Island would likely experience increased energy bills transitioning from a gas furnace with a capacity switchover temperature. These increases would come nearer to cost parity if they set a higher switchover temperature.

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[28] Homes with an electric resistance furnace would also experience savings across the board, with a heating cost parity of around 1.0, as any increase in efficiency would be directly reflected in a decreased electricity bill.

Overlaying modeled results with the market opportunity quantities reported in the market opportunity section, we estimated the number of homes within each state who would likely experience operational cost savings, based on current state average utility rates determined by the research team, by retrofitting their existing central AC with a ccVS heat pump, sized to cooling and running down to capacity switchover. The states with the greatest addressable market under this definition (in order) are Pennsylvania, Maryland, West Virginia, Connecticut, New York, and Delaware, which all have over 100,000 total homes with central ACs that would likely see operational cost reductions by installing a ccVS heat pump with a capacity switchover.

Some states with a large proportion of gas heating have a gas to electric spark gap that is not currently favorable to a heat pump and could see an expanded opportunity with rate reform interventions or economically optimized switchover temperature settings.

However, there is still potential for AC to HP retrofits in homes with an unfavorable gas to electric spark gap. Programs targeting dual-fuel systems, as opposed to full electrification, will result in better economic outcomes for these customers. New Jersey is an example of a state with a relatively low gas rate that is focusing on dual-fuel programs to increase heat pump adoption while maintaining customer affordability. In addition, since strategic switchover controls could bring operational costs near cost-parity in all modeled scenarios, switchover considerations are especially important in these locations.

Energy Use Impacts

Key Insights

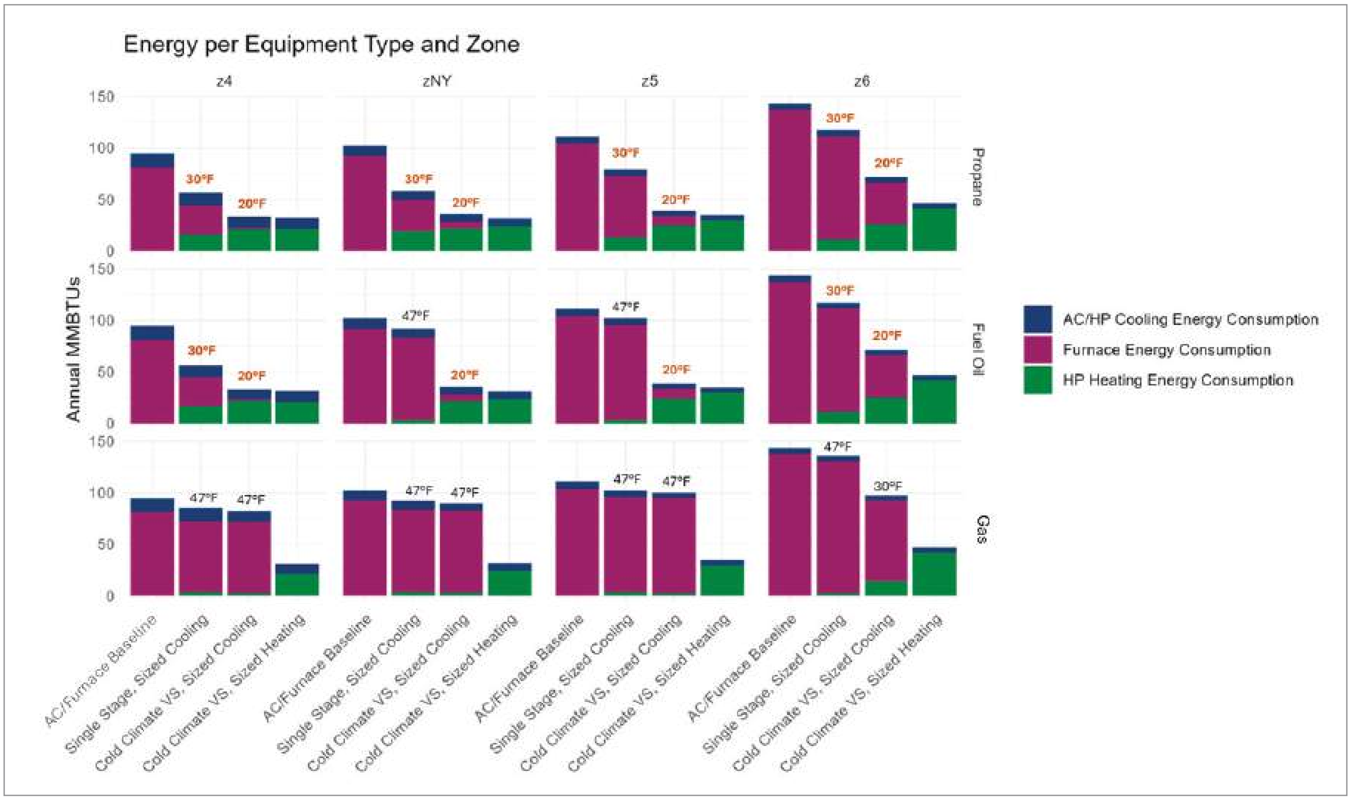
- All modeled switches from an AC to an HP saved energy due to increased system efficiencies. ccVS heat pumps save more energy than single-stage due to higher capacity maintenance at low-temperatures and higher efficiencies. The higher the switchover temperature, the less energy saved.
- A heat pump sized to cooling could cover more of the heating load than modeled in the case of an overestimated home heating or cooling load, increased home weatherization, and/or an indoor droop temperature switchover setting.

All switches from an AC to a heat pump saved energy due to increased system efficiencies. Figure 9 below includes the MMBTUs saved by single-stage and cold climate variable-speed model installs sized to cooling, assuming the economic switchover for the heat pumps that were sized to cooling, with the lowest possible switchover being the capacity balance point. These switchovers are noted above the relevant bars. When this switchover is also the capacity balance point, it is shown in orange. Energy impacts are also given for the ccVS heat pump if the heat pump was sized to cover 100 percent of the heating load as an all-electric system.

The ccVS heat pump saves more energy than the single-stage due to higher capacities and efficiencies. The higher the switchover temperature, the less energy that is saved, as the heat pump displaces less of the heating load. In these conditions, there is a trade-off between cost and energy and environmental priorities. Note that since the propane switches were most economic with a capacity switchover, and we are assuming the same AFUE for all furnace types, the energy savings at capacity switchover for the other furnace types would mirror the propane results.

Keep in mind that since these numbers are energy consumption of the HVAC equipment, rather than energy load served, and that because of higher efficiencies, heat pump consumption is lower than furnace consumption for each unit of load served.

Figure 9: ***Energy use for baseline versus various heat pumps and sizing methods by zone and furnace fuel, economic switchover temperatures noted for sized-to-cooling scenarios***



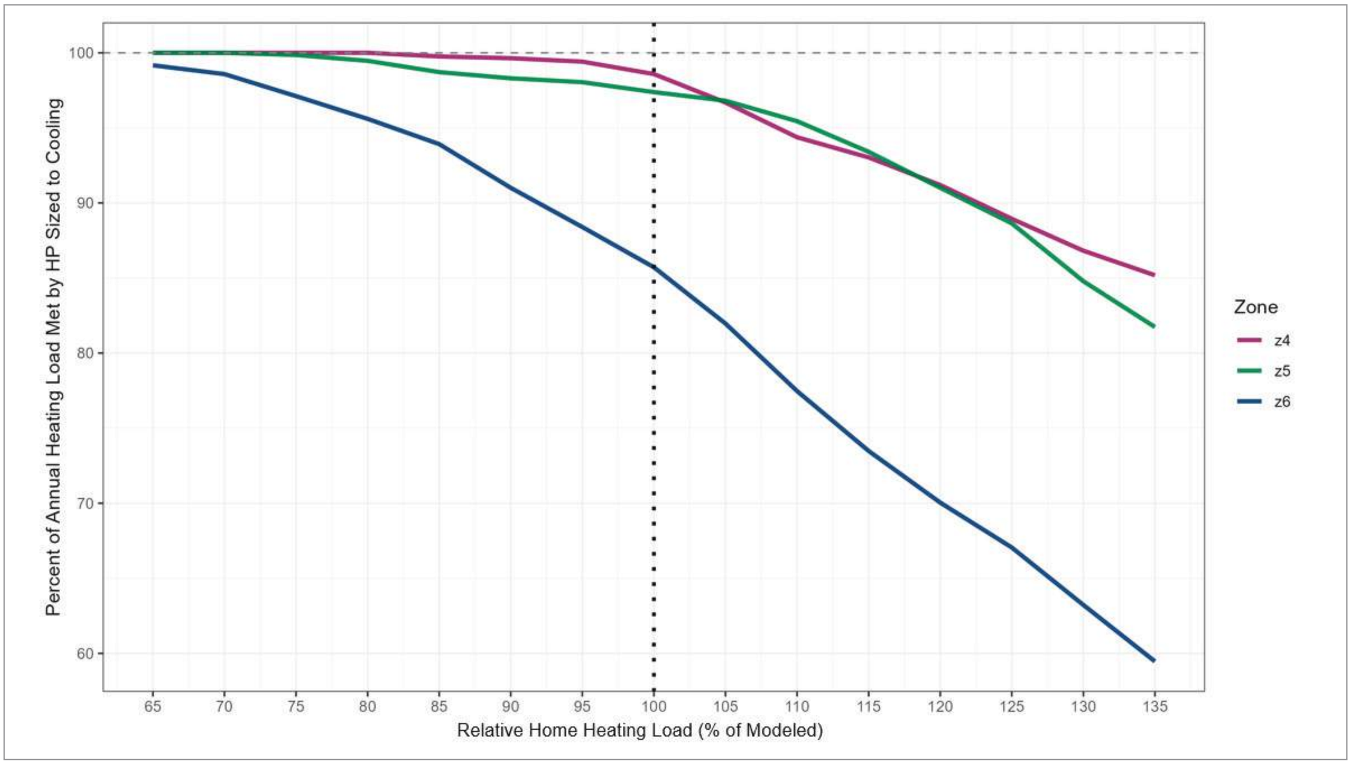
Heating Load Coverage

Even sizing to cooling, the modeled heat pumps were able to cover a large portion of the total heating load when running with a capacity switchover. Appendix C can be referenced for figures showing load coverage of modeled scenarios across the year.

In the case that the heating load of a home is overestimated during equipment selection and installation, which happens relatively often due to conservative assumptions in sizing protocols, the heat pump can end up covering more of the load than anticipated. Figure 10 illustrates the percentage of the modeled home’s heating load that could be covered at design temperature by the ccVS heat pump sized to cooling in each climate zone, if actual heating loads were lower or higher than estimated.

Figure 10 can also be interpreted as a showcase of the potential impact weatherization measures could have on heat pump heating load coverage. In some cases, especially in warmer climates, weatherizing a home can decrease the heating load far enough that the heat pump effectively becomes "sized for heating," not needing a furnace backup, without the costly electrical or distribution system (i.e., ductwork) upgrades needed to size for heating pre-weatherization. NEEP recently completed a report to this end, analyzing current programs and offering best practices for co-promoting weatherization and high-performance HVAC.29 More research is needed on the exact trade-offs between these approaches (i.e., how much weatherization is needed to bring the heating load equal to the cooling load, and the average cost of that weatherization in different climates).

Figure 10: ***Percent heating load coverage of ccVS system sized to cooling at design temperature and running down to capacity balance point, per actual home heating load***



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[29] NEEP. (2025, May). *Co-promotion of Weatherization and High Performance HVAC in Programs: Best Practice Guide.* https://neep.org/sites/default/files/media-files/neep_co-promotionofwxandhigh_eff_hvac_bestpracticeguide_final.pdf

Emissions Impacts

Key Insights

- All modeled retrofits resulted in lower emissions than the baseline furnace and CAC, with greater emissions savings when the HP covered more of the heating load.
- Due to less renewable energy projected on the grid than in other grids in the region, all-electric HP emissions are highest in D.C., even though yearly loads are the lowest.
- When assuming a social cost of carbon of $51 per metric ton, switching to an all-electric heat pump in these modeled scenarios may be worth up to $5,500 over the lifetime of the equipment.

We analyzed the end-use emissions intensity of each modeled scenario to understand the environmental implications of varying climate zones, grid operators, furnace fuels, and heat pump types. We modeled two locations in climate zone 4: D.C., on the PJM East grid, and New York, on the NYISO grid. Massachusetts, in climate zone 5, and Vermont, in climate zone 6, are both on the ISO-NE grid. For grid emissions, we used NREL's 2024 Cambium workbook, which outputs marginal hourly projected emissions of each grid operator that can be applied over the equipment's useful life.[30] These projections assume that additional renewable energy will be added to the grid in the coming years. The totals in this section assume the projected grid emissions in the "mid-case," or most likely, renewable adoption scenario, over a 15-year equipment lifetime. Results are found in Figure 11 below.

The least emissions-intensive technology is the all-electric heat pump across all scenarios. Gas is the fossil fuel with the least emissions, and fuel oil is the most emissions intensive.

Emissions levels are determined by a combination of energy load and grid composition. The higher energy loads in climate zone 6 lead to higher fossil fuel and dual-fuel emissions. Similarly, the difference in emissions between the single-speed versus ccVS systems is due to the greater portion of load taken on by the furnace. The NYISO and ISO-NE grids are projected to generate cleaner electricity over the coming decade than PJM East. This is evidenced by the higher heat pump emissions in climate zone 4, even with the lower HVAC energy loads in this region.

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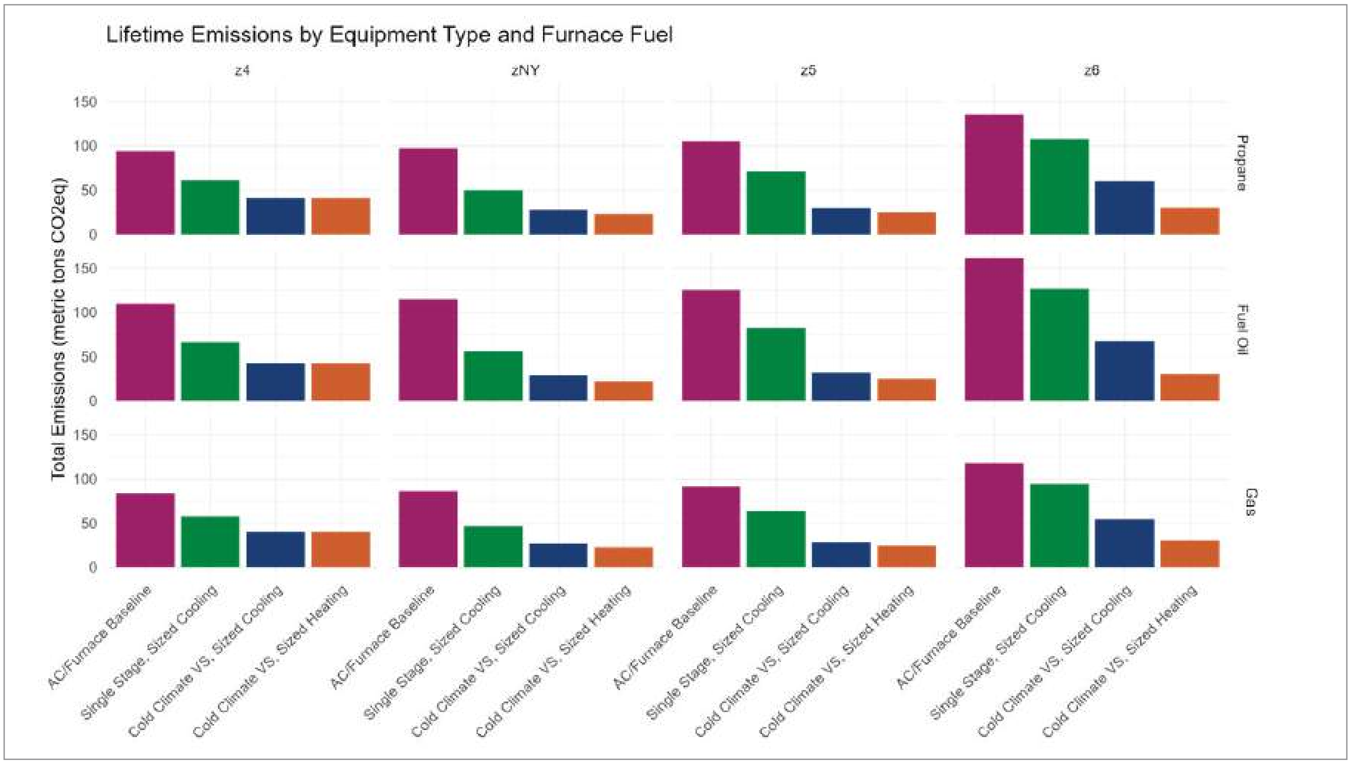
[30] A default 3 percent damages-equivalent levelization value is assumed for these calculations, placing slightly greater weight on near-term years.

Figure 11: ***Lifetime emissions (15 years) by equipment type and furnace fuel, with capacity switchover temperatures, using grid operator projections from NREL's 2024 Cambium workbook***



It should be kept in mind that there is some willingness in certain portions of the population to pay a premium in incremental and operating costs for the environmental benefits shown above. Assuming even a modest social cost of carbon recently used by the federal government, $51 per metric ton, switching to an all-electric heat pump in these modeled scenarios may be worth up to $5,500 over the lifetime of the equipment, about half of the higher end of likely incremental equipment cost. Switching to a ccVS system sized to cooling may be worth up to $4,000, and switching to a single-speed system sized to cooling may be worth up to $2,500.[31] In both cases, this is close to, or more than, the incremental installation cost of the equipment.

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[31] This is inclusive of Cambium's default 3 percent damages-equivalent discount rate that weights near-term years (with assumed lower margins of error) more heavily.

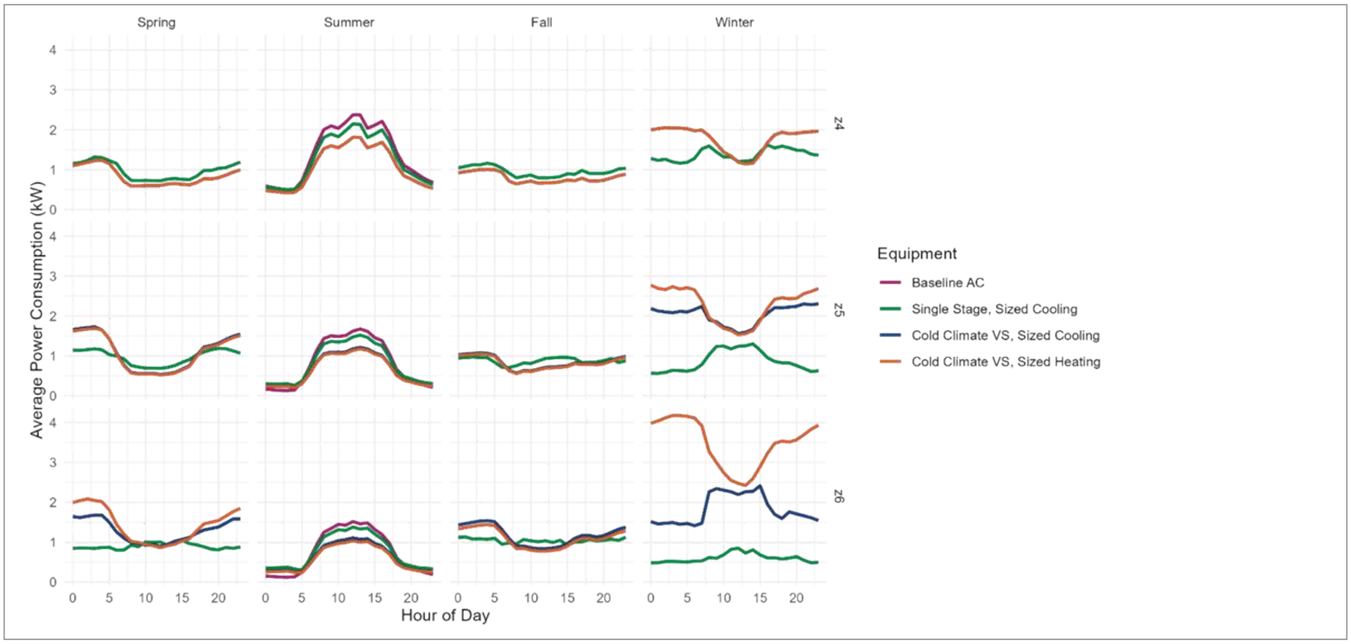
Grid Demand Impacts

Key Insights

- Currently, the highest demand on the Northeastern electrical grid typically occurs during summer days, when the most AC is needed. Were modeled homes to fully electrify heating loads, the grid would experience winter peaking with the highest demand in winter mornings. There would be a more dramatic shift to this end in colder climates.
- The backup heat of dual-fuel systems takes over during the coldest hours, decreasing this winter peak down to summer levels in climate zones 4 and 5, significantly reducing the winter peak in climate zone 6.
- Time-of-use rates can benefit HP users and can be paired with HVAC demand response controls to shift electricity consumption away from peak hours and ease grid strain.

In planning for large-scale deployment of heat pumps, it is helpful for utilities to consider the aggregate electrical load impact that operation will have at various times of the day. Figure 12 below illustrates the average daily demand of different modeled heat pump systems in each season for each climate zone. For the dual-fuel systems, this is the demand scenario when the heat pumps run to their capacity balance point temperatures. If a higher switchover were set, average winter electrical demand would be lower for these dual-fuel systems, especially during the colder nighttime hours. These models assume no setback controls. If a home set a setback overnight, there would be lower demand overnight, and depending on whether the heat pump or furnace was called, there could be a peak in the morning as the home warmed back up.

Figure 12: ***Average hourly load by season and region for various equipment types, with capacity switchover temperatures***



Currently, the highest demand on the Northeastern electrical grid occurs during summer days, when the most air conditioning is needed. Modeled households demand 2.4kW at the summer times with maximum demand in climate zone 4, 1.7kW in climate zone 5, and 1.4kW in climate zone 6. Due to the higher modeled cooling efficiency of the HP systems when compared to the baseline AC, this summer demand would decrease slightly with a single-stage heat pump, and more dramatically with a variable-speed system, with the most dramatic decrease being in climate zone 4, to 1.6kW.

Were these homes to electrify fully, they would become winter peaking, with the highest demand in winter mornings. This demand would be 2kW in climate zone 4, 2.6kW in climate zone 5, and 4.1kW in climate zone 6. This change in maximum HVAC electricity consumption levels is the most drastic for climate zone 6, which currently does not need much electricity for cooling and would need the most electricity for heating.

In most Northeastern climates, the dual-fuel systems sized to the cooling load exhibit different patterns in the winter than the all-electric system sized to heating.[32] This is due to outdoor temperatures dipping below the capacity balance point, especially during the colder evening, nighttime, and early morning hours. Because backup heat takes over at these times, the modeled ccVS system sized to cooling exhibits average winter demand values close to those of summer in climate zone 5, as well as during colder mornings and evenings in climate zone 6. Average winter heat pump demand in climate zone 6 then climbs to around 2.4kW during the warmer afternoons. These lower average winter electricity demands present a potential lever for utilities' system planning were dual-fuel systems deployed at a broader scale.

Since single-stage models lose their capacity and efficiency at a higher rate at colder temperatures when compared to variable-speed models, these systems rely much more heavily on backup heat in the winter, resulting in a lower average demand on the grid.

Electric Space Heating Rates and Demand Response

Utilities structure electric space heating time-of-use rates and demand response programs to benefit ratepayers who shift electricity use off of peak periods, supporting near-term grid needs and creating a smoother pathway toward electrification over time. There are several Northeastern time-of-use rates that increase electricity prices in the afternoons and during summer months, when household demand is highest.[33] Because of the dynamics described in the previous section, with heat pumps consuming more electricity in the winter and overnight, households with heat pumps can benefit from utilizing these rate structures. We looked at three special rate structures available in the region to illustrate the impact of time-of-use pricing on the operating cost of HP technologies.

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[32] In Washington, D.C., (z4), the ccVS sized to cooling covers the full heating load.

[33] NEEP. (2025). *Modern Rate Design in the Northeast: Unlocking Efficiency, Affordability, and Electrification.* https://neep.org/sites/default/files/media-files/neep_modern_rate_design.pdf

Our model is “dumb” to rate jumps, consuming energy based on the temperature difference between indoors and outdoors regardless of time of day. However, peak heat pump demand can overlap with peak grid demand, creating meaningful opportunities for demand response controls. Homeowners who are comfortable with modest temperature flexibility—slightly warmer summer afternoons or slightly cooler winter afternoons—can benefit from timed setback controls that shift energy use to lower-cost periods. These strategies can reduce customer energy bills while easing stress on the grid. Opportunities for savings from strategic setback controls are highlighted below.

When the New York home is modeled with the ConEd seasonal time-of-use (TOU) rate, which consists of different values for peak, off-peak, and super-peak rates,[34] the average cost per kWh is $0.26, five cents lower than the $0.31/kWh NY rate and resulting in a savings of about $500 in HVAC costs annually. In climate zone 4, this offsets operational cost increases from the all-electric heat pump. These savings could be increased further by shifting heat pump load to off-peak times, when electricity costs are around $0.15/kWh. This rate is starred in the climate zone 4 figures in Appendix B.

Modeling the D.C. home with the Maryland Baltimore Gas and Electric TOU, we saw prices per kWh average out to about the same with the TOU rate as the regular Maryland rate of $0.18/kWh. Setting controls such that consumption is shifted to non-peak hours could move these electricity prices closer to the $0.12 non-peak hour price per kWh. This situation highlights the importance of load shifting and related controls education to unlock special rate benefits.

Modeling the Massachusetts home with the Massachusetts Interagency Rates Working Group (IRWG) rate also kept average prices about constant, at $0.33/kWh. This seasonal rate structure decreases electricity prices to $0.29 during the winter and hikes them up to $0.45 during summer months. Sizing a heat pump to the cooling load does not take full advantage of the lower winter electricity prices. When sized for heating, this rate saved about half of a cent per kWh, or about $50 annually, for participants. Greater benefits could be seen from this rate structure in both sizing scenarios if cooling demand were less than modeled (i.e., a higher cooling setpoint).

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[34] This rate charges $0.35/kWh from 8 a.m. to midnight in the months of June through September, $0.13/kWh from 8 a.m. to midnight other months, and $0.025/kWh during all other hours of the year.

Overcoming Barriers to Adoption

Technical and Financial

Key Insights

- Each HVAC installation should strive for the most efficient system that the homeowner can afford. At each potential install, customers should be made aware of the benefits of a heat pump and any available programs to reduce upfront costs.
- The most long-term economic heat pump system (dual-fuel or all-electric) and type (single- or two-stage or variable-speed) depends on whether the incremental installation cost would likely pay back over the equipment's life. This is determined by utility rate structures, home electrical and ductwork conditions, and the condition of the current furnace.
- There are several additional considerations upon install, such as dual-fuel system controls, that take additional job time but are important to evaluate.

Contractors specify new central HVAC equipment at the point of furnace failure, at the point of AC failure, or during a planned replacement of either the furnace or the AC. While this report focuses on system upgrades prompted by a need for a new central AC, considerations for the point of furnace failure are included as well, since a heat pump sized to cooling typically necessitates a furnace for backup heating.

At the most basic level, every HVAC installation should strive for the most efficient system that the homeowner can afford. Every contracted service should meet the customer's needs while balancing the customer's additional wants and budget. One primary recommendation emphasized at many high-efficiency HVAC trainings is that the benefits and trade-offs of different heat pump systems should be walked through with each customer. Many customers are simply unaware of the environmental and potential economic benefits of a heat pump in the first place.

In the case that a customer's priorities and budget align with a heat pump installation, there are a variety of additional installation considerations when compared to a furnace/AC replacement. These are summarized below and broken down in more detail in training-specific resources, including a NEEP document outlining contractor training recommendations in cold climates.[35]

Sizing and Equipment Selection

First, a contractor must determine the heating and cooling needs of the new system. Heat pump systems that are sized for 100 percent of heating needs can have higher upfront costs but avoid the need for future HVAC retrofits in the case of imminent furnace failure and often qualify for more substantial incentives in the

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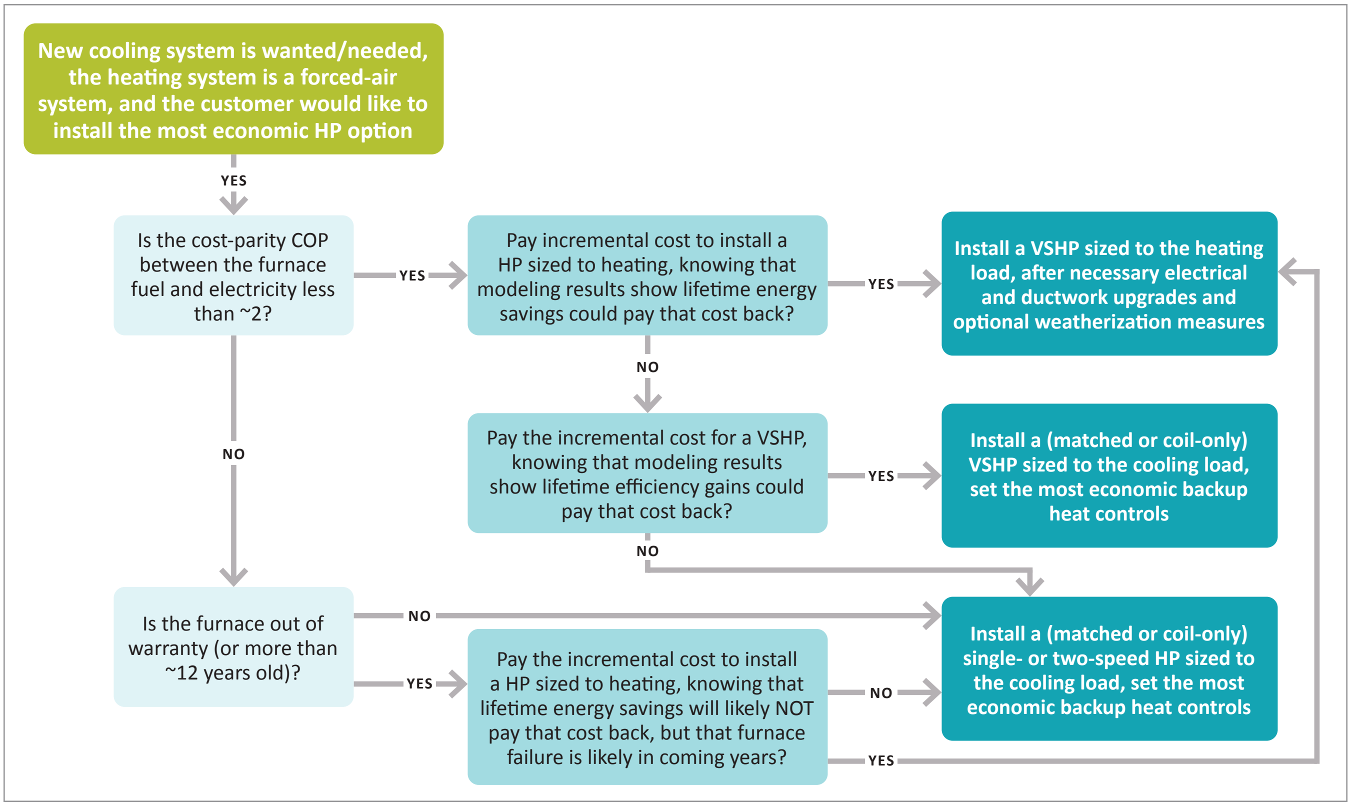
[35] NEEP. (2025, August). *Training Recommendations for Designing & Sizing Air Source Heat Pumps in Cold Climates.* https://neep.org/sites/default/files/media-files/neep_training_recommendations_for_designing_sizing_air_source_heat_pumps_in_cold_climates_final.pdf

Northeast that are intended to cover incremental costs. Upgrading to an all-electric heating system is always the most **environmentally** beneficial, as detailed in the "Emissions Impact" section. Dual-fuel systems that retain an existing furnace, on the other hand, are typically cheaper up front. They also provide greater resiliency given the availability of a second system in case one system fails, as well as flexibility in system controls that can be optimized to economic or environmental customer goals.

In the case that a customer would like the most **economic** heat pump system option, the following sizing and equipment selection decision tree outlines the trade-offs between upfront and operational costs, based on data pulled from previous sections. Note that this chart assumes a climate in which heating loads are greater than cooling loads. Further, the chart does not account for influencing factors like upfront cost incentives or the availability of utility rate structures like electric heating or time-of-use rates that have significant impact on the economics of a project.

Customer decisions, even when prioritizing lowest cost, often incorporate many other drivers, and this decision tree may be too complex to be used on-site. However, the principles behind this decision tree should be integrated into contractor training to promote understanding of the economic trade-offs between sizing to cooling versus heating loads and single- or two-stage versus variable-speed heat pumps.

Figure 13: ***Sizing and equipment selection decision tree, assuming that a customer would like to install the most economic heat pump option, and that home heating loads are greater than home cooling loads***



The main economic trade-off in the decision tree is driven by an operational cost-parity (break-even) COP so that the chart can be applied to varying and fluctuating rate structures. Table 1 in the "Northeastern Energy Rates" section can be referenced to see which fuel types have a cost-parity COP of less than two in Northeastern states at the average assumed fuel and electricity rates for this report. In Table 1, the cost-parity COP is less than two for all propane rates and some fuel oil rates. All examined gas rates had a cost-parity COP of above two.

In the case that the cost-parity COP between fuels is more than two, and the furnace is in good enough condition to be kept for backup, sizing to cooling is more economic than sizing for heating, with the heat pump being used only at higher temperatures (where it is more efficient). This also means that a single- or two-speed system proves more economic than variable-speed systems, as the economic switchover temperature would be too high to take full advantage of variable-speed capacity retention and efficiency benefits.

Other Installation Considerations

There are several system design, setup, and planning nuances that are not built into the decision-making tree but should be considered. These nuances often present barriers to contractors. Lack of customer awareness of these considerations, combined with the additional planning, time, and budget required to incorporate them (and the premium placed on retrofit speed and lowest upfront cost during emergency replacements) often make it difficult for contractors to effectively address them as part of their standard practice.

Controls:

Controls are a vital component of every heat pump installation but are especially important for dual-fuel systems. Dual-fuel systems present potential for greater resiliency and optimization to economic or environmental priorities with proper control setup. However, for this beneficial operation to be realized, dual-fuel compatible thermostats need to be set with different system considerations, rate structures, and customer priorities in mind at each home. Training is required for this assessment and customization to fit easily into a contractor's visit. A recent study by Center for Energy and Environment found that thermostat selection and setup was the most challenging difference between AC and cooling-sized heat pump installations for installers.[36]

Minimizing Electrical Work and Ductwork:

Weatherization should ideally be leveraged prior to the sizing and selection of a new system. In the case that a heat pump is being sized to heating, weatherization can decrease the heating load of the home to the point where electrical or distribution system upgrades are unnecessary.

In scenarios in which there are operational cost savings from switching to an HP, these savings can be maximized while avoiding upgrades by sizing the HP to more than the cooling load, but less than the heating load (i.e., install the largest heat pump that does not trigger electrical or distribution system upgrades).

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[36] Hill, S., Schoenbauer, B., Shah, P. (2024). "Better Than a Dupe: How to Use Heat Pumps for AC Replacements." ACEEE. https://www.aceee.org/sites/default/files/proceedings/ssb24/pdfs/Better%20than%20a%20Dupe%20-%20How%20to%20Use%20Heat%20Pumps%20for%20AC%20Replacement.pdf

AHRI Matching and Coil-Only Systems:

When possible, heat pumps should be installed as part of an AHRI matched system to ensure that the combination of the heat pump outdoor unit, indoor coil, and air handler or furnace are under warranty and operate correctly. Because they can operate with a single- or two-speed air handler, single- and two-stage HPs can be matched with a wide variety of furnaces. Variable-speed HP matches are more constrained, as this type of HP requires a variable-speed air handler.

When maintaining an existing furnace that cannot easily be matched to an outdoor heat pump and indoor coil combination, a coil-only variable-speed HP (i.e., standalone inverter) can be an option. This technology provides an efficient variable-speed heat pump system without as many needed modifications, but if repairs are later needed, they can be less straightforward and are less likely to be under warranty.

Table 5 provides a brief overview of the capabilities, benefits, and trade-offs of various heat pump types, including single-stage, two-stage, and variable-speed systems. Multizone variable-speed HPs, not mentioned previously, connect one outdoor unit to multiple indoor units for greater flexibility, higher efficiency, and a higher upfront cost.

Table 5: ***Heat pump types and furnace matching requirements***

	Single-stage (coil-only or matched)	**Two-stage (coil-only or matched)**	**Variable-Speed (matched)**	**Standalone Add-on Variable-Speed (coil-only)**	**Multizone Variable-Speed (matched)**
Potential Heat Pump Cold Temperature Performance	No	No	Yes	Yes	Yes
Largest Possible Heat Pump Sizing Choice	Cooling load[37]	Cooling load at low stage	Heating load	Heating load	Heating load
Furnace Blower Type	Any	Two-stage or variable-speed	Variable-speed	Any	Two-stage or variable-speed
Proprietary Communicating Control Typically Required	No	No	Yes	No	Yes
Relative Upfront Cost	Low	Low	Moderate-High	Moderate-High	High

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[37] When sizing to the cooling load, ACCA Manual S sizing guidelines should be referenced, as there is a risk of compromising single- and two-stage systems‘ dehumidification abilities by oversizing.

Future Furnace Failure

When a coil-only heat pump is installed alongside an existing furnace, there is a risk that the existing furnace backup system will fail prior to the end of the heat pump's life. This risk is minimized by installing cooling-sized heat pumps only when the furnace is still under warranty (or less than 10-12 years old). In the case that the furnace does fail, there are several options outlined below.

- Replace the heat pump and furnace with a heat pump sized to the heating load.
- Add an additional ductless mini-split to cover the heating load of the failed furnace. Depending on type of furnace failure, this may require installing an air handler unit on the coil-only heat pump as well.
- Replace the furnace with the highest-efficiency furnace within budget.

Note that home weatherization in the years after a sized-to-cooling heat pump installation can decrease the home's estimated heating load and minimize or eliminate the need for the above options. The heat pump in this case would have to be variable-speed in most of the Northeast.

Market Actor Readiness

Key Insights

- Market inertia currently limits the pace of HP adoption in the region. AC to HP replacements offer a particularly promising entry point for HP technology. The installation process of an HP sized to cooling closely mirrors that of a central AC, enabling contractors to adopt the technology with minimal disruption and reducing perceived technological risk.
- Customer awareness and trust remain critical barriers to HP adoption, especially during emergency replacements when homeowners default to familiar AC technologies. Modern cold climate heat pumps can reliably meet regional heating and cooling needs, but many customers and contractors have limited firsthand experience with their performance. Robust contractor training on the benefits and use cases of dual-fuel and all-electric systems, paired with targeted customer education and strategic incentives, can help overcome these barriers.

Over the past decade, the Northeast has been actively priming the market for widespread adoption of air source heat pumps (ASHPs) through policies, programs, and workforce development and training initiatives. Yet transitioning from incremental adoption to a fully transformed market requires that the full ecosystem of actors, including manufacturers, distributors, installers, contractors, and end-customers, be ready to shift. The region has made significant progress, as evidenced by ASHP sales increasing nearly 400 percent in New York and New England from 2013 to 2021.[38] However, the region must continue to address the inertia of existing HVAC business

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[38] NEEP. (2025). *Northeast High-Performance HVAC Market Assessment Report.* https://neep.org/sites/default/files/media-files/neep_ne_high_performance_hvac_market_assessment_final__0.pdf

models, build confidence in, and comfort with, heat pump technology, and ensure that the workforce and supply chain capacity expand in step with rising demand.

The barriers that exist for general heat pump market readiness largely apply to the AC to HP transition as well. However, sized-to-cooling AC to HP conversations offer a distinct advantage: A heat pump can function as almost a drop-in replacement, leveraging existing infrastructure and practices while familiarizing market actors with the technology. This section examines the readiness of key market actors, identifying the barriers and opportunities for overcoming "go with what you know" tendencies and accelerating widespread, beneficial adoption across the region.

Supply-Side Readiness

The supply side of the market includes manufacturers, distributors, installers, and the broader workforce infrastructure that delivers, installs, and maintains HVAC systems. Readiness among these actors determines whether the market can reliably meet growing customer demand for efficient heat pump systems.

Manufacturers & Distributors

The HVAC industry is currently bifurcated between AC and HP products. While heat pump manufacturers have business lines dedicated to producing and selling a variety of heat pumps, most continue to also produce and sell air conditioner equipment. Manufacturers are reluctant to shift entirely to heat pump production due to competitive risk. Many fear being undercut by lower-cost ACs if they were to cease production of ACs themselves. This dual market increases warehouse and logistics costs for distributors, who must stock both AC and HP equipment.[39] This also creates supply constraints during emergency replacements, meaning an HP may not be available at the distributor at the time it is needed.

A coordinated, region-wide move toward HPs would reduce market risk and drive economies of scale. Midstream incentives and stocking initiatives can align distributors and manufacturers to increase HP availability and lower upfront costs.[40] As HP adoption rises, manufacturers can streamline production lines, and distributors can optimize inventory and logistics.

Installers & Workforce Development

Many HVAC contractors still split their business between AC, HP, and fossil fuel equipment installations, increasing ongoing training costs and reducing specialization.[41] Lower installer familiarity with HPs can result in poor design, system selection and sizing, or commissioning, leading to lower efficiency and customer

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[39] Pantano, S., Malinowski, M., Gard-Murray, A., & Adams, N. (2026, May 26). *3H Hybrid Heat Homes: An Incentive Program to Electrify Space Heating and Reduce Energy Bills in American Homes.* CLASP. https://www.clasp.ngo/research/all/3h-hybrid-heat-homes-an-incentive-program-to-electrify-space-heating-and-reduce-energy-bills-in-american-homes/

[40] NEEP. (2025, May). *High-Performance HVAC Midstream Program Best Practice Guide.* https://neep.org/sites/default/files/media-files/neep_high_performance_hvac_midstream_program_best_practice_guide_final.pdf

[41] Hill, Schoenbauer, Shah. (2024). "Better Than a Dupe."

satisfaction.[42] Lower installer familiarity also misses out on economies of scale. Contractor economics of HP installations improve as contractor HP installation experience grows; each additional HP installation reduces job time.

Today, it is not common practice to train contractors on selling or implementing an AC to HP replacement strategy. However, recent findings from Colorado's Accelerated Adoption of Heat Pump Technology analysis show that there are no major technical or workforce barriers preventing the existing HVAC workforce from installing heat pumps instead of central air conditioners. Contractors emphasized that the installation process for a centrally ducted HP is highly similar to that of a central AC, suggesting that normalizing AC to HP as a standard offering would be straightforward given current skillsets. However, gaps remain in contractor familiarity and confidence with newer cold climate models, and rural HVAC businesses in Colorado lack access to training opportunities that are concentrated in urban areas. These stakeholders recommended expanding statewide heat-pump-specific training, implementing licensing or quality assurance programs, and ensuring that training emphasizes both cold climate applications and customer communication skills to build trust in HP technology.[43]

Today, the workforce pipeline in the Northeast is fragmented. Licensing, curriculum standards, access to training, and installer network requirements vary by state.[44] Regional workforce initiatives can standardize curricula, create apprenticeship pathways, and improve training access to a wider range of workers. State- and utility-run programs can embed training requirements into incentive participation to ensure that installers are both qualified and confident in promoting HPs, especially in place of ACs.

Demand-Side Readiness

As manufacturers, distributors, and contractors expand their capacity to deliver and support HPs, including in AC to HP conversions, the market's continued growth will depend on demand growing in step with supply. The progress made on the supply side must be matched by increasing customer understanding and motivation so that equipment availability, installer expertise, and consumer readiness advance together across the region.

Even with an estimated 400 percent increase in heat pump sales in the Northeast between 2013 and 2021, gaps in customer and contractor awareness of the technology, its applications, and potential benefits remain a hurdle to more widespread adoption.[45] One recent national survey from a manufacturer found over a quarter (27 percent) of homeowners have either never heard of heat pumps or do not know what they are, and another found that over half (54 percent) were unsure or unknowledgeable about their full capabilities, particularly the

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[42] Urban Green Council. (2024). *Cool Switch: Replacing Central Acs With Heat Pumps in New York State's Single-Family Homes.* https://www.urbangreencouncil.org/wp-content/uploads/2024/11/Cool-Switch-PDF_10.31.2024.pdf

[43] Colorado Energy Office. (June 1, 2025). *Accelerated Adoption of Heat Pump Technology.* Available at: https://drive.google.com/file/d/1yqKHgH4kqLaw4cVyN5jr6AoA-JGfOnUf1/view

[44] NEEP. (2025, May 27). Best Practice Guide: High-Performance HVAC Workforce Development. https://neep.org/best-practice-guide-high-performance-hvac-work-force-development

[45] NEEP. *Northeast High Performance HVAC Market Assessment Report.*

ability to provide both heating and cooling.[46,47] In the comparable climate of the Midwest, a recent survey of over 4,000 residents found 35 percent of residents were unaware that heat pumps can replace a traditional air conditioner.[48]

Thanks to advances in variable-speed compressor technology, modern heat pumps have proven capable of efficiently delivering comfort and performance in cold climates across the region.49 However, customers or contractors without firsthand experience of a successful cold climate heat pump installation may hesitate to recommend or adopt such a product, fearing that it may not adequately perform during the coldest days of the year. This lack of trust is often most prominent for full system replacements where the heat pump must meet the full heating load. In these cases, AC to HP replacement presents an opportunity to avoid those concerns by retaining a fossil fuel backup system for the coldest hours of the heating season, while still increasing heat pump market share, which remains a goal for many states in the region.[50]

Many customers only consider HVAC upgrades when their existing equipment fails, resulting in emergency replacements. In these situations, contractors often prioritize restoring service quickly, reinforcing the “go with what you know” tendency to install a like-for-like AC unit rather than proposing a new solution. During the hot summer months, customers who are not familiar with heat pumps may not even realize that they provide cooling, often more efficiently than a one-way AC.[51] The incremental cost of installing a heat pump rather than an AC can be an added barrier during emergency replacements, even when lifetime operational cost savings are likely to pay that cost back over time.[52] Incentives and rebates can assist in bridging this gap, and installing a cooling-sized heat pump can provide the benefits of partial electrification at a lower incremental cost.

Once a customer decides to make the switch from a one-way AC to a two-way heat pump, operational best practices become paramount to realizing household comfort, performance, and monthly energy and bill savings. Thermostat hardware and software need to be properly configured, and dual-fuel systems in particular require controls programmed for maximizing pollution reductions or economic savings. Customers need to understand that adjustments to the switchover settings can result in poor system performance, which could lead to negative savings or thermal discomfort. Additionally, it is important for customers to fully understand during the cooling season that the heat pump equipment provides cooling services. Households unfamiliar with heat pump

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[46] Mitsubishi Electric Trane HVAC US. (2024). The 2024 Heat Pumps & Homeowners Index. https://dw2p0k56b2hr9.cloudfront.net/METUS_IRA_SOV_FF_02_14_25_337f85dac3.pdf

[47] Midea. “Midea Unveils Stark Awareness Gap in Heat Pump Technology Among Homeowners and Contractors.” Press Release. https://www.prnewswire.com/news-releases/midea-unveils-stark-awareness-gap-in-heat-pump-technology-among-homeowners-and-contractors-302024824.html?utm_source=chatgpt.com

[48] Center for Energy and Environment Behavioral Insights Team. (2024, August). *Messaging Strategies to Drive Heat Pump Adoption in Minnesota.* Efficient Technology Accelerator. https://www.etamn.org/sites/default/files/research-papers/Communication%20Strategies%20to%20Drive%20Heat%20Pump%20Adoption%20in%20Minnesota%20FINAL.pdf

[49] Hill, Schoenbauer, Shah. (2024). “Better Than a Dupe.”

[50] Pantano, Malinowski, Gard-Murray & Adams. *3H Hybrid Heat Homes.*

[51] Takemura, A. F. (2025, July 3). “Need Air Conditioning? Consider the Heat Pump.” Canary Media. https://www.canarymedia.com/articles/heat-pumps/air-conditioning-replacement-guide

[52] California Energy Codes & Standards. (2025, August 8). *2025 Cost-Effectiveness Study: Single Family AC to Heat Pump Replacement.* https://localenergycodes.com/download/2034/file_path/fieldList/2025+Single+Family+AC+to+HP+Cost-eff+Study.pdf

technology may not have proper cooling settings integrated into their thermostats and could be missing comfort opportunities.

Targeted messaging and marketing campaigns can help increase awareness of the benefits and functionalities of heat pumps, as well as the incentives and space heating rates that could improve their economic value proposition. Efficiency Maine's Retail Initiatives Program provides a model through its strategy to increase heat pump water heater adoption. This program ran "an aggressive marketing campaign, placing messaging via store shelves, Google AdWords, email, and postal mail. These ads targeted people searching for water heaters, new home buyers, and recipients of heat pump rebates."[53] Maine's high adoption rate of heat pump water heaters proves this strategy's effectiveness, and regional programs could apply similar strategies to expand heat pump awareness and normalize AC to HP conversions as a reliable, efficient, and financially smart default choice.

Policy and Programs

The Northeast region uses a suite of policy and program levers to encourage the adoption of heat pumps;[54] however, there are currently no explicit policies or programs designed to encourage the adoption of heat pumps as central AC replacements. This section assesses enabling and constraining conditions across codes, regulations, and incentive programs and highlights opportunities for alignment between emerging research findings and regional policy and program development.

Policy

Key Insights

- The federal policy landscape shapes what state and local actions are legally permissible. Recent court cases confirmed that the federal Energy Policy and Conservation Act preempts local regulations regarding appliance efficiency. However, subsequent court decisions demonstrate that states retain broad authority to pursue emissions-based and performance-based policies to shift markets toward efficient electric heating equipment if designed carefully.
- Viable pathways include performance-based building codes, Clean Air Act planning tools, and emerging clean heat standards.
- Rate reform is another critical lever; modernizing electric and gas rate structures can make HPs more cost competitive.

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[53] Efficiency Maine Trust. (2024, February 28). *Executive Director's Summary Report to the Board of Trustees – February 28, 2024.* https://www.efficiencymaine.com/docs/ED_Report-_2-28-2024.pdf

[54] NEEP. (2024). Regional Roundup. https://neep.org/public-policy-and-programs/regional-roundup

Energy and housing policy landscapes shift due to a multitude of reasons, at times leading to various impacts on the HVAC market. Federal policies like the Energy Policy and Conservation Act (EPCA) provide umbrella structures and requirements for industry standards, like minimum efficiency levels for certain appliances, including HVAC products. At the same time, states and jurisdictions have authority over important policies impacting the built environment, like building codes. In this intersecting policy arena, Northeast jurisdictions can leverage performance-based, emissions-based, or fuel-neutral policies as tools to advance AC to HP conversions, so long as those policies do not impose energy use or efficiency standards on federally covered products.

Building Energy Codes

EPCA's safe harbor provision allows states and cities to adopt building energy codes that include requirements or incentives for heat pump installation. This approach can apply to both new construction and retrofit scenarios, including AC replacement. Indeed, in California several jurisdictions[55] have adopted amendments to their building codes to encourage heat pump adoption rather than one-way ACs at the time of major HVAC equipment upgrades in existing single-family dwellings.[56] Meanwhile in Oregon, state officials recently approved an update to the energy code that requires the installation of a heat pump over a one-way central air conditioner in new residential construction.[57] Jurisdictions interested in pursuing code updates that facilitate more AC to HP adoptions should consult with code experts and key stakeholders to right-size the policy for their locality.

Clean Air Act State Implementation Plans

Under the federal Clean Air Act (CAA), states must develop state implementation plans (SIPs) to describe how the state will meet and maintain National Ambient Air Quality Standards (NAAQS). These EPA-approved plans address six criteria pollutants: ozone, nitrogen oxides, sulfur dioxide, carbon monoxide, particulate matter, and lead. While GHG emissions are not criteria pollutants under the CAA, states can include GHG reduction measures voluntarily in their SIPs or design SIP measures that target co-pollutant reductions while delivering GHG co-benefits. As described in the "Additional Customer Benefits" and "Emissions Impacts" sections, HP adoption can play a role in decreasing both outdoor criteria pollutants and GHGs.

Clean Heat Standards

Clean heat standard (CHS) designs vary across the United States. Colorado passed legislation requiring gas utilities to meet specific pollution reduction targets through implementation of utility-specific CHSs. Meanwhile, Northeast states that have initiated evaluation of CHS designs—Vermont,58 Maryland,59 and Massachusetts60—primarily explored structures that place an annually increasing "clean heat" obligation on

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[55] Pontecorvo, E. (2025, December 10). "California's Latest Climate Gambit: Turn Air Conditioners Into Heat Pumps." Heatmap. https://heatmap.news/politics/california-heat-pumps

[56] ICC Digital Codes. (2026, January 1). 2025 California Green Building Standards Cod, Title 24, Part 11 with January 2026 Errata. https://codes.iccsafe.org/content/CAGBC2025P3/appendix-a4-residential-voluntary-measures#CAGBC2025P3_AppxA4_SecA4.204.1.1

[57] Oregon Building Codes Division. (2026, February 18). Residential & Manufactured Structures Board: Meeting Agenda. https://www.oregon.gov/bcd/boards/Documents/rmsb-20260218-agenda.pdf

[58] Vermont Department of Public Service. Clean Heat Standard. https://publicservice.vermont.gov/clean-heat-standard

[59] Maryland Department of the Environment. Clean Heat Rules. https://mde.maryland.gov/programs/air/Climate-in-md/Pages/Clean-Heat-Rules.aspx

[60] Massachusetts Department of Environmental Protection. Massachusetts Clean Heat Standard. https://www.mass.gov/massachusetts-clean-heat-standard

heating fuel providers. This obligation would establish a market mechanism encouraging the generation and procurement of clean heat credits, similar to some electric-sector renewable portfolio standards.

AC to HP conversions could act as a qualifying clean heat action within a CHS program thanks to the emissions reductions associated with displaced furnace or boiler use-hours. The ability of an AC to HP replacement to generate clean heat credits in a CHS program would incentivize households, heating fuel providers, and contractors simultaneously.

CHS designs can be complex and require careful consideration of issues like clean heat definitions, attribution of savings, ownership of credits, cost burden on consumers, scope of compliance, and much more.[61] Regardless, should a state choose to establish a clean heat standard program, AC to HP conversion projects could play a pivotal role in compliance plans for regulated entities.

Rate Reform

Utility gas and electricity rates are a significant factor in household economic prosperity and are likely to be a major determining force in a consumer's decision on whether to move forward with an AC to HP retrofit. As detailed throughout this paper, even though heat pumps are 2-4 times more energy-efficient than furnaces, monthly bill savings from a gas to heat pump conversion are often situationally specific, dependent on factors like envelope efficiency, equipment sizing, and, critically, the spark gap.

Many existing electric rates are not set up to fully take advantage of, and respond to, a more modern, dynamic electric system. States have started to consider implementation of modern rate designs to better align rates with the electric system and adoption of new efficient technology, like heat pumps.[62] These rates can be tailored to heat pump customers or implemented on a larger scale. In general, time-of-use rates that lower volumetric costs and charge higher prices when grid demand is highest are fairer to heat pumps, as heat pumps consume more energy during the winter and night, when grid demand is lower.[63],[64] Seasonal rates lower winter volumetric charges to better reflect actual costs to serve customers. Demand charges reallocate costs to align with customer demand. Rates that incorporate these principles are referred to as electric space heating rates.

The "Grid Demand Impacts" section demonstrates that electric space heating rates, such as those recently enacted in New York, can result in additional monthly cost savings in AC to HP retrofits, but are most effective when paired with HVAC demand response controls that strategically shift HP demand further away from peak hours.

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[61] Resource for clean heat standard guidance: Santini, M., Thomas, S., Lowes, R., Gibb, D., Cowart, R., & Rosenow, J. (2024, April 17). *Clean Heat Standards Handbook.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/clean-heat-standards-handbook/

[62] NEEP. (2025, December). *Modern Rate Design in the Northeast: Unlocking Efficiency, Affordability, and Electrification.* https://neep.org/sites/default/files/media-files/neep_modern_rate_design.pdf

[63] Malinowski, M., Sussman, R., Mooney, P., & Lewallen, G. (2025, April 23). Electricity Rates That Keep Bills Down After Electrification of Home Heating. ACEEE. https://www.aceee.org/research-report/b2502

[64] Murray, B., & Velez, J-P. (2025, July 22). *Heat Pump Rates in Massachusetts.* Switchbox. https://www.switch.box/mahprates

Examples of other recently enacted heat-pump-relevant rates include:

- Colorado recently enacted legislation requiring the state's investor-owned utilities to propose new rates for customers with heat pumps.[65]
- Massachusetts DPU drove adoption of seasonal heat pump rates statewide through a regulatory order and recently launched new seasonal rates for heat pump customers served by three of the state's largest utilities.[66]
- ConEd in New York has launched a seasonal, time-varying demand charge rate with a structure that can benefit customers with heat pump HVAC equipment.
- Excel in Minnesota has established two dual-fuel-specific rate programs for customers that utilize demand response practices. Instead of charging more money during times of peak grid strain, the customer gives the utility permission to switch them onto backup fuel systems instead of using electricity.[67]

For heat pump installations, including AC to HP conversions, it is also important to look at utility bills as a whole, not simply the volumetric rate. Utility bills include fixed charges and fees, demand charges, distribution charges, system charges, and low-income protections. Most relevant to AC to HP system design considerations are gas system charges. An AC to HP project that retains a gas furnace can be optimized to maximize monthly usage cost savings by programming an ideal switchover temperature; however, the customer that retains the gas service continues to pay certain fixed or system charges on their gas bill. A customer that opts to have the heat pump serve their entire heating needs for the year may be able to disconnect from the gas system entirely, thereby eliminating their monthly gas service charges, which could translate to hundreds of dollars of savings annually.

Greater electric space heating adoption changes how much energy is used in the winter as well as the system load profile throughout the entire year. While most states are not expected to be winter peaking until the mid-2030s, long-term utility system planning can leverage dual-fuel systems to decrease peak energy consumption and smooth electrical demand growth over time.

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[65] Colorado General Assembly. *SB24-214 Implement State Climate Goals.* https://leg.colorado.gov/bills/sb24-214

[66] Massachusetts Department of Public Utilities. Residential Electric Seasonal Heat Pump Rates. https://www.mass.gov/info-details/residential-electric-seasonal-heat-pump-rates

[67] Xcel Energy. Back-Up Relief Program. https://mn.my.xcelenergy.com/s/residential/heating-cooling/back-up-relief-program

Programs

Key Insights

- Voluntary incentive programs remain the region's most flexible and immediate mechanism to influence HVAC purchasing behavior.
- Optimally structured rebates should align with incremental costs, expand eligibility beyond only the highest-efficiency HP systems, and offer both partial- and whole-home electrification pathways. Programs can further shape outcomes that fit their HP goals through actions such as phasing out rebates for central ACs or strategic switchover temperature requirements for dual-fuel situations.
- Programs should ensure that technical resource manuals and savings methodologies accurately capture dual-fuel and coil-only heat pump performance to avoid unintended barriers or consequences.

Voluntary incentive programs play an important role in the regional HVAC market, as rebates directly influence purchasing decisions and can shift both contractor and customer preference toward higher-efficiency technologies. Surveys and program data across the region show that financial incentives are among the top factors motivating customers to choose heat pumps over like-for-like replacement of heating or cooling systems, particularly when rebates cover a meaningful share of incremental costs.[68]

By lowering the upfront cost to customers, programs can make heat pumps more attractive and raise adoption rates, resulting in higher energy and emissions savings across the population. Programs can intervene at the time of furnace or AC failure, near the end of equipment useful life, or during new construction. In the case of ACs, programs can also intervene during first-time cooling installations. As detailed in the "Market Opportunity" section, there are about 330,000 central AC equipment replacements and 14,000 new central AC installations in the Northeast per year.

Each state in the region now offers state- or utility-administered rebates for HVAC equipment (heat pumps and/or air conditioning). Voluntary incentive programs offer a nimble and legally low-risk pathway for influencing HVAC purchasing behavior. Unlike policies, rebate structures can be updated frequently, pilot new approaches, and avoid federal preemption barriers under EPCA. Programs can target AC to HP replacements using design levers to align with state efficiency and affordability goals.

The analysis below draws from 2025 program data across the major single-family programs in each state and was last updated in September 2025.

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[68] RMI. (2025). Regional Roundup, UGC.

Table 6: *Northeast ducted program summary of key considerations for AC to HP conversions*[69]

State	Program	HP Rebate Amount	HP Equipment Performance Specification	Partial- vs. Whole-Home (% of heating load)	Eligibility Related to Customers’ Existing Fuel Type	Rebates for AC?
CT	Energize Connecticut	\$250-\$750/ton, up to \$15,000	ENERGY STAR V6.1 Cold Climate	Any	Higher incentive for replacing propane, oil, gas, or electric resistance	☒
DC	D.C. Sustainable Energy Utility	\$1,000-\$5,000/ outdoor unit	ENERGY STAR V6.1 Cold Climate	Any	Higher incentive for replacing gas; electric to electric	☑ \$250/ ducted unit
DE	Energize Delaware	\$800-\$1,600/ outdoor unit Hybrid HP with furnace: \$1,450-\$2,250/outdoor unit	Several HP tiers within a Home Performance with ENERGY STAR program[70]	Any	No restrictions	☑ \$650-\$1,750/ ducted unit
MA	Mass Save	\$1,250-\$3,000/ ton, up to \$10,000	ENERGY STAR V6.1 Cold Climate	Higher incentive for whole home (90-120%)	No restrictions	☒
MD	BGE, Potomac Edison Company, Delmarva Power & Light, PEPCO, Washington Gas Light Company, SMECO	\$400-\$10,000/ project	ENERGY STAR	Any	Fossil fuel replacement bonus	☑ \$300-\$10,000/ project[71]
ME	Efficiency Maine	\$1,000-\$3,000/ outdoor unit, up to \$9,000	NEEP Cold Climate + Additional Requirements	Whole home (80%+)	No restrictions	☒
NH	NH Saves	\$250-\$1,250/ton	NH Saves QPL: SEER2 ≥15.2, HSPF2 ≥8.5, HCR@5F ≥70%, COP@ 5F ≥1.75	Any	Higher incentive for replacing electric resistance	☑ \$70/ton

continued

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[69] Research on these programs was conducted in the fall of 2025.

[70] Energize Delaware. (2024, November 11). Home Performance With ENERGY STAR. https://energizedel.wpenginepowered.com/wp-content/uploads/2025/08/048-1167-10-072025-DESEU-Available-Rebates-Flyer.pdf

[71] Some Maryland utility programs have eliminated central air conditioner incentives. For example, BGE has eliminated one-way central air conditioner incentives as of Q3 2025 according to the company’s 2025 annual report on EmPOWER Maryland programs, filed on February 17, 2026, in Case 9705 at the Maryland Public Service Commission.

NJ	PSEG, Orange & Rockland, JCP&L, Atlantic City Electric	$300-$700/ outdoor unit; 30-60% of project cost for Hybrid Heat	Varying HSPF2, SEER2, EER2, COP @ 5°F requirements	Any, except for O&R Clean Heat whole home (100-120%)	No restrictions; one utility has higher incentives for replacing gas or delivered fuel	☑ $60-$200/ ducted unit
NY	NY Clean Heat	$500-$1,600/10k BTU/h @ 5°F or $1,000-$8,000/ project	NEEP Cold Climate	Whole home (100-120%)	No restrictions	☒
PA	PPL, PECO, FirstEnergy, Duquesne Light Co., UGI	$200-$450/unit	ENERGY STAR, variable	Any	No restrictions	☑ $150-$300/ ducted unit
RI	RI Energy, Clean Heat RI	$400-$1,250/ton	ENERGY STAR V6.1 Cold Climate OR CEE 25C Tax Credit Tiers	Any	Higher incentive for replacing electric resistance; Clean Heat RI incentives only for existing gas, propane, or oil	☒
VT	Efficiency Vermont	$1,200-$2,200/ ducted system	NEEP Cold Climate	Any	No restrictions	☒
WV	Appalachian Power Take Charge WV, Mon Power	$300-$700/home	SEER ≥ 16-19	Any	No restrictions	☑ $300-$700/ ducted unit

The study finds that program design varies significantly across several dimensions that shape the feasibility and attractiveness of AC to HP conversions:

- Eligible equipment efficiency levels
- Rebate magnitude relative to incremental cost
- Heating load coverage requirements (partial- vs. whole-home) and fuel-switching incentives
- Continued availability of cooling-only incentives
- Energy savings measurement and attribution methods
- Midstream versus downstream interventions

Collectively, these factors determine how easily programs can transform an AC failure event into an opportunity for partial or full heat pump replacement. The following subsections summarize each program design consideration.

Eligible Equipment and Efficiency Requirements

Most major programs in the region require heat pumps to meet cold climate specifications to qualify for incentives. For example, Energize Connecticut, D.C. Sustainable Energy Utility, Mass Save, Rhode Island Energy, and Clean Heat Rhode Island all offer rebates to systems that meet ENERGY STAR V6.1 Cold

Climate specifications. While this helps ensure installations deliver efficient year-round performance, it can unintentionally narrow the market. As we found in "Upfront Cost Considerations," cold climate variable-speed systems are offered in the market at a higher price point than single-stage, two-stage, and variable-speed heat pumps, posing a potential upfront cost barrier to customer adoption. Programs emphasizing only the top-tier products risk excluding cost-sensitive customers who might otherwise electrify part of their heating load through lower-capacity, more affordable systems.

Allowing a broader range of systems may expand participation without sacrificing comfort or efficiency benefits. Programs may consider tiered incentives for less efficient single- and two-stage heat pumps, as well as the variable-speed systems that are usually incentivized. In areas where utility rates favor fossil fuels over electricity, keeping a backup heating source can make economic sense for homeowners. In these cases, it is also sometimes more economic to install a single- or two-speed heat pump than a variable-speed system, as the economic switchover temperature is higher.[72] While these systems do cover less of the heating load, resulting in less savings than variable-speed, every heat pump is an improvement in efficiency and capabilities compared to a central AC and furnace system, and cutting "lower end" heat pumps out of programs may decrease total heat pump adoption.

Rebate Magnitude vs. Incremental Cost

Market-rate rebate amounts range widely across the region, from $250 per ton to up to $3,000 per ton. Programs near the upper end of this range may nearly offset the entire incremental cost of switching from an AC to a heat pump, whereas smaller rebates may leave a sizeable portion to be paid out of pocket by customers.

Aligning rebate levels with incremental cost findings ensures that heat pumps are a viable replacement option at the point of AC failure. Additionally, programs should consider stackable federal incentives where possible to further close cost gaps. Programs may also consider setting rebate amounts to target "easy wins," like providing incentives for propane and fuel oil customers buying heat pumps that bring the incremental installation cost to $0, recognizing that there is not an operational cost barrier for this switch.

Additionally, weatherization and ductwork upgrade incentives can encourage residents to upgrade their home to be ready for an HP installation before an HP installation is actually needed. This can help to spread upgrade costs over time, as well as decrease the incremental cost of the HP installation itself.

Heating Load Requirements and Fuel-Switching Incentives

Most major programs in the region allow and incentivize fuel switching but differ in whether they reward partial-load or whole-home installations.

Many programs are moving toward supporting whole-home retrofits by either excluding partial-load systems or structuring incentives to favor whole-home electrification. A properly designed whole-home electrification incentive can ensure full load coverage by heat pumps while maintaining customer affordability but may require significant upfront costs to protect against potential operational cost changes.

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[72] See Figure 8 for a breakdown of when this is the case.

Programs should consider a blend of both program types, rewarding full displacement where feasible and also offering a dual-fuel on-ramp in AC to HP scenarios. Programs should promote dual-fuel systems when they represent the most suitable option for a given household, such as in homes with limited duct capacity or electrical infrastructure, where partial electrification can offer a practical, cost-effective step toward decarbonization when full electrification isn't immediately affordable. Inclusion of lower tier incentives for these partial-load systems can also stretch program incentive budgets to bring savings and benefits to more homes.

In existing dual-fuel programs, states and utilities are increasingly pairing integrated control requirements with incentive tiers to ensure energy savings. Integrated controls or maximum switchover temperature requirements can act as levers for balancing affordability, comfort, and energy savings goals in partial-load programs. For example, Mass Save requires that customers seeking partial-load incentives (Mass Save provides higher incentives for full heating load replacement and fossil fuel furnace disconnection) set their system's automatic switchover temperature to no higher than 30°F for oil or gas and 5°F for propane.[73],[74] This requirement helps ensure that participating hybrid systems achieve the desired reductions in fossil fuel use while maintaining comfort and affordability and avoiding high peak demand on the coldest days.

Phasing Out Cooling-Only Rebates

The lowest-hanging fruit with regards to promoting heat pump adoption and transforming the HVAC market through programmatic changes lies in phasing out or amending existing AC-only rebates. Various incentive programs in the region, especially in the Mid-Atlantic, provide rebates or discounts on more efficient one-way central air conditioners.

In 2024, the Maryland Energy Efficiency Advocates coalition (MEEA) and the Office of the People's Counsel (OPC) recommended the end of central air conditioner incentives for the EmPOWER 2024-2026 program cycle to allow for more focus on the promotion of heat pumps.[75] The Maryland Public Service Commission (PSC) denied this request, recognizing that heat pumps may be superior and offer higher energy efficiency than central AC, but concerned that ratepayers may not be in a position to replace their central AC and heating system with a high-efficiency HP. While the PSC did not shut the door on eliminating or restricting central AC incentives in the future—indeed, programs were able to selectively adjust cooling-only incentives since the order, and Baltimore Gas and Electric ended central AC incentives in 2025[76]—they cited the need for more time for the market to prepare. To overcome this barrier, programs should provide evidence on the potential cost benefits of AC to HP retrofits to support proposals to phase out cooling-only rebates.

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[73] Mass Save. Integrated Control Switchover Temperature Calculator. https://www.masssave.com/residential/switchover-temperature-calculator

[74] Guidehouse. (2022, September 2). Memorandum Re: Heat Pump Switchover Temperature Optimization Study Memo. https://ma-eeac.org/wp-content/uploads/Heat-Pump-Switchover-Temperature-Optimization-Study-Memo_2Sept2022_Final.pdf

[75] Maryland PSC. (2024, December 27). Order on Revised 2024-2026 EmPOWER Plans, Semi-Annual Reports, and Work Group Reports. https://www.psc.state.md.us/wp-content/uploads/Order-No.-91461_2024Q1Q-9705.pdf

[76] According to the company's 2025 annual report on EmPOWER Maryland programs, filed on February 17, 2026, in Case 9705 at the Maryland Public Service Commission.

If a program is successful in phasing out cooling-only rebates, customer education and messaging can steer customers toward heat pumps. For example, Connecticut successfully ended residential central AC rebates after the 2022 program year and redirected dollars and messaging to HPs. Energize Connecticut's website hosts a Central Air Conditioner webpage with the following language: "Considering a New Central Air Conditioner? Before making a decision, explore the benefits of heat pumps. These versatile systems not only provide efficient cooling in the summer but also offer heating during the winter, all in one unit. Plus, we offer generous rebates on qualifying heat pump systems."[77] ComEd, a utility program outside of the NEEP region, offers another messaging example for capturing AC to HP customers, including customer and installer testimonials: "Never miss an air conditioner upgrade opportunity again."[78]

There has been related action recently at the federal level. In 2023, driven by a focus on the potential for electric heat pumps to deliver gains in energy efficiency, the EPA proposed to sunset the ENERGY STAR label certification pathway for central ACs. The EPA finalized the sunset of the central AC ENERGY STAR specification in 2024, and as of February 1, 2026, central ACs are no longer part of the ENERGY STAR program.[79] This action serves as a strong market signal to utility incentive programs to no longer incentivize one-way ACs.

Energy Savings Measurement and Attribution

Utility incentive programs in the Northeast rely on technical resource manuals (TRMs) to quantify savings and determine whether measures meet state cost-effectiveness thresholds. While an evaluation of the TRMs in the region is outside the scope of this report, it is important to note that most TRMs are outdated and do not capture the full performance value of AC to HP conversions.

For one, most existing TRMs were developed before dual-fuel heat pumps became common and therefore rely on static assumptions that favor full-load, all-electric systems. TRMs often undervalue hybrid heat pump savings by using the incorrect baseline, ignoring peak demand reduction, excluding dynamic switchover temperature considerations, and omitting comfort or humidity benefits.

Additionally, for variable-speed coil-only heat pumps paired with existing furnaces, AHRI coil-only rating methods assume the lowest performance permanent split capacitor (PSC) motor in calculation of rated efficiency metrics.[80] However, early field research has suggested that performance in the field is influenced more by sizing and thermostat controls than by the rated efficiency of the installed equipment, illustrating that coil-only[81] systems are capable of meeting or exceeding rated efficiencies in the field.[82] Program designs and savings calculations should keep these considerations in mind and be as flexible as possible in specifying variable-speed coil-only

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[77] Energize CT. Air Conditioners. https://www.energizect.com/explore-solutions/heating-cooling/central-air-conditioning

[78] ComEd. Variable Speed Heat Pumps. https://www.comed.com/ways-to-save/for-your-business/resource-center/fact-sheets/variable-speed-heat-pumps

[79] U.S. Environmental Protection Agency. (2024, December 2). ENERGY STAR CAC sunset letter. https://www.energystar.gov/sites/default/files/2024-12/ENERGY%20STAR%20Central%20Air%20Conditioner%20Sunset%20Cover%20Letter.pdf

[80] AHRI classifies unitary coil-only split ASHP products with no indoor fan as "HRCU-A-C."

[81] Hill, Schoenbauer, Shah. (2024). "Better Than a Dupe."

[82] Hill, Schoenbauer, Shah. (2024). "Better Than a Dupe."

system eligibility and calculating energy savings; otherwise they may unfairly penalize these systems and thus limit their market adoption as an AC replacement.

Midstream vs. Downstream Interventions

While most programs in the region currently operate downstream, offering rebates to customers upon installation, midstream incentives, which are paid to distributors or contractors, can also accelerate AC to HP adoption by influencing stocking and sales behavior earlier in the supply chain.

In AC replacement scenarios, product availability and distributor and contractor familiarity strongly influence what equipment is offered at point of sale. By providing incentives at the distributor or contractor level, programs can align and raise the likelihood both that a customer is recommended a heat pump at time of AC replacement and that the HP will be available at the distributor.

Recommendations

The AC to HP retrofit landscape varies significantly across the Northeast. Each state operates within a distinct combination of policy frameworks, incentive programs, building codes, rate structures, climate conditions, and housing characteristics—all of which shape the trade-offs contractors and residents face when selecting the size and type of HP to install. Because these retrofit decisions involve nuanced considerations related to cost, performance, and system configuration, states and program administrators cannot rely on a single prescriptive approach. Instead, a portfolio of coordinated actions is needed to help customers, contractors, and market actors navigate these trade-offs and create economic conditions for sustained market transformation. The following recommendations highlight crosscutting opportunities that states, grid planners, and program administrators can adapt to their specific market and regulatory contexts.

Key Recommendations

1. Promote public awareness of heat pumps as “two-way ACs” to normalize adoption during replacements of central ACs, highlighting their ability to deliver year-round comfort.
2. Reexamine and recalibrate incentive programs to spur HP market transformation via prioritization of AC to HP retrofits.
3. Support workforce development and contractor training on heat pump sizing, heat pump selection, and heat pump controls in the context of regional economics.
4. Consider modern electric rates to improve full electrification economics and lower economic switchover temperatures.
5. Align building codes and regulatory frameworks with AC to HP opportunities.
6. Develop and implement multi-year program plans and policies that consider and integrate the strategic role of dual-fuel systems in long-term energy system planning and transitions that account for affordability, reliability, and decarbonization goals.

Promote public awareness of heat pumps as “two-way ACs” to normalize adoption during cooling replacements, highlighting their ability to deliver year-round comfort.

Customer awareness is a relatively low-cost lever that can greatly shift the demand side of the market by unlocking customer pull. There is a meaningful proportion of households that are unaware that heat pumps provide both heating and cooling. Framing heat pumps as “two-way ACs” can help normalize HPs as the natural next generation of central cooling equipment.

Utilities, manufacturers, and other organizations should emphasize this framing and stress heat pumps’ efficient cooling capabilities and other benefits in communications to contractors and customers. Distribution of information about customer success stories, and about the cost savings available through different installation conditions, can increase market awareness of the variety and flexibility of heat pump use cases. In addition, campaigns should highlight available space heating rates and HP incentives. Programs like these that improve customer HP economics can increase confidence in, and knowledge of, the technology, which can further spread by word of mouth.

Reexamine and recalibrate incentive programs to spur HP market transformation via prioritization of AC to HP retrofits.

Voluntary incentive programs are a driving force behind the growth of the HP industry and remain flexible enough to respond to an evolving market. Over the past 15 years, programs have adapted to better reflect the non-energy benefits of energy efficiency, target specific sectors of the market, and support the advancement of the efficiency workforce. Lately, these incentive programs have started to respond to advances in HP technology and the center-stage role that HPs have taken in state policy goals. States and utilities are now in position to optimize incentive programs to help spur lasting and accelerated market transformation and have many levers to pull to achieve those goals. For example, many programs are in prime position, given the energy, emissions, and economic benefits of AC to HP retrofits, to phase out rebates for one-way central air conditioners. Incentive dollars previously spent on less-efficient and less-capable central AC systems can be transitioned to tiered HP incentives that reflect incremental cost differentials. Key programs in states like Connecticut and Massachusetts have already successfully phased out central AC rebates and coupled the phase-out with robust customer messaging and contractor training to raise awareness across market actors.

In tandem, programs should evaluate the role of dual-fuel systems and promote them where appropriate to boost heat pump adoption, HVAC system resiliency, and in many cases, operational cost savings. In cases where a home has constrained ductwork and electrical systems, and the program does not have sufficient offerings to support these upgrades, partial electrification may be the only type of electrification that is feasible within a customer's budget. For rate structures with an unfavorable spark gap and limited offerings for more beneficial TOU or similar HP-friendly rates, retaining an existing backup heating system can unlock better operational economics for the customer as well, due to strategic switchover settings.

Flexible heat pump incentive programs that support partial heating load coverage projects as well as full electrification, whole-home systems can help households save money and states achieve critical policy goals. Inclusion of coil-only variable-speed heat pumps and single- and two-stage heat pumps as rebate qualifying products can expand market penetration of affordable heat pump applications for homes with existing furnaces and limited household budgets. Inclusion of lower tier incentives for these dual-fuel systems can also stretch program incentive budgets to bring savings and benefits to more homes. These flexibilities that support partial heating load coverage act as positive complements to the whole-home incentives.

Customer and contractor educational materials should emphasize the importance of planning potential HVAC system modifications for the greatest overall savings. For example, weatherization, or the installation of a ductless mini-split unit a few years after partial electrification, can allow for full electrification further down the line, with the added benefit of spreading incremental cost out over time. To the extent possible, incentive program structures should also reflect the importance of planning, and program designs should make it easy for customers to plan and for contractors to support customers in leveraging specific incentives for weatherization or ductwork upgrades prior to or after HP installation.

Support workforce development and contractor training on heat pump sizing, selection, and controls in the context of regional economics.

Contractor training is a vital component of AC to HP market transformation, as installer confidence and competency can determine whether heat pumps are offered and properly designed and commissioned, and contractor sales economics improve as their HP installation experience grows.

Increasing understanding of heat pump sizing options and trade-offs, as well as the trade-offs between different heat pump types, can make the retrofit process smoother and help to ensure that customer priorities align with the HVAC system that is ultimately installed. Tools and resources that provide clear information on the cost-parity COP or spark gap between fuels with different rate structures that are specific to the household's utility territory could be used to understand the trade-offs between fuel types and equipment selection and sizing, as well as switchover control strategies, in each region.[83]

Consider modern electric rates to improve full-electrification economics and lower economic switchover temperatures.

Studies have shown that traditional rates unfairly overcharge heat pump customers due to the increased use in the winter, when grid demand is lower.[84],[85] Modernizing rate design through implementation of TOU or seasonal rates can improve the economics of fully electric systems and lower the economic switchover temperature for dual-fuel configurations. Further, implementing them can ensure that rates reflect cost of service.

Programs can complement electric space heating rates with integrated control requirements that automatically optimize heat pump operation by outdoor temperature, fuel cost, or emissions intensity. Together, these approaches ensure that gas and electric system economic signals and equipment usage reinforce one another to achieve desired energy and cost savings outcomes.

Align building codes and regulatory frameworks with AC to HP opportunities.

As states update their building energy codes, performance-based compliance pathways or electric-ready provisions can encourage HP adoption at the time of AC replacement, and examples from jurisdictions already exist. Embedding efficiency requirements within broader energy frameworks ensures long-term policy alignment beyond rebate cycles. Where applicable, states may integrate electrification measures into state implementation plans or clean heat standards to prioritize partial and full electrification while remaining compliant with EPCA.

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[83] There are several existing tools to this end, including a basic cost-parity COP calculator (https://www.heatpumpswork.com/cop-target) based on rates, a ComEd contractor guide (https://goelectric.comed.com/wp-content/uploads/2024/08/001425_ComEd_SwitchoverGuide_WEB_ADA.pdf) to switchover temperature based on rates, and a cost-optimal switchover temperature calculator from Mass Save (https://www.masssave.com/residential/switchover-temperature-calculator).

[84] NYSERDA. (2019, January). "New Efficiency: New York. Analysis of Residential Heat Pump Potential and Economics." New York State Energy Research and Development Authority. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/PPSER/NYSERDA/18-44-HeatPump.pdf&ved=2ahUKEwjVqMXt4YGQAxV1D-1kFHQeuF74QFnoECAsQAQ&usg=AOvVaw2NzbowtYdxNfspnnY1GerD

[85] Murray & Velez. *Heat Pump Rates in Massachusetts.*

Develop program plans that align with multi-year system planning, carefully considering the role of dual-fuel systems in a region with ambitious decarbonization commitments.

In addition to accounting for geographically dependent demand-side conditions, as well as state electrification policies, states and utilities should develop AC to HP program plans that equitably align with integrated resource plans and system planning efforts. Amidst growing building electrification and aging gas infrastructure, customers who retain gas furnaces, with either a central AC or HP, stand to bear the increased rate burden to pay for expensive gas infrastructure. This challenge of a diminishing customer base becoming increasingly responsible for system costs will be exacerbated if those customers are low-income. Supply-side gas and electric system coordination, such as targeted whole-building electrification alongside gas pipeline decommissioning that prioritizes transitions for low-income communities, can help to avoid locking in economically vulnerable ratepayers to pay for aging gas pipeline replacements.

Additionally, policies and energy-efficiency programs should consider the impact of dual-fuel systems at scale on the gas and electric system. Partial electrification can deliver energy and emissions savings, not to mention grid constraint mitigation and peak demand management opportunities that a dual-fuel system makes possible in the near- and medium-term as energy system infrastructure continues to be built out to prepare for more sector- and economy-wide electrification.

Conclusion

This study demonstrates that replacing central air conditioners with heat pumps represents a significant opportunity for achieving energy savings, emissions reductions, and potential cost savings in the Northeast. Modeling across diverse climates and rate structures shows how the economic feasibility and environmental benefit of heat pumps depend on local fuel prices and utility rates, climate conditions, and equipment configuration.

All-electric, heat pump only systems result in the highest energy and environmental benefits but often require higher upfront investments for electrical and distribution system (i.e., ductwork) upgrades. Only in certain rate structures do these systems pay back their incremental installation cost. Dual-fuel systems can present a practical electrification strategy, providing energy and environmental benefits while allowing backup heat for the coldest days that can often lower homeowner operational costs. These systems also contribute to greater HVAC system resilience for customers and grid demand benefits for utilities.

Realizing the full opportunity of AC to HP retrofits at scale will require aligned action across the market. Targeted contractor training, improved customer awareness, and streamlined product distribution can ensure that every AC replacement is seen as an opportunity for heat pump adoption, in either a hybrid, dual-fuel configuration or heat pump only. Clear messaging that positions heat pumps as efficient “two-way ACs” can help to normalize adoption during natural equipment turnover.

Because many current results are based on modeled HVAC performance, real-world data will be essential to validate these findings at scale across a diverse building stock and evolving rate structures and market conditions. Further research on dual-fuel system performance, especially variable-speed coil-only systems, and the integration of this evidence into energy savings measurement protocols, will be increasingly important in the coming years. Also valuable will be deeper research on the potential ability for weatherization to lower home heating loads nearer to home cooling loads, unlocking some of the benefits of dual-fuel systems even in full-home electrification.

Success will depend on aligning program design, rate structures, codes, and workforce initiatives to reinforce one another. When these strategies move in step, supported by regional coordination and consistent messaging, states and utilities can advance their energy, affordability, and resilience goals while delivering tangible benefits to households across the region.

Appendix A: Modeling Archetypes and Assumptions

We modeled a 2,030 square-foot single-family home, which is the average single-family square footage in the Northeast ResStock dataset. The modeling assumes this same "basic home" across the board, preserving the same assumed levels of weatherization and home vintage. Variances in load and cost outcomes are thus due to varying climates, baseline furnace fuel type, and heat pump type. Weatherization levels were calibrated by comparing model annual output to the annual heating and cooling loads of ResStock homes with similar square footage in similar locations. For context, the average vintage of these ResStock homes is 1970.

Four locations in the Northeast were modeled in order to capture a range of climate zones and grid operators.

Modeled locations and their cooling and heating design temperatures and loads are shown in Table AA-1 below. Heat pumps were sized in accordance with ACCA Manual S guidelines. This sizing protocol specifies that to maintain proper dehumidification, single- and two-stage heat pumps cannot be sized above a factor of 1.15-1.25 times the cooling load (often preventing full heating displacement). Due to the larger cooling design loads for homes in climate zone 4 (modeled scenarios of D.C. and New York), the single- and two-stage ASHPs for homes in those modeled locations were sized to 30kBTUh and displace more heating than the 24kBTUh single/two-stage ASHPs specified for modeled locations in climate zones 5 and 6.[86] Variable-speed systems can be sized up to much higher factors due to their inverters. For modeling, these systems were thus sized to 30kBTUh across the board for scenarios sized to cooling, and higher for full heating displacement.

Note that estimation protocols like Manual J often use conservative assumptions that overestimate heating and cooling loads.[87] Sizing rules of thumb, commonly used in the field, can oversize equipment even more excessively. Oversizing can result in both larger cooling equipment than needed and lower heating loads than estimated, meaning that equipment sized for cooling can take on more of the heating load than originally calculated.

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[86] Note that the heating and cooling loads are close enough in Washington, D.C., to be served by the same sized ccVS heat pump.

[87] Mowris, R., & Jones, E. (2008). ***Peak** Demand and Energy Savings From Properly Sized and Matched Air Conditioners*. In Proceedings of the 2008 ACEEE Summer Study on Energy Efficiency in Buildings. https://www.aceee.org/files/proceedings/2008/data/papers/1_692.pdf

Table AA-1: ***Modeled locations' design temperatures, loads, and equipment sizes for modeled home***

Location	Cooling Design Temperature (°F)	Cooling Design Load (BTUh)	Equipment Sized to Cooling[88] (BTUh)	Heating Design Temperature (°F)	Heating Design Load (BTUh)	Equipment Sized to Heating (BTUh)
Essex Junction, VT (Climate Zone 6)	85	22,000	One-stage, two-stage, and AC: 24,000 Variable-speed: 30,000	(-3.5)	44,500	ccVS: 60,000
Boston, MA (Climate Zone 5)	88	22,000	One-stage, two-stage, and AC: 24,000 Variable-speed: 30,000	12	34,000	ccVS: 36,000
NYC, NY (Climate Zone 4)	89	25,000	All equip: 30,000	15	31,500	ccVS: 36,000
Washington, D.C. (Climate Zone 4)	92	25,500	All equip: 30,000	20	27,500	ccVS: 30,000

We modeled homes with gas, propane, and fuel oil furnaces. We did not model electric furnace transitions, as these types of retrofits would always see operational cost savings and energy savings.

We modeled a furnace efficiency of 80 percent, which is characteristic of the current ResStock Northeastern building stock, though furnaces currently being sold on the market average at a higher efficiency. We assumed the specified furnace's annual fuel utilization efficiency (AFUE) remained constant across all temperatures, which is consistent with standard energy-modeling tools and furnace rating procedures. However, note that this is an area of developing knowledge and that constant thermal efficiency may be a conservative assumption. For example, recent lab test data shows that furnace AFUEs decrease by zero to 20 percent at partial loads.[89]

Results were modeled for four different heat pump types: single-speed, two-speed, variable-speed, and cold climate variable-speed (ccVS). Figure AA-1 below shows the modeled COPs of each of these equipment types across outdoor air temperatures. COP values range from 2.3 to 3.7 at temperatures above freezing, and are taken from manufacturer specifications with adjustments detailed below. Heating COPs are slightly higher across the board for variable-speed models than single- and two-speed. Note that with the modeled equipment, the efficiency gains from two-speed versus single-speed equipment is primarily realized at lower load temperatures. The modeled baseline AC unit had a SEER2 of 15, leading to cooling efficiency gains post-retrofit.

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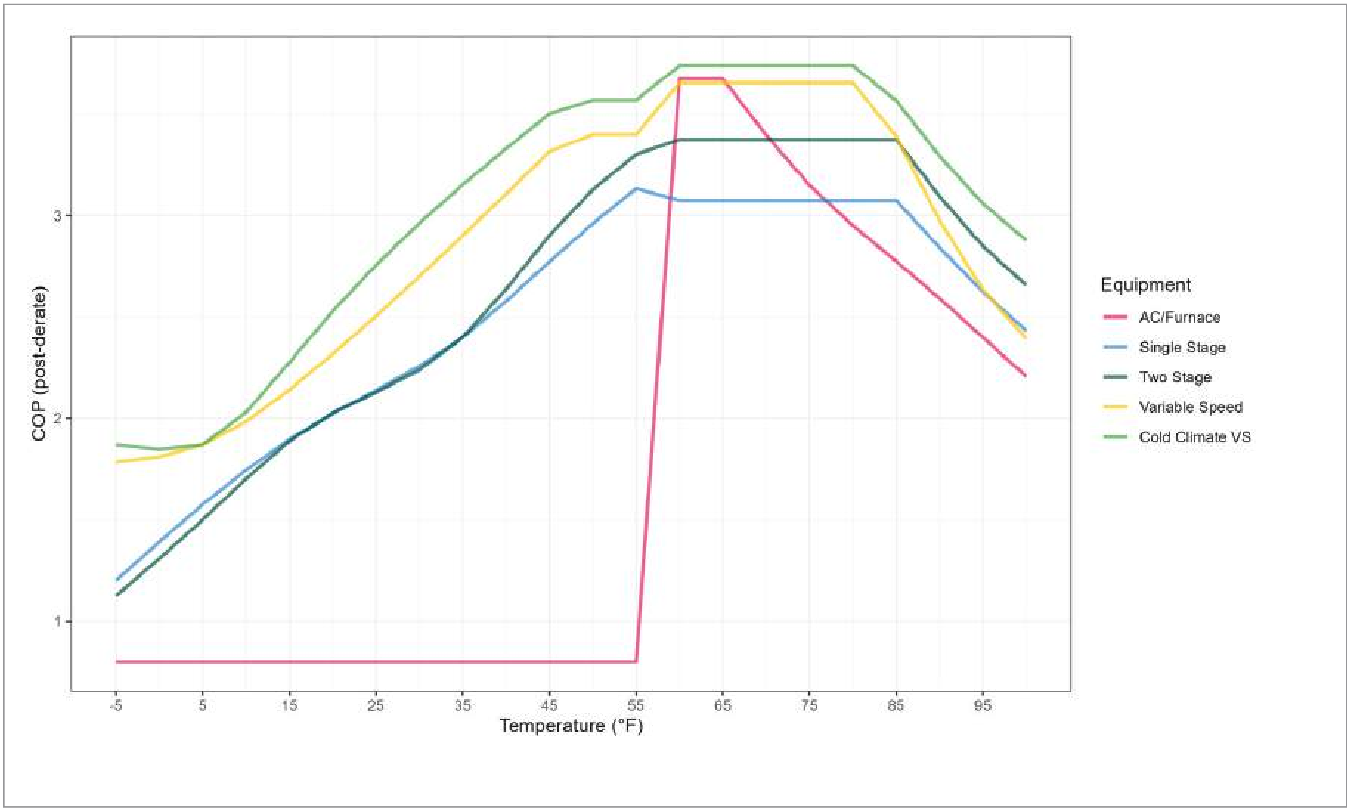
[88] Sizes here are maximized to displace heating load, while generally adhering to ACCA Manual S oversizing guidance and limits according to the total cooling size factor (1.15 for single-stage ASHPs and 1.25 for two-stage ASHPs).

[89] Northwest Energy Efficiency Alliance. (2025, September 3). *Dual-Fuel Heat Pump Systems Analysis.* https://neea.org/resource/dual-fuel-heat-pump-systems-analysis/

We have derated COPs by 25 percent for single- and two-speed models and ACs, and 15 percent for variable-speed models, based on the assumption that inverter-driven modulation decreases cycling, providing part-load efficiency boosts that support better real-world performance. These derates are based on field testing literature, which consistently shows field performance lagging behind manufacturer specified performance (i.e., system performance under laboratory testing procedures). For example, NEEP's recent Residential Heat Pump Efficiency Rating Representativeness Project found that laboratory ratings overestimated field performance by 10 to 36 percent.[90]

Note that the deviation between manufacturer specifications and field performance varies. In high-quality installations the gap may be small, whereas systems with poor sizing, ductwork limitations, or sub-optimal controls may underperform significantly. A recent field study of 12 variable-speed heat pumps illustrates this range, showing both close alignment and substantial divergence between measured and rated COP depending on site conditions.[91] Our modeling approach is therefore designed to represent the typical direction and magnitude of underperformance observed across field studies, while acknowledging that real-world outcomes depend heavily on installation quality and system conditions.

Figure AA-1: ***Modeled heat pump COPs vs. temperature, 25% derate applied to single- and two-stage models and AC, and 15% derate applied to variable-speed models***



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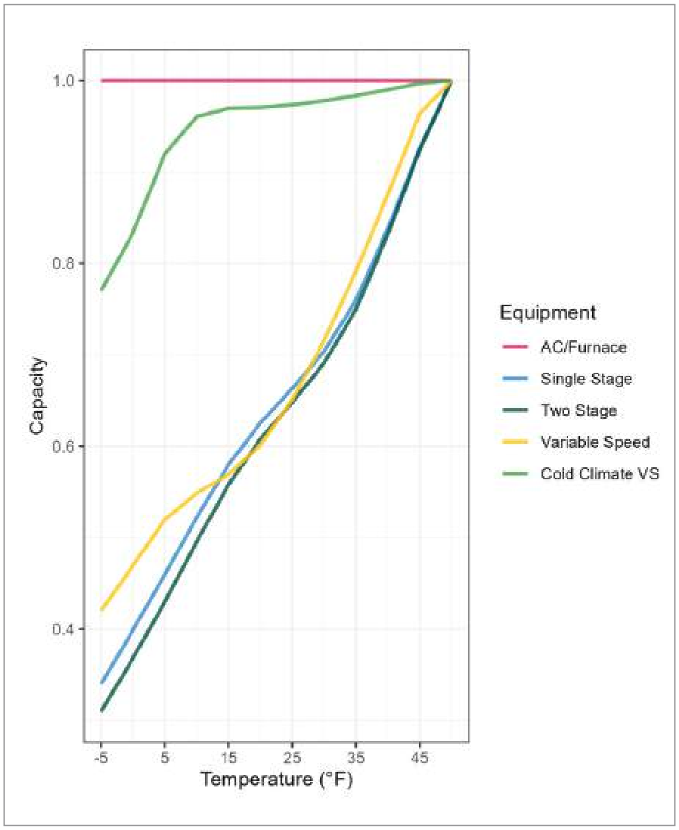
[90] NEEP. (2024, November 25). *Heat Pump Rating Representativeness Study: Phase 2*. Final report. DNV & University of Nebraska–Lincoln for NEEP.

[91] Winkler, J., & Ramaraj, S. (2023). *Field Validation of Air-Source Heat Pumps for Cold Climates.* NREL/TP-5500-84745. National Renewable Energy Laboratory.

Figure AA-2 below shows the modeled percentage of maximum capacity maintained by each heat pump type across outdoor temperatures. Capacities measure 70 to 100 percent in temperatures above freezing, degrading lower at lower temperatures, and are taken from manufacturer specifications. The ccVS heat pump in this study maintains 75 percent of its capacity down to -5°F, while the other models only provide output of about 40 percent of their maximum capacity at this temperature.

Figure AA-2: ***Modeled heat pumps heating capacity vs. temperature***



Note that there are certain heat pump models, such as those that were produced in association with the U.S. Department of Energy (DOE) Cold Climate Heat Pump Technology Challenge,[92] that can retain their capacities better than the equipment shown above.

These heat pump data are intended to be indicative of trends across heat pump types. It is important to note that additional factors could improve or worsen performance. For one, electronically commutating motors (ECMs) are assumed in both pre- and post-retrofit scenarios (a variable-speed ECM for the variable-speed systems, and a constant torque ECM for the other systems). Replacing an old permanent split capacitor (PSC) motor would lead to additional efficiency gains, while keeping an old PSC motor (an option only for single- and two-stage heat pumps) would worsen heat pump performance. Also, heat pumps generally perform slightly better when installed with a matched furnace, which is not assumed to be the case here.

Figure AA-3 below shows the baseline loads of the modeled home in each location. The solid lines show energy consumed by the HVAC equipment, while the dashed lines show energy load served. Proportionally, there is a larger difference across the region in cooling needs than in heating needs. Summer cooling loads in D.C. are double those in Vermont, but winter heating loads are 70 percent of those in Vermont (the gap between loads in D.C. versus Vermont, however, is about six MMBTUs at both times of the year). There is less variation in load across geography during the shoulder seasons.

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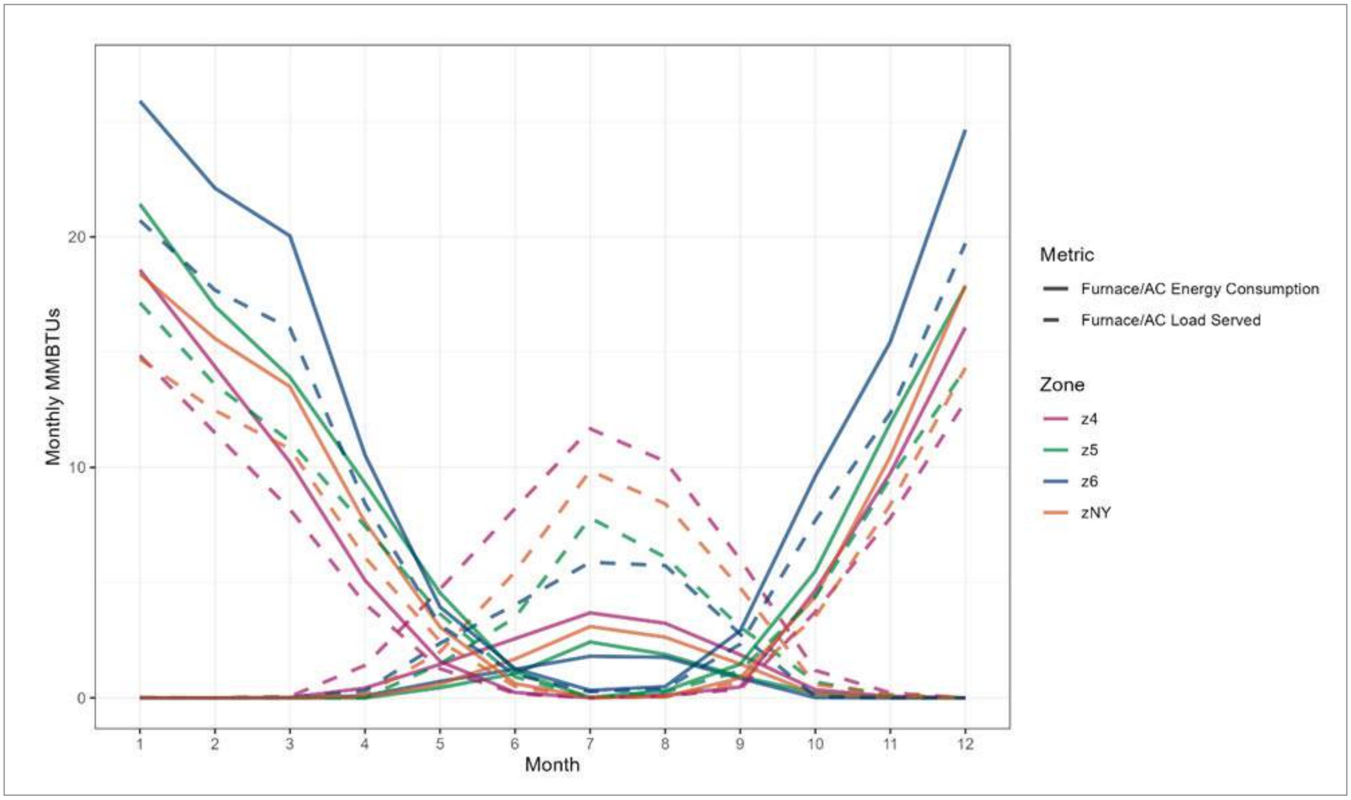
[92] U.S. DOE. Residential Cold Climate Heat Pump Challenge. https://www.energy.gov/eere/buildings/residential-cold-climate-heat-pump-challenge

Figure AA-3: *Baseline energy usage all zones, 80 AFUE furnace*



This modeling assumes full-home cooling in both the pre-retrofit and post-retrofit cases. In practice, particularly in more northern areas, many homes have central AC systems that are smaller than the estimated cooling load because homeowners or contractors did not believe full-home cooling was necessary in the cold climate. Pre-retrofit cooling loads and costs for such homes would be lower than modeled. Post-retrofit cooling loads and costs would depend on whether the household chooses to expand cooling use with the new equipment.

The model used in this paper is built and run in the R programming language. Model inputs include weather, home, and HVAC system attributes. It then runs heat transfer and energy use calculations for each hour of the year and outputs hourly data and graphics. Key functions and underlying assumptions of this model are outlined in Table AA-2 below.

Table AA-2: ***Key functions and underlying assumptions of hourly thermal model***

Function	Underlying Assumptions
Imports hourly weather file (e.g., T, RH, solar heat), selects/cleans variables, converts units, calculates solar gains per ft² of façade.	• Weather data is representative of modeled conditions. • Hourly resolution captures all meaningful thermal variation. • Solar radiation is uniformly distributed across each façade (no absorption or shading dynamics).
Uses building geometry (e.g., levels, ceiling height, wall/window ratios), R-values (e.g., walls, ceiling, floor), and infiltration inputs to compute façade areas and UA values.	• Heat transfer is steady-state (UA × ΔT). • No dynamic thermal mass, thermal bridging, thermal storage, or time lag. • Infiltration is constant per hour. • Window and wall areas are uniformly distributed. • Provided components fully define the building's thermal behavior.
Builds hourly internal gains from occupancy, appliances, and lighting schedules for weekdays and weekends.	• Internal gains follow deterministic schedules. • Gains do not vary with holidays or weather.
Takes HVAC COP and max capacity values at three to five temperature datapoints and converts them into temperature-dependent performance curves for each stage.	• COP and capacity curves accurately reflect real equipment behavior across temperatures. • HVAC stages operate as discrete on/off levels (no modulation or short-cycling). • Outdoor temperature alone determines performance variation.
Calculates solar and internal gains, determines active heating/cooling stage per hour, precomputes hourly metadata before the thermal simulation.	• Stage selection relies solely on system controls, outdoor temperature, stage capacities, and setpoints.
Simulates each hour: calculates thermal gains/losses, determines whether HVAC systems can meet the load, computes energy use and run-time of primary and backup HVAC systems and fans, computes resulting indoor temperature.	• Fan performance is linked to the enthalpy of the conditioned air stream; fan power increases with required sensible and latent heat delivery and heat delivery is capped at the equipment's specified maximum CFM. • Home setpoint is maintained unless capacity is insufficient.
Computes fuel/energy use from thermal model outputs and multiplies by hourly fuel/electricity rates.	• Hourly cost is dependent on an inputted TOU rate schedule or a fixed rate, and is assumed to be volumetric.

Appendix B: Modeled Economic Contour Plots

To illustrate the impact of utility pricing on these economic outcomes, we show several contour plots in the figures below. These figures show the annual operational cost outcomes of running a cold climate variable-speed heat pump sized for cooling down to the capacity switchover point at different fuel and electricity rates. Plots are provided for all fuel types in all climate zones with the heat pump sized to the cooling load, as well as for gas in climate zones 5 and 6 with the heat pump sized to the heating load as an all-electric system. Note that savings due to cooling efficiency gains are included in these totals and that the savings from a non-VS heat pump would be lower.

An indoor temperature droop switchover setting would result in more electricity use compared to gas backup, moving cost outcomes further into the green when savings are shown, and further into the red when a cost increase is shown. This effect is even stronger if a heat pump is installed sized to the heating load.

The utility rates of Northeastern states within each climate zone are shown on the plots, as well as a trendline of fuel prices over time from the consumer price index (CPI) in the Northeast regions.93 Note that some states, such as New York, Pennsylvania, and New Hampshire, have regions within multiple climate zones, and thus are shown on multiple plots.

As discussed in this report, there is a wide variety in the rate structures across the region. However, the general operational cost outcomes in each state are similar, with substantial savings when switching from propane and slight to substantial savings when switching from fuel oil. Most states hover close to the break-even point switching from gas with a capacity switchover.

To illustrate the sensitivity of modeling results to rate changes, we consulted historical fuel and electricity prices, pulled from the CPI through the Bureau of Labor Statistics. As shown in the CPI trend line, while fuel and gas prices have varied widely over the past five years, electricity prices have been trending steadily upwards, moving cost outcomes into the red for gas and decreasing savings for the other two fuel types.

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[93] We analyzed the Bureau of Labor Statistics Urban U.S. monthly sampling in each region. Note that while the state average rates do not include fixed bill charges, the CPI does. As the Bureau of Labor Statistics does not publish propane prices at as granular of a level, the propane prices used here are from the EIA for each region. https://www.bls.gov/cpi/factsheets/household-energy.htm

Figure AB-1: ***Climate zone 4 contour plot and average rates, cold climate heat pump sized to cooling, capacity switchover point, 80 AFUE propane furnace***

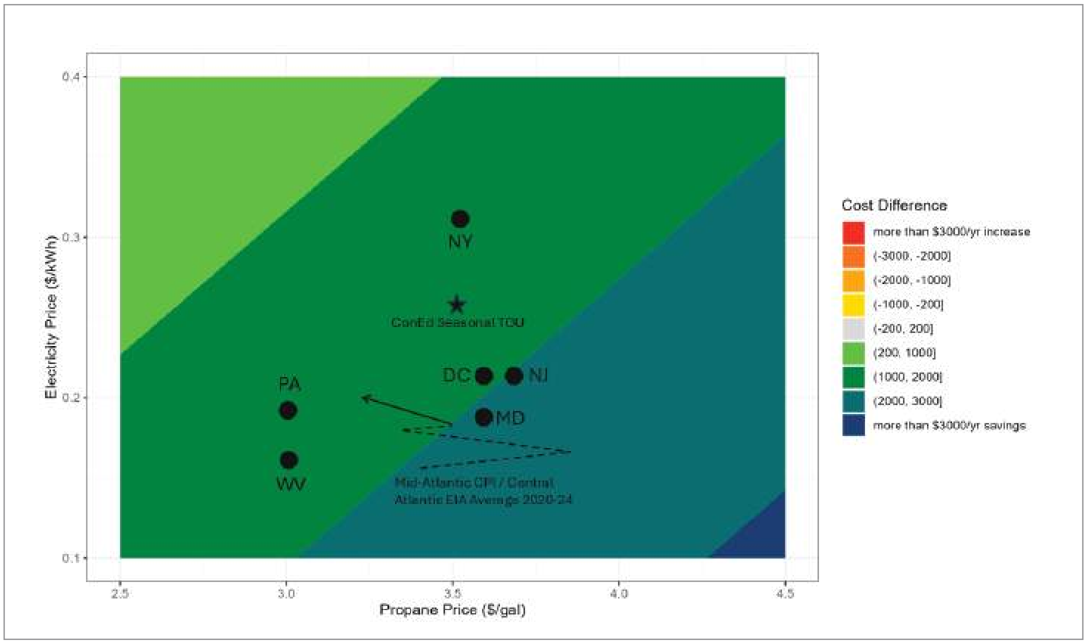


Figure AB-2: ***Climate zone 4 contour plot and average rates, cold climate heat pump sized to heating, full heating electrification, 80 AFUE propane furnac***e

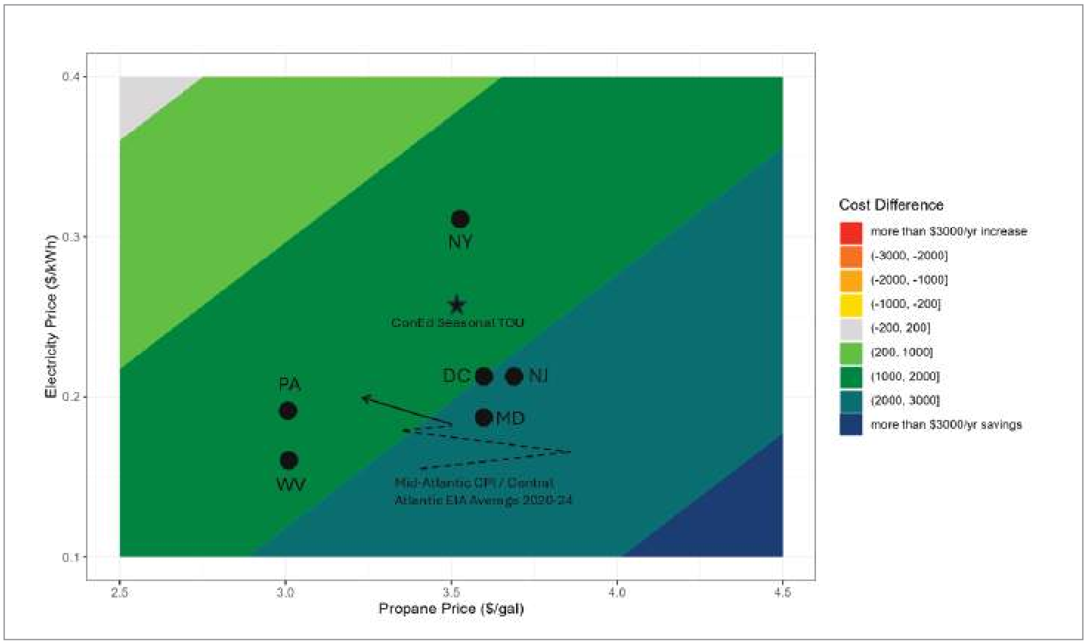


Figure AB-3: ***Climate zone 4 contour plot and average rates, cold climate heat pump sized to cooling, capacity switchover point, 80 AFUE fuel oil furnace***

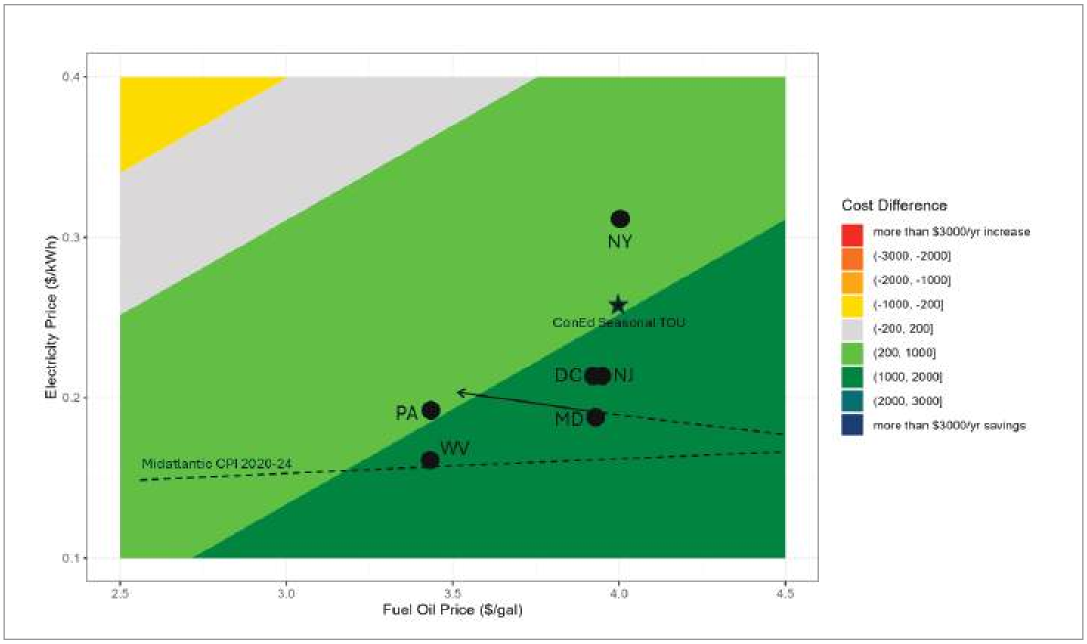


Figure AB-4: ***Climate zone 4 contour plot and average rates, cold climate heat pump sized to heating, full heating electrification, 80 AFUE fuel oil furnace***

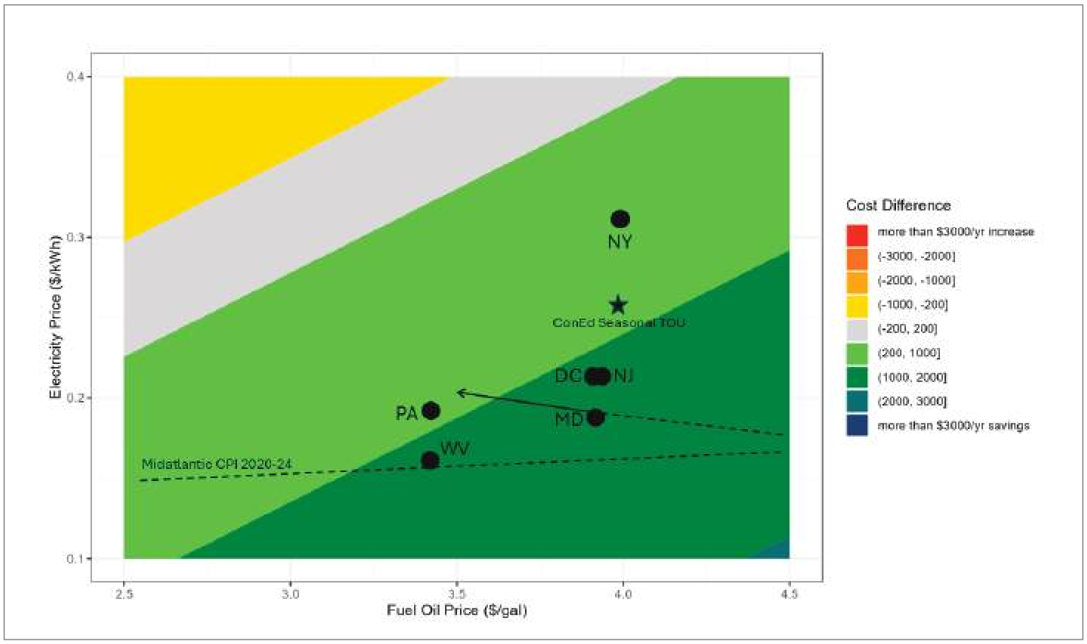


Figure AB-5: *Climate zone 4 contour plot and average rates, cold climate heat pump (cooling and heating same size in this scenario), capacity switchover point, 80 AFUE gas furnace*

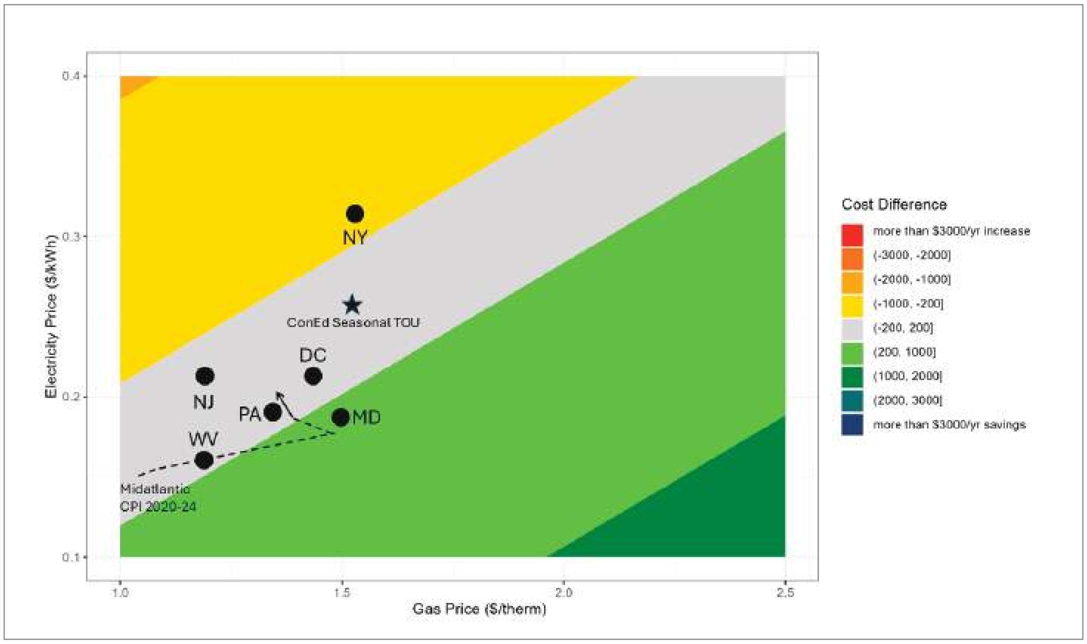


Figure AB-6: *Climate zone 4 contour plot and average rates, cold climate heat pump sized to heating, full heating electrification, 80 AFUE gas furnace*

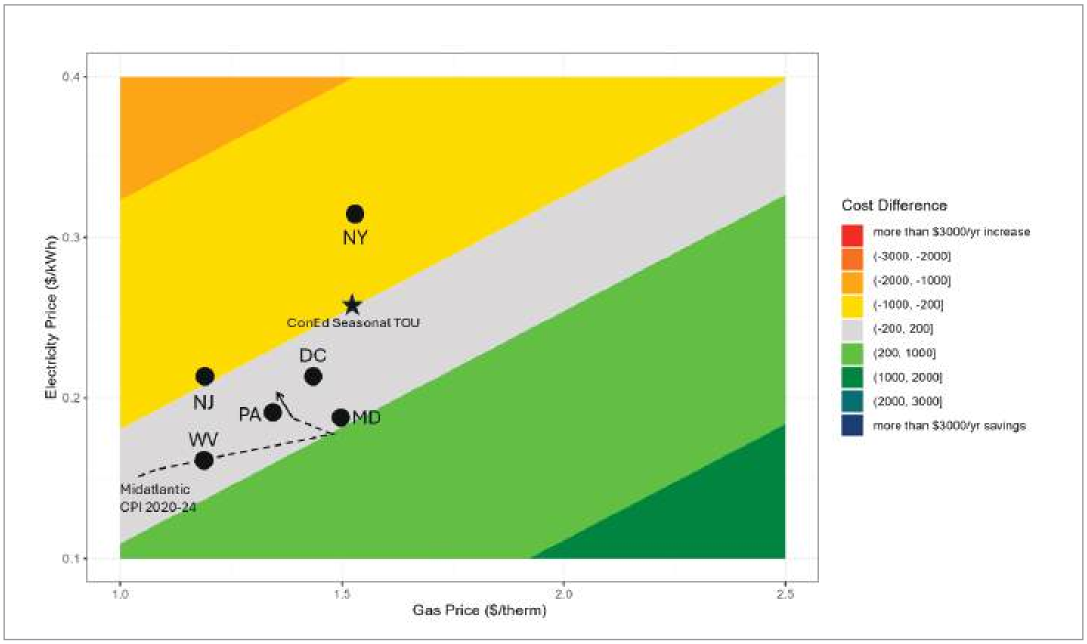


Figure AB-7: ***Climate zone 5 contour plot and average rates, cold climate heat pump sized to cooling, capacity switchover temperature, 80 AFUE propane furnace***

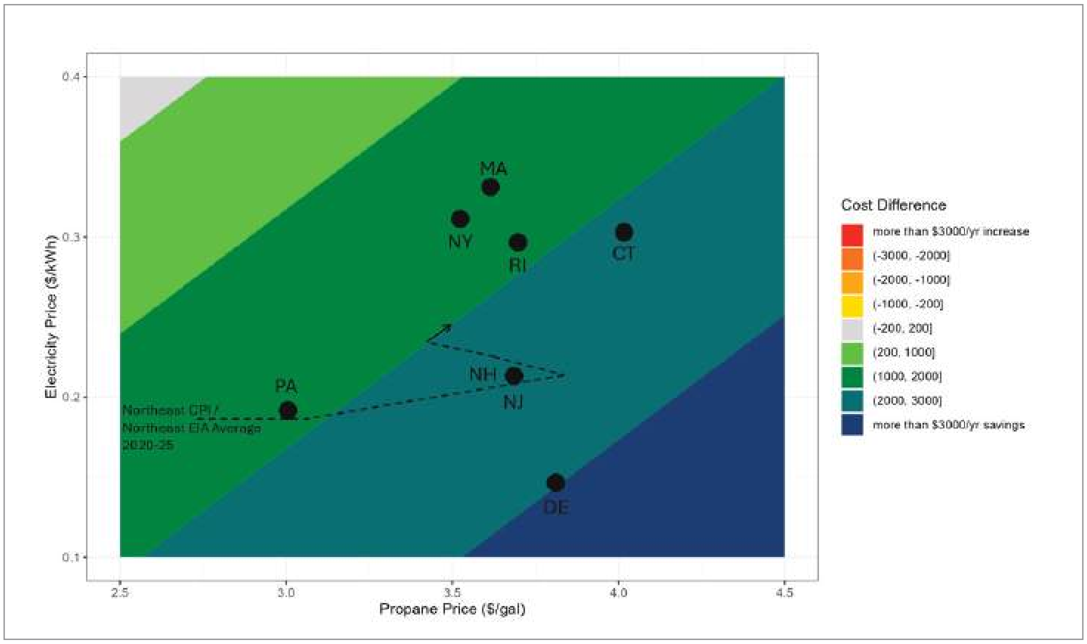


Figure AB-8: ***Climate zone 5 contour plot and average rates, cold climate heat pump sized to heating, full heating electrification, 80 AFUE propane furnace***

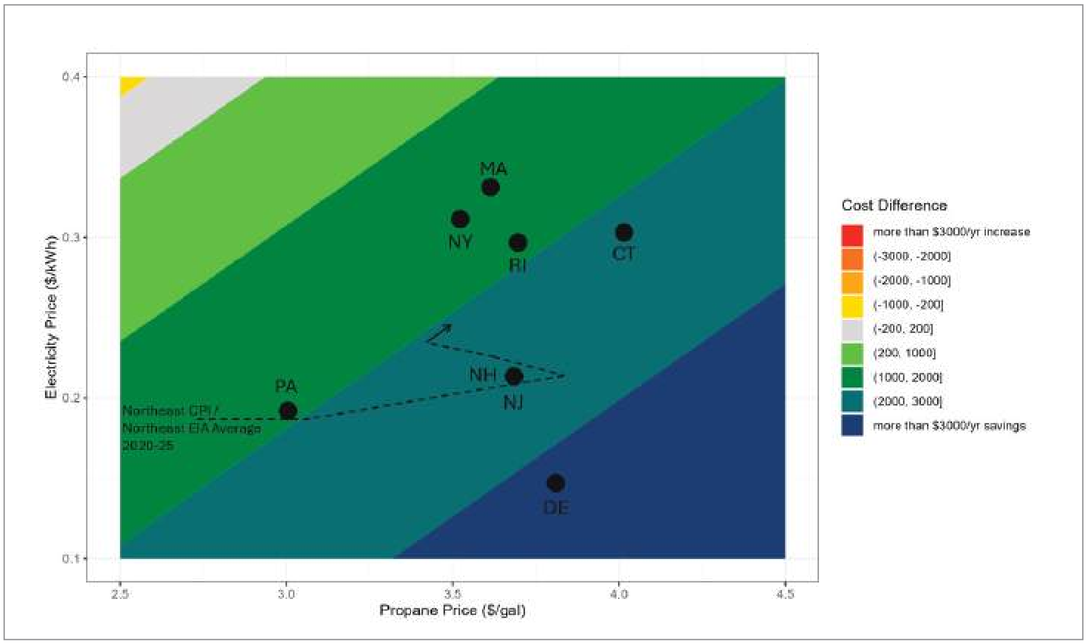


Figure AB-9: ***Climate zone 5 contour plot and average rates, cold climate heat pump sized to cooling, capacity switchover temperature, 80 AFUE fuel oil furnace***

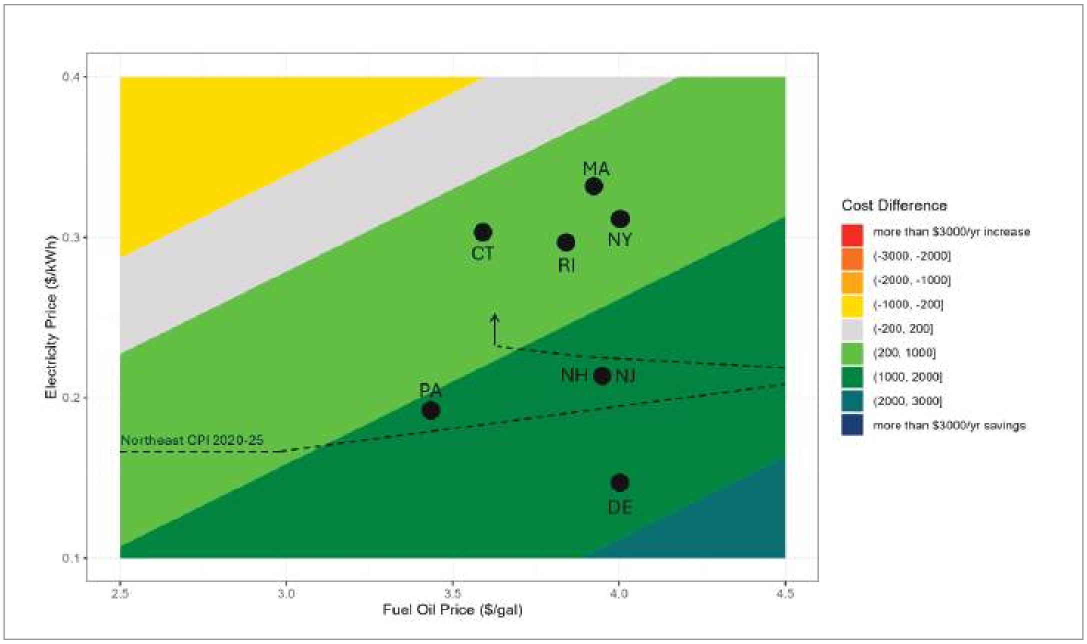


Figure AB-10: ***Climate zone 5 contour plot and average rates, cold climate heat pump sized to heating, full heating electrification, 80 AFUE fuel oil furnace***

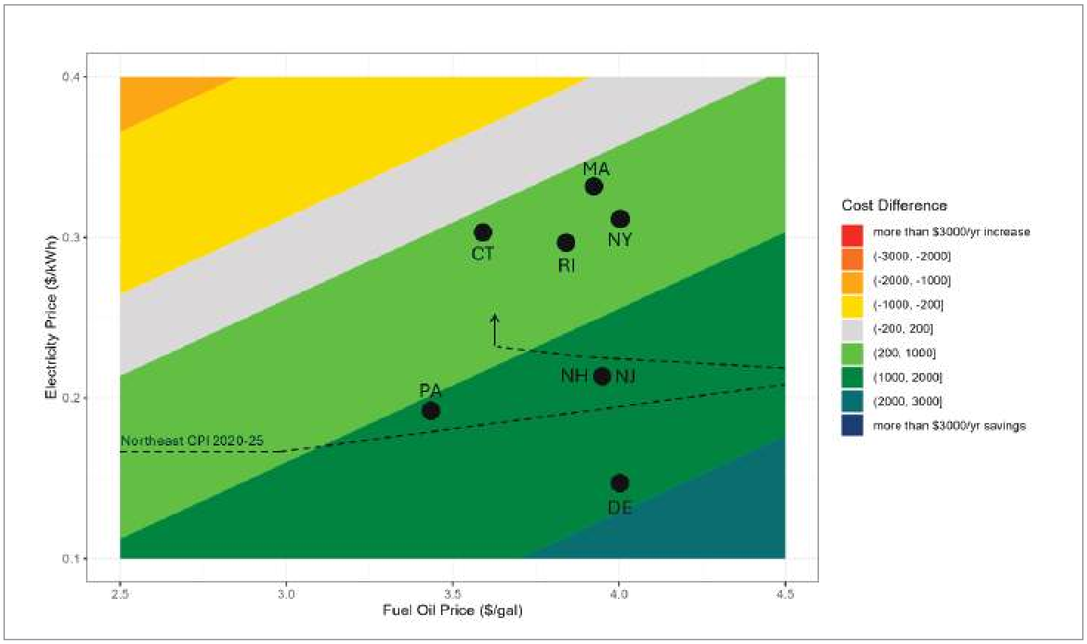


Figure AB-11: ***Climate zone 5 contour plot and average rates, cold climate heat pump sized to cooling, capacity switchover temperature, 80 AFUE gas furnace***

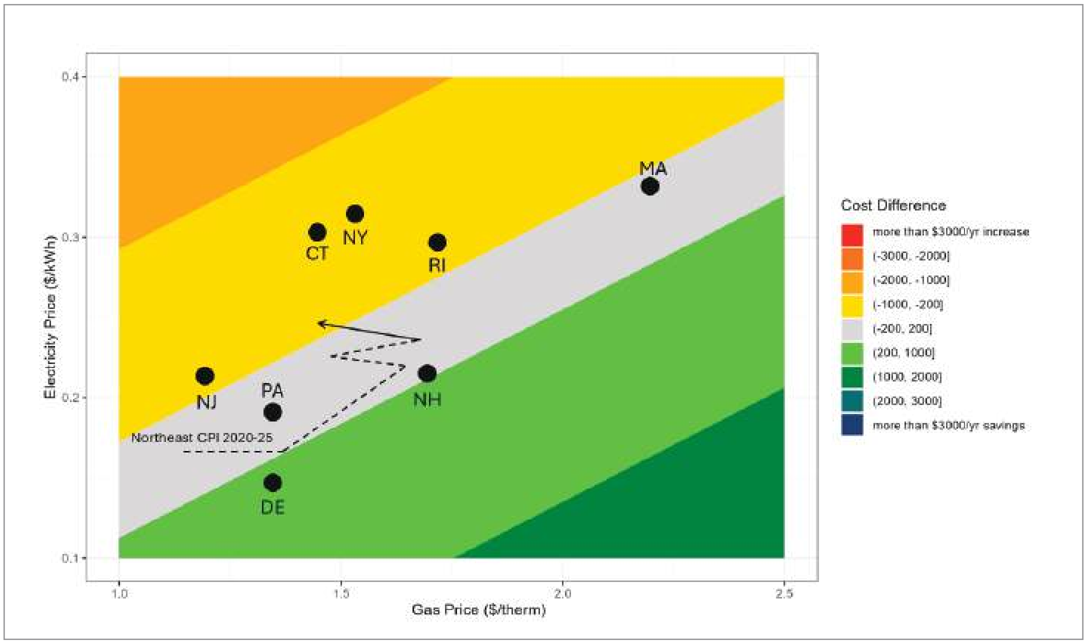


Figure AB-12: ***Climate zone 5 contour plot and average rates, cold climate heat pump sized to heating, full heating electrification, 80 AFUE gas furnace***

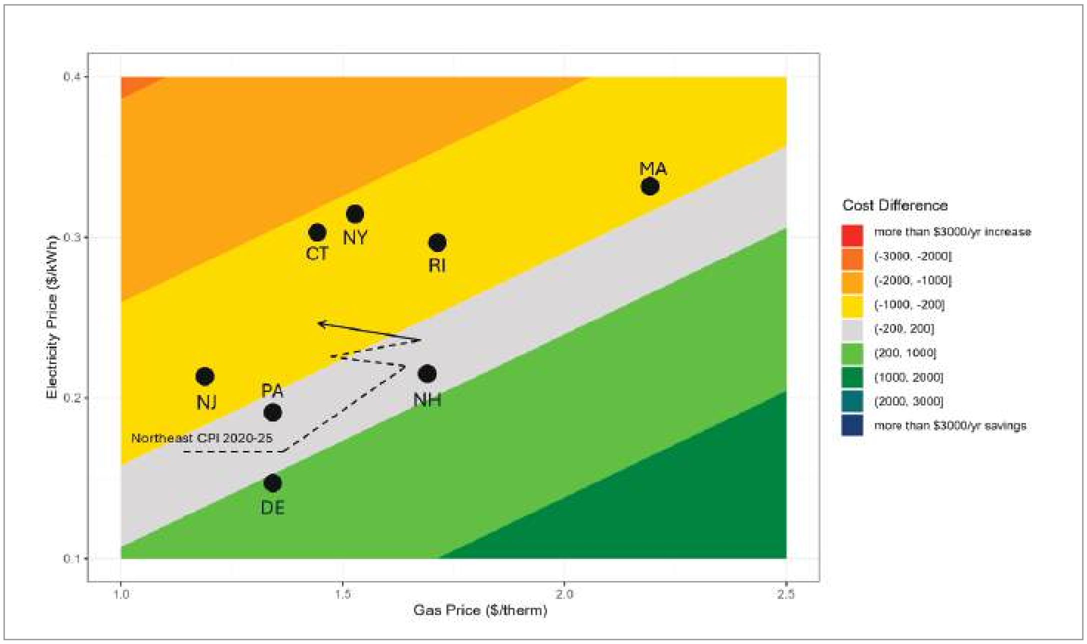


Figure AB-13: *Climate zone 6 contour plot and average rates, cold climate heat pump sized to cooling, capacity switchover point, 80 AFUE propane furnace*

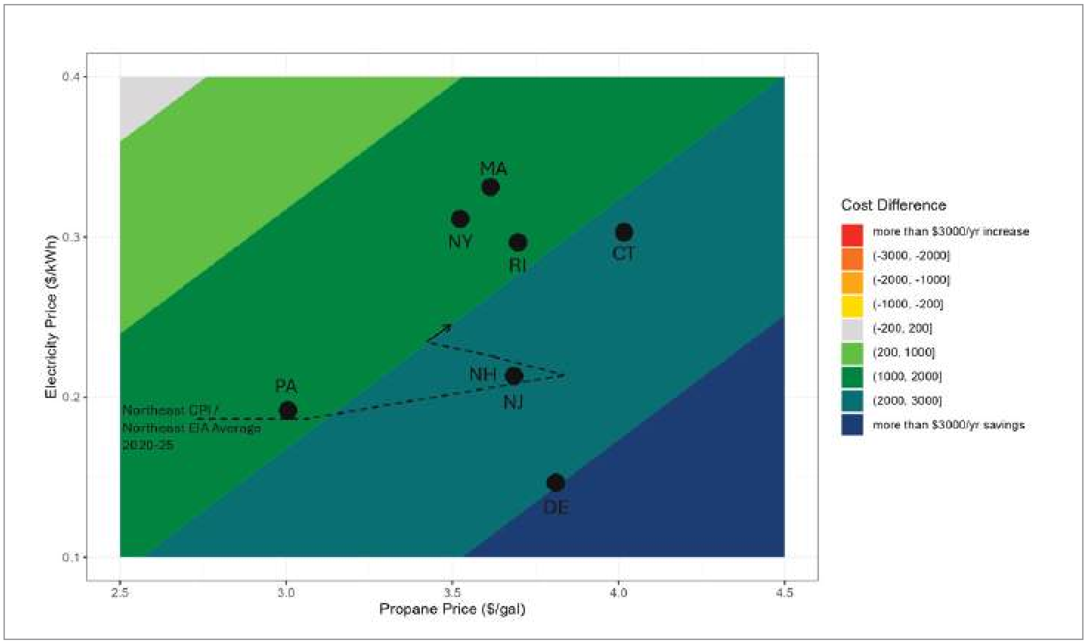


Figure AB-14: *Climate zone 6 contour plot and average rates, cold climate heat pump sized to heating, full heating electrification, 80 AFUE propane furnace*

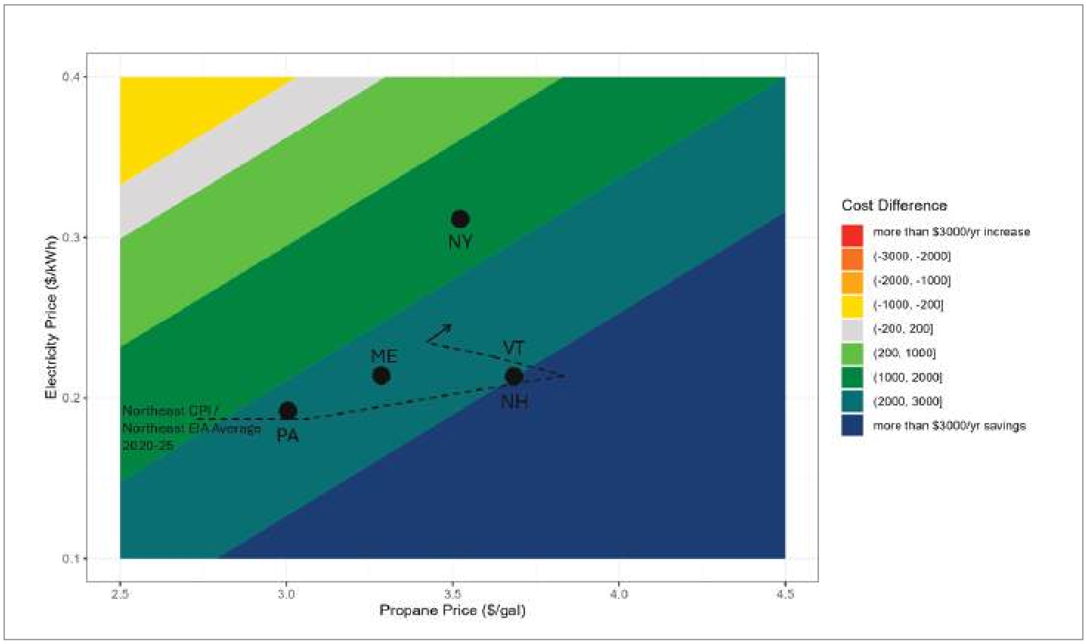


Figure AB-15: *Climate zone 6 contour plot and average rates, cold climate heat pump sized to cooling, capacity switchover point, 80 AFUE fuel oil furnace*

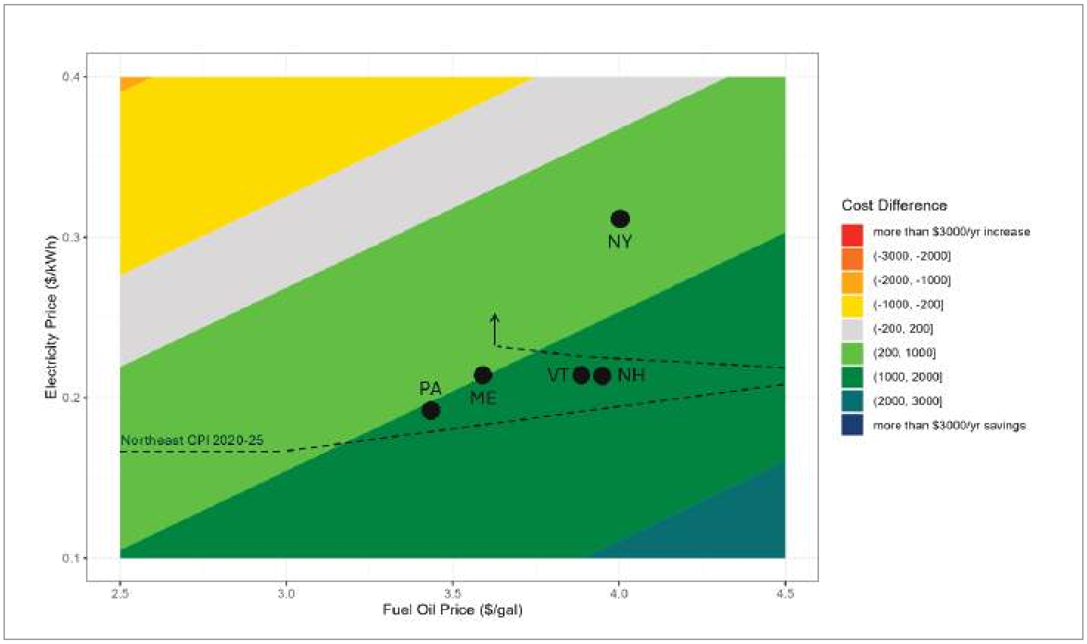


Figure AB-16: *Climate zone 6 contour plot and average rates, cold climate heat pump sized to heating, full heating electrification, 80 AFUE fuel oil furnace*

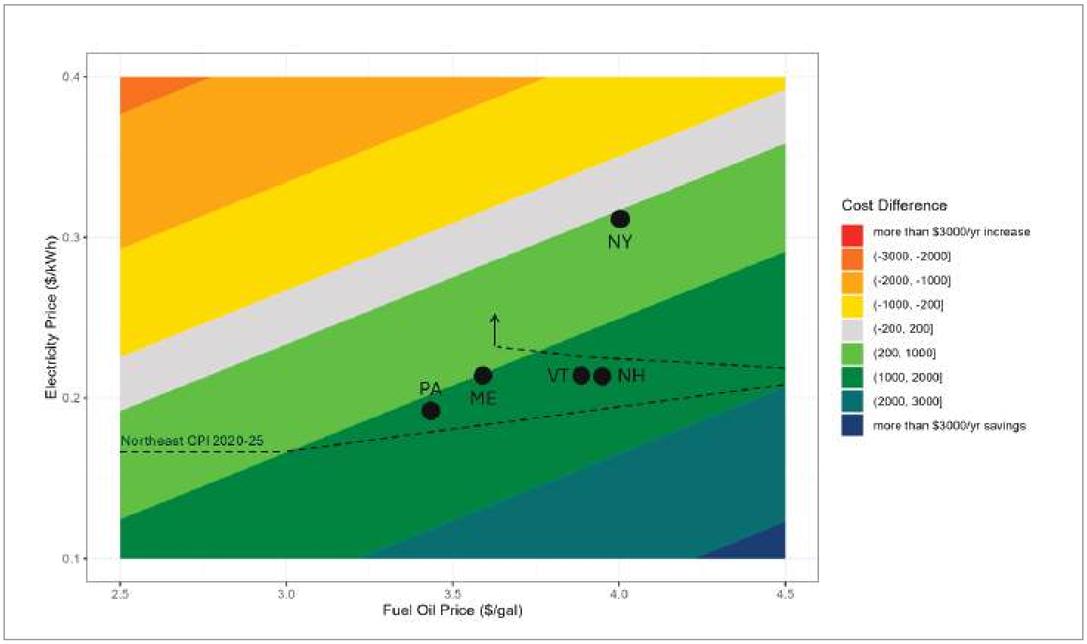


Figure AB-17: *Climate zone 6 contour plot and average rates, cold climate heat pump sized to cooling, capacity switchover point, 80 AFUE gas furnace*

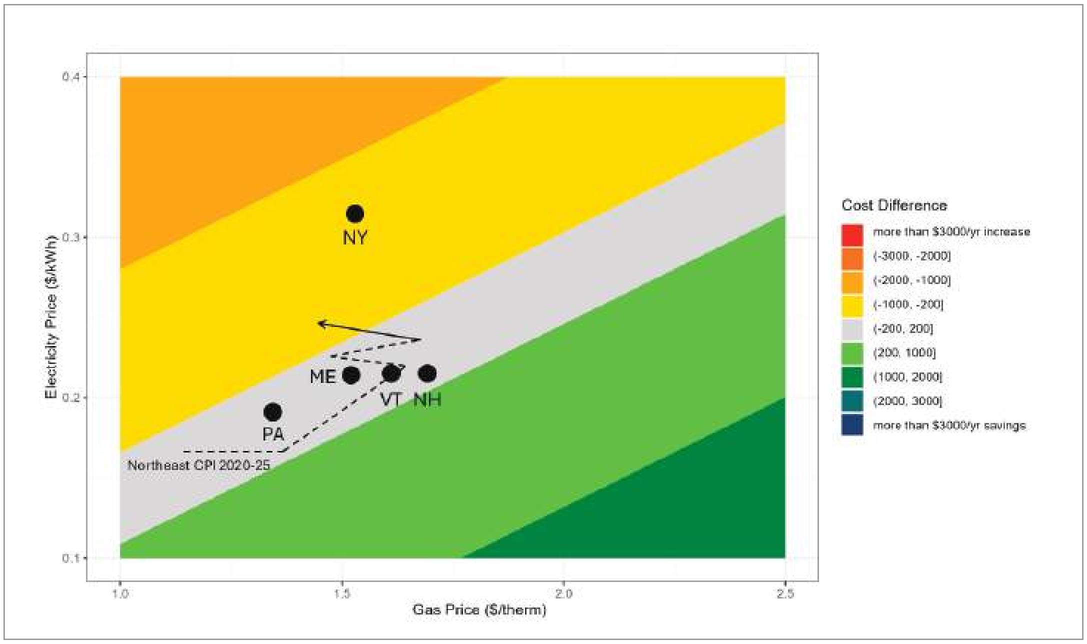
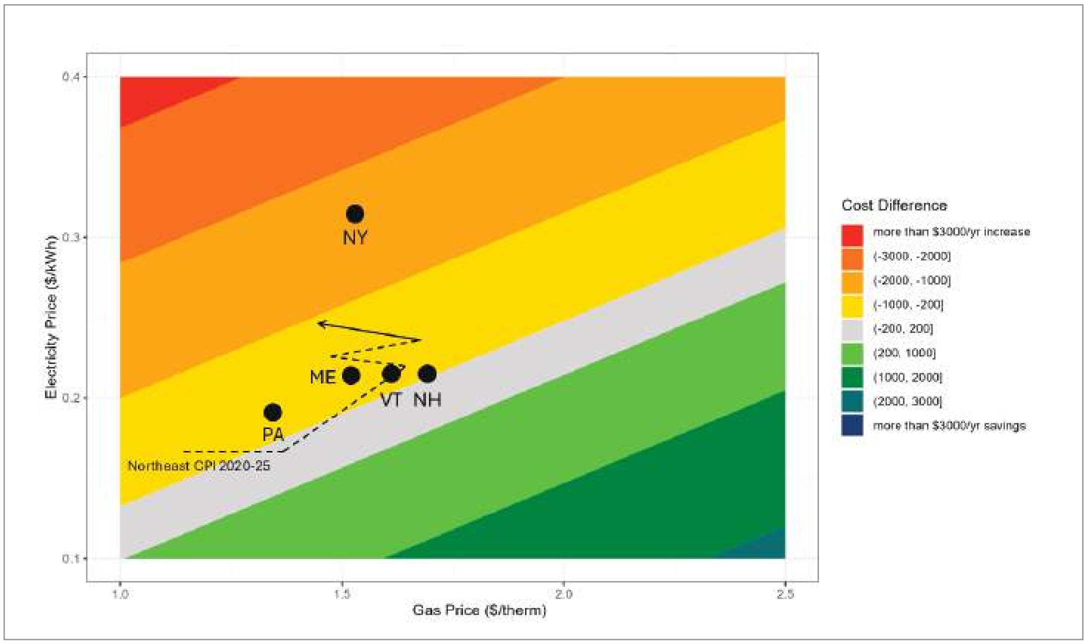


Figure AB-18: *Climate zone 6 contour plot and average rates, cold climate heat pump sized to heating, full heating electrification, 80 AFUE gas furnace*



Appendix C: Modeled Load Coverage

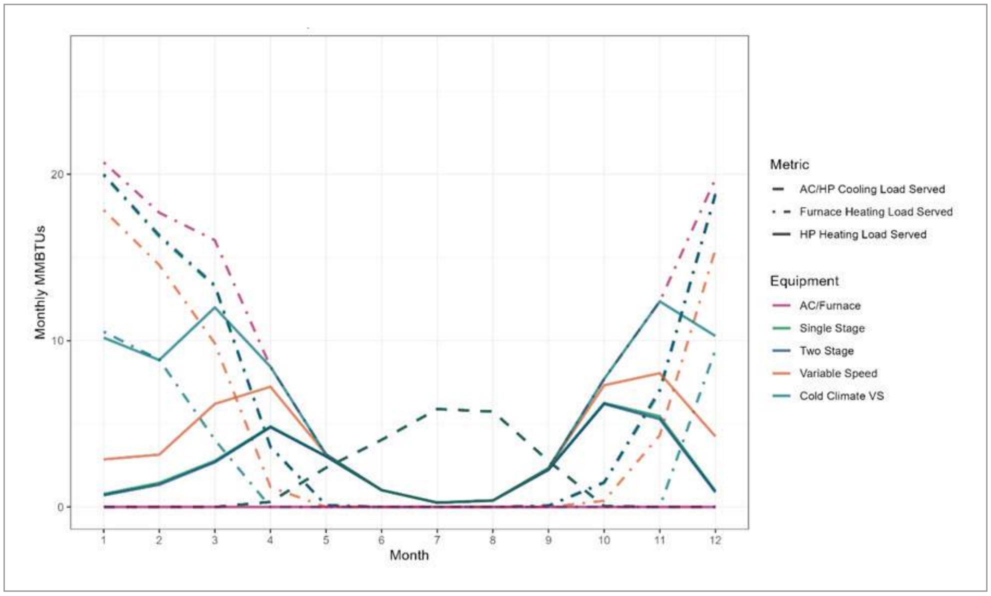
Figure AC-1, Figure AC-2, and Figure AC-3 below show heat pump load coverage as solid lines, furnace load coverage as dash-dot lines, and cooling load (met 100 percent by the cooling equipment in all scenarios) as the dashed lines in the summer months.

The ccVS heat pump (shown in teal) covers around 70 percent of baseline heating load (shown in pink) throughout the year in Vermont, with that percentage increasing to more than 90 percent in Massachusetts, New York, and D.C. In D.C., this load coverage is close enough to 100 percent that in the case that the heat pump were operating without any furnace backup, it could maintain the home's load down to design temperature.

For Vermont, covering the final 30 percent of low-temperature load requires upsizing the heat pump by two and a half tons, highlighting the potential benefits of a dual-fuel system.

Variable-speed, single-stage, and two-stage heat pumps require increasingly more furnace backup due to their lower capacities and COPs in colder temperatures.[94] Depending on the installation costs of these systems as opposed to the ccVS heat pump, the ccVS model could pay back its increased installation cost through cost savings in locations with lower relative electric rates.

Figure AC-1: ***Load served in VT, 80 AFUE furnace, HPs sized to cooling load, with capacity switchover temperature***



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[94] The two-stage heat pump archetype reported on here actually performs slightly worse than the single-stage heat pump at the coldest temperatures, though the two-stage benefits at milder temperatures result in a better yearly performance.

Figure AC-2: ***Load served in MA, 80 AFUE furnace, HPs sized to cooling load, with capacity switchover temperature***

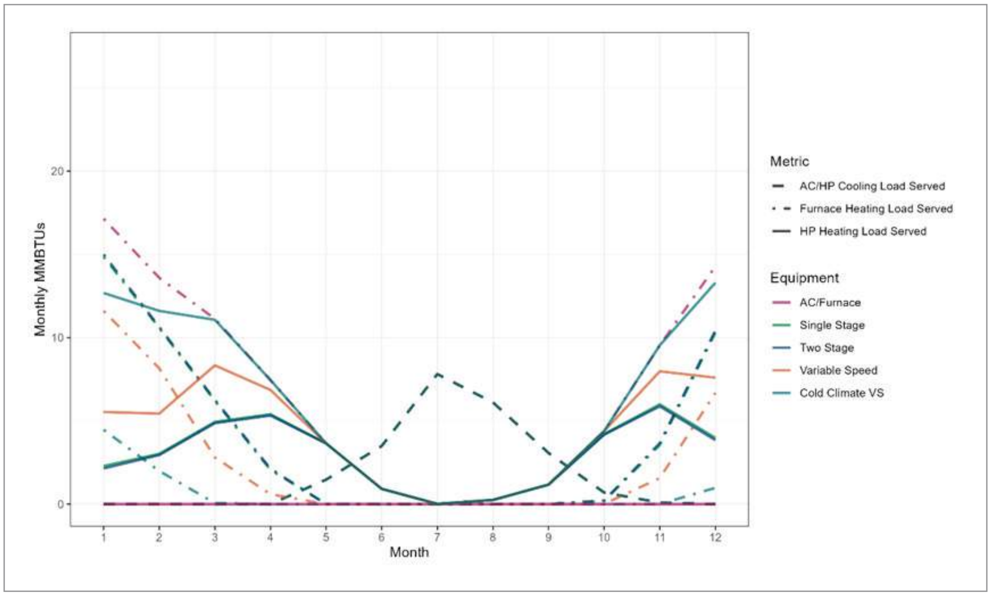
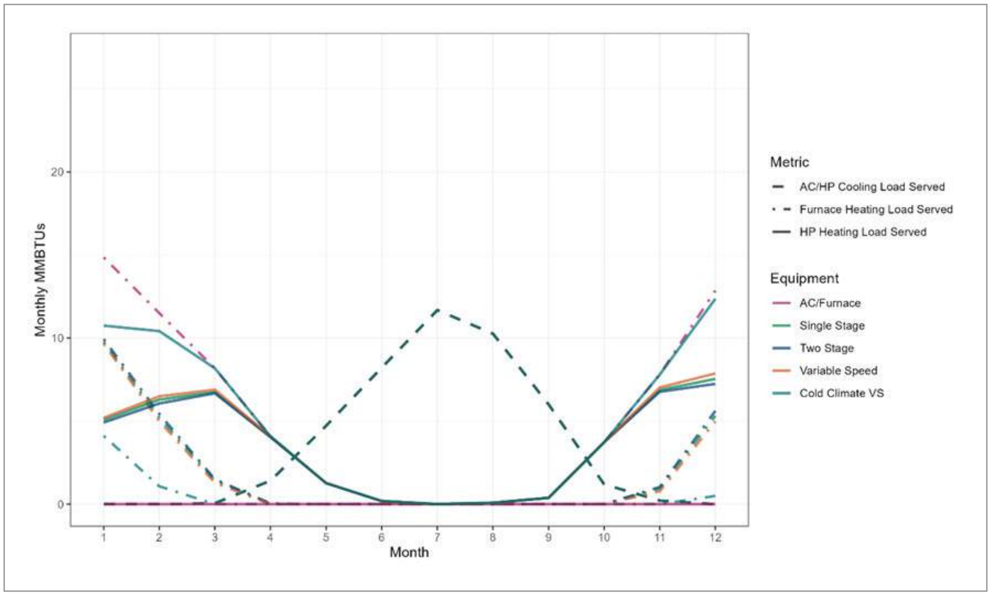


Figure AC-3: ***Load served in DC, 80 AFUE furnace, HPs sized to cooling load, with capacity switchover temperature (NY results similar)***



Modeled load coverage in all scenarios would be considerably higher (likely up to 90 percent in VT annually for ccVS systems) were the heat pumps configured with an indoor droop temperature setting, allowing the heat pump to run lower than the capacity switchover temperature until indoor comfort is affected.