Heat Pumps in the Northeast and Mid-Atlantic: Costs and Market Trends

Prepared for

Northeast States for Coordinated Air Use Management (NESCAUM) and the Ozone Transport Commission (OTC)

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Table of Contents

List of Tables

List of Figures

Report Definitions and Glossary

ASHP: Air-Source Heat Pump. In general, this report uses ASHP to refer to air-to-air heat pumps, to distinguish from air-to-water heat pumps, which are often referred to specifically

AWHP: Air-to-Water Heat Pump

DOE: US DOE

EIA: Energy Information Administration

EESC: Equipment Emissions Standards Cohort

Equipment Cost: Cost of the water heating equipment, excluding electrical upgrades

eTRM: Electronic Technical Reference Manual

HVAC: Heating, Ventilation, and Air Conditioning

Installation Cost: Combined cost of labor and equipment costs

Labor Cost: Cost of labor and materials needed to install the equipment

Methane Gas: A fuel commonly combusted for gas furnaces, boilers, and water heaters; in this report, the term methane gas is used in place of natural gas

NESCAUM: Northeast States for Coordinated Air Use Management

NOx: Oxides of Nitrogen

OTC: Ozone Transport Commission

RECS: Residential Energy Consumption Survey

TSD: Technical Support Document

TRM: Technical Reference Manual

WH: Water Heating

About Energy Solutions

Energy Solutions is a mission-driven clean energy implementation firm that specializes in programs that align with the market to deliver significant resource impacts. For over 25 years we've been pioneering end-to-end, market-driven solutions that deliver reliable, large-scale, and cost-effective savings to our utility, government, and private sector clients across North America. Our passionate, smart employee-owners are committed to excellence and to building long-lasting, trusted relationships with our clients.

Executive Summary

Project Overview

Northeast States for Coordinated Air Use Management (NESCAUM) and the Ozone Transport Commission (OTC) commissioned this study in partnership with the Massachusetts Clean Energy Center (MassCEC) to analyze the installation and operating costs and trends for whole-home air-source heat pumps (ASHPs) and air-to-water heat pumps (AWHPs), compared with baseline fossil fuel and electric resistance heating, ventilation, and air conditioning (HVAC) equipment.

This study is intended to inform states' decision-making as they consider policies to reduce greenhouse gas (GHG) emissions and air pollution from residential buildings. The report provides cost analyses for Northeast and Mid-Atlantic states in the Ozone Transport Region (OTR): Connecticut (CT), Delaware (DE), the District of Columbia (DC), Maine (ME), Maryland (MD), Massachusetts (MA), New Hampshire (NH), New Jersey (NJ), New York (NY), Pennsylvania (PA), Rhode Island (RI), Vermont (VT), and Virginia (VA), henceforth referred to as "all states." To further inform MassCEC, the study incorporates a more detailed analysis of installation costs and cost drivers for ASHPs in Massachusetts.

Installation Cost Summary

This report assesses the total installation (equipment plus labor) costs for residentially sized, whole-home heating, ventilation, and air conditioning (HVAC) systems based on publicly available sources. "Baseline" equipment types analyzed include methane gas, oil, and propane furnaces and boilers, zonal electric resistance heaters, and split unitary air conditioners (AC). "Measure" equipment types analyzed include several types of ASHPs — split and packaged unitary ducted heat pumps, ductless mini- and multi-splits, and ducted mini-splits — as well as AWHPs.[1] These systems were selected based on their ability to provide whole-home heating, and are assumed to meet current or proposed federal efficiency standards.[2] Home heating loads vary based on size, vintage, and climate zone, so real-world installations of heat pumps may use a variety of system configurations and combinations to meet heating loads. All equipment costs were normalized to an energy output of 65,000 Btu/h to facilitate fair comparisons among whole-home heating systems.

The installation cost analysis resulted in the following key observations:

Increased Installation Cost for Heat Pumps: Across all OTR states and most HVAC equipment configurations, heat pump systems have a higher installation cost than fossil fuel heating systems. Average fossil fuel system plus AC total installation cost ranged from $10,000-$13,000, whereas ASHP total installation cost ranged from $12,000-$23,000. These results highlight the importance of supplemental incentive programs to offset heat pumps' higher installation costs, as well as the potential to promote heat pumps to

[1] In this report, ASHP is generally used to refer to air-to-air heat pumps, to distinguish from air-to-water heat pumps, which are often called out separately.

[2] This study does not assume that ASHPs meet cold-climate specifications.

households installing central ACs – particularly as cooling needs increase with warming temperatures.

Impact of Ductwork Costs: Ductwork adds significant cost to central heat pump system installations. On average, adding new or replacing insufficient ductwork added about $4,500 in material cost to heat pump installations. Where existing ductwork is already in place, typically in homes with forced air furnaces and/or central ACs, installing ducted heat pumps that use existing ductwork can significantly reduce retrofit costs, getting heat pump installation cost closer to parity with replacing an existing furnace and AC. In cases where there is no existing ductwork, ductless mini- and multi-splits may be a more economical choice, and AWHPs are an emerging technology that will provide another option for homes with hydronic heating systems in the coming years.

Impacts of Electrical Infrastructure Upgrades: When necessary, electrical infrastructure upgrades such as replacing panels and running new circuits increase heat pump installation costs by an average of $2,400. This points to the importance of using load management strategies to support electrification within existing electric panel capacity, as well as incorporating electrical upgrade costs into incentive programs.

High Labor Cost Variance: Labor cost indices vary widely across OTR states, from 72.2 percent (VA) to 161.4 percent (NY) of the United States (US) average labor rate. This can cause significant differences in overall installation cost by state. Labor costs are also highly variable due to other factors, such as installation complexity and varying levels of contractor training on and comfort with heat pumps.

Low Equipment Cost Variance: Material cost indices, measuring the cost of the HVAC equipment itself, are relatively consistent from state to state, from 97.7 percent (VT) to 101.5 percent (DE) of the US average material cost index.

High AWHP Installation Cost: An emerging technology that is widely adopted in Europe but currently uncommon in the US, AWHPs cost significantly more than any other type of heat pump, with total installation cost in the range of $50,000. This price is expected to come down as the industry matures and more products are manufactured in the US.

Operating Cost Summary

The report analyzes the annual operating costs associated with using a heat pump system to fully heat and cool a residential building. Operating cost results are reported by state, equipment type, fuel type, and state-specific utility rates. This report’s analysis represents a snapshot-in-time of 2024 energy costs; future energy costs are uncertain, and changing prices for electricity and methane gas would impact the calculus.

The operating cost analysis resulted in the following key observations:

Operating Cost Savings for Electric Resistance Heating System Replacement: In all states, we found significant operating cost savings when converting from electric resistance baseboard to heat pump space heating systems. Annual cost savings for electric resistance baseboard heating replacement are $1,200 to $7,000 per year depending on utility rates, climate, and building vintage. This represents an opportunity for states to help residents who still rely on electric resistance baseboard heating significantly reduce their heating costs.

Operating Cost Savings for Delivered Fuel Heating System Replacement: Switching from fuel oil or propane heating systems to heat pumps results in operating cost savings that average about $1,100 per year, and these fuels are also subject to price volatility. Residents using these expensive delivered fuels should also be targeted for heat pump replacements.

Increased Operating Costs for Methane Gas Heating System Replacement in CT, DE, ME, MA, NH, NJ, NY, RI, and VT: With current gas and electric rates, heating loads, and building envelope characteristics, converting from methane gas to heat pump space heating systems would increase operating costs in New England states, as well as NY, NJ, and DE, even with the increased efficiency of heat pump systems and accounting for AC use. The increases in annual operating costs range from around $90 (DE) to $1,200 (NH). As noted, these results are subject to change with rising methane gas prices and evolving electricity rate design, such as Massachusetts' upcoming heat pump electricity rate.[3] The risk of higher operating costs for customers who switch from methane gas equipment to heat pumps points to the importance of rate reform as a long-term policy solution. In the near-term, states should implement strategies to ensure that low- and moderate-income (LMI) households that electrify do not experience increased energy burden, such as promoting comprehensive retrofits that bundle heat pumps with weatherization and solar (including community solar), caps on customer bills or enrollment in other low-income rates, and continued access to fuel assistance for households that electrify.

Operating Cost Savings for Methane Gas Heating System Replacement in DC, MD, PA, and VA: Converting from methane gas to heat pump space heating systems would save approximately $50 to $400 per year in operating costs in southern Mid-Atlantic states. The savings in these states are due to a combination of higher methane gas rates and lower electric rates.

High Energy Cost Variance: Utility rates and delivered fuel costs vary significantly from state to state and across utilities within a state. The "NESCAUM HVAC Operating Cost Calculator" is available to states upon request as a supplemental tool to determine operating costs for specific utility territories or rate structures within their state.[4]

Market Trends Summary

The research team conducted interviews with equipment manufacturers, wholesale distributors, and installation contractors to understand current and future installation costs and market trends for residentially sized heat pumps. We spoke with five manufacturers, three manufacturer's representatives, three distributors, and three contractors during the study. Manufacturers interviewed operate across the entire OTR, and the distributors and contractors interviewed mainly operate in Massachusetts and throughout New England, as

[3] https://energynews.us/2024/10/01/more-good-news-for-heat-pumps-in-massachusetts-as-regulators-order-national-grid-to-develop-special-rate/

[4] Email elevin@nescaum.org to request access to the calculator.

well as New York. These market actors cited commodity costs, regulatory requirements, and labor costs as the primary drivers for equipment and installation costs. Specifically, global markets and shipping dictate costs of equipment; new regulations supporting lower global warming potential (GWP) refrigerants increase business costs and risks; and having a qualified workforce to ensure properly sized and installed heat pumps systems affects labor costs. Several market actors interviewed were optimistic about the future of heat pump technology, though cited the need for increased consumer awareness and education to support successful adoption.

The cost trend market interviews resulted in the following key observations:

Commodity Cost Impacts: Primary commodities needed for heat pump manufacturing — such as steel, copper, and microprocessors — are also needed in other markets such as heat pump water heaters, electric vehicles, and batteries. This direct competition for high-demand materials and components may increase heat pump equipment costs. Some components are also needed for conventional HVAC equipment, potentially causing an increase in furnace, boiler, and air conditioner equipment costs as well.

Economies of Scale: Manufacturers stated that equipment costs for air-to-air heat pump systems such as mini-splits, multi-splits, and unitary heat pumps, that are produced on a global scale, are unlikely to benefit from economies of scale associated with increased demand because their manufacturing facilities are already mature. On the other hand, labor costs may decrease if workforce development programs expand contractor networks to meet demand, and as contractors grow more comfortable with and skilled at heat pump installations. Equipment costs for newer technologies such as AWHPs will benefit from economies of scale.

Refrigerant Impacts on Cost: Requirements to transition to refrigerants with low flammability and global warming potential may increase heat pump and AC costs in the near-term due to expenses related to regulatory compliance, developing new product lines and technologies that accommodate acceptable refrigerants, and risk mitigation associated with new refrigerant technologies.

Workforce Shortage: Workforce shortages are impacting the timelines and prices of heat pump installations. Without targeted workforce development efforts, this trend is expected to worsen as heat pump adoption accelerates. Leveraging existing supply chain relationships to deliver workforce training was identified as a proven path to success in scaling contractor capabilities. Specific to AWHPs, contractor knowledge is extremely limited.

Incentive Impacts on Pricing: Market actor interviews revealed that incentive programs could lead to increased installation costs if not carefully designed to prevent gaming of incentive programs by the industry. For example, incentives provided per ton of capacity can lead to oversizing due to the increased incentive for higher capacity systems. More detailed program design recommendations are listed in the Heat Pump Incentive Design Considerations section of the report. States with robust incentive programs for heat pumps may also be reaching parts of the market that are more complex or harder to electrify, leading to increased installation costs. While equipment costs are more consistent across states, as would be expected due to the international nature of those supply chains, larger differences occur in labor costs. Energy Solutions infers that these costs likely reflect real-world differences in installation considerations and cost-of-living variations, but they could also contain mark-ups that offset some of the incentive amounts provided.

Risk Drives Costs: A leading mini-split manufacturer stated that risk premiums are included in heat pump installation costs to mitigate the risk associated with newer technology installations and complex retrofit scenarios. Risk premiums may decrease over time as heat pumps become a more conventional heating technology and contractors become more familiar with installation best practices.

Financing Helps Support Heat Pump Installations: Market actors interviewed noted the presence of attractive financing — such as zero-percent loans and other financing options — can reduce upfront price pressure, allowing people to afford technologies they otherwise could not afford.

Importance of System Sizing in Retrofits: Retrofits, especially those combined with building envelope upgrades, require use of Manual J or another appropriate method to properly size equipment to the heating and cooling loads of the building. Neglecting to use proper sizing practices can lead to oversized heat pump systems, which both cost more to install and increase utility bills if they operate less efficiently.

Introduction

Objectives of Study

Northeast States for Coordinated Air Use Management (NESCAUM) and the Ozone Transport Commission (OTC) commissioned this study in partnership with the Massachusetts Clean Energy Center (MassCEC) to analyze the installation and operating costs and trends for whole-home air-source heat pumps (ASHPs) and air-to-water heat pumps (AWHPs),[5] compared with baseline fossil fuel and electric resistance heating, ventilation, and air conditioning (HVAC) equipment.

This study is intended to inform states' decision-making as they consider policies to reduce greenhouse gas (GHG) emissions and air pollution from residential buildings. It provides cost analyses for Northeast and Mid-Atlantic states in the Ozone Transport Region (OTR): Connecticut (CT), Delaware (DE), the District of Columbia (DC), Maine (ME), Maryland (MD), Massachusetts (MA), New Hampshire (NH), New Jersey (NJ), New York (NY), Pennsylvania (PA), Rhode Island (RI), Vermont (VT), and Virginia (VA).

To further inform MassCEC, the study incorporates a more detailed analysis of installation costs and cost drivers for ASHPs in Massachusetts.

Project Scope

The following tasks were included in the study scope:

1. <u>Installation cost research and analysis:</u> Conduct a literature review of heat pump studies to understand existing resources available to support cost analysis. Analyze full and incremental equipment and labor costs, including labor and associated necessary upgrades (e.g., panels, wiring) to enable installation of ASHPs.
   - <u>Massachusetts-specific installation cost analysis</u>: Perform more detailed analysis of installation cost drivers and opportunities for cost compression for MassCEC.
2. <u>Operating cost analysis:</u> Analyze state-by-state operating costs for each type of HVAC equipment.
3. <u>Cost trend analysis and market interviews:</u> Research and summarize technology trends and innovations over the next five to ten years by conducting both literature research and primary research through manufacturer interviews.
4. <u>Massachusetts-specific cost trend analysis and market interviews:</u> Interview Massachusetts-specific market actors for additional insights in the Massachusetts region.

[5] In this report, ASHP is generally used to refer to air-to-air heat pumps, to distinguish from air-to-water heat pumps, which are often called out separately.

Background and Key Assumptions

Equipment Types Assessed

This report estimates the installation and operating costs associated with a selection of residential HVAC equipment replacement scenarios. The different types of heating and cooling systems assessed are shown below in Table 1.

TABLE 1. EQUIPMENT TYPES ASSESSED IN THIS REPORT

Equipment Type	Image
Furnace: Methane gas, propane gas, or fuel oil-fired heating system that heats air and distributes heated air through ductwork.	
Boiler: Methane gas, propane gas, or fuel oil-fired heating system that heats water and distributes it through a hydronic distribution system.	
Electric Resistance Heater: Unit heat that utilizes electric resistance elements in an integrated baseboard distribution system.	
Central Air Conditioner: Central ACs have an outdoor condensing unit attached to an indoor air handler by refrigerant lines; however, the refrigerant only flows in one direction, limiting capabilities to cooling only, unlike heat pumps.	

Equipment Type	Image
Split Unitary Heat Pump: Heat pump with an outdoor condensing unit attached to an indoor air handler by refrigerant lines. The air handler distributes warm and cool air through ductwork.	
Packaged Unitary Heat Pump: Heat pump with an outdoor condensing unit and integrated air handler. The air handler distributes conditioned air through ductwork.	
Ducted Mini-Split Heat Pump: Heat pump with a slim-profile condensing unit attached to ductwork to distribute conditioned air.	
Ductless Multi-Split Heat Pump: Heat pump with a slim-profile condensing unit attached to multiple indoor evaporators (referred to as "heads" by the industry) through refrigerant lines.	
Air-to-Water Heat Pump: Heat pump that utilizes a low-temperature hydronic system to distribute heat through hot water.	

Existing Housing Stock in the Northeast and Mid-Atlantic

For any given home, a range of heat pump replacements could be installed. Variables such as home vintage, heating system configuration, distribution system, presence or absence of central air conditioning, and panel capacity mean there is not always a simple solution to match a heat pump configuration to a home. To better contextualize the installation and operating cost information in this report, Table 2 compiles information from the US Energy Information Administration (EIA) RECS 2020[6] to show how common certain scenarios are across the residential sector in different parts of the country, noting that the South Atlantic region includes southernmost OTR states but also extends down the Atlantic Coast. There is no single "residential" prototype building or HVAC configuration, but some scenarios are more or less common in various regions.

TABLE 2. SYSTEM TYPE PREVALENCE BASED ON RECS 2020 DATA

	New England (defined by EIA as ME, NH, VT, MA, RI, CT)	Mid-Atlantic (defined by EIA as NY, PA, NJ)	South Atlantic (defined by EIA as DE, MD, DC, VA, WV, NC, SC, GA, FL)[7]
Percent of homes primarily heating with electricity: non-heat pump	12%	14%	26%
Percent of homes primarily heating with electricity: heat pump systems	3%	5%	32%
Percent of homes primarily heating with methane gas	42%	61%	28%
Percent of homes primarily heating with fuel oil or kerosene	33%	13%	2%
Percent of homes primarily heating with propane	6%	4%	3%
Percent of homes with central AC	28%	43%	85%
Percent of homes heating with fossil fuels (methane gas/oil/propane) that have a central furnace and ductwork	52%	48%	30%
Percent of homes heating with fossil fuels that have hydronic systems	23%	27%	2%

[6] US Energy Information Administration Residential Energy Consumption Survey (EIA RECS) 2020, Tables HC6.7, HC6.8, HC7.7, and HC7.8. https://www.eia.gov/consumption/residential/data/2020/

[7] Note that the RECs data for South Atlantic includes several states outside of the OTC. The OTC states (MD, DC, DE, VA) represent ~24 percent of the population of the South Atlantic RECS district per US Census.

Key Assumptions

This section summarizes key assumptions used in the installation and operating cost analysis.

Target Market

The study focuses on residential-scale equipment suitable for installation in single-family homes. Multifamily homes were not included in the analysis due to the added complexity in modeling the various multifamily building and HVAC system configurations.

Equipment Efficiency and Capacity Assumptions

"Baseline" equipment types analyzed include methane gas, oil, and propane furnaces and boilers, zonal electric resistance heaters, and split unitary ACs. "Measure" equipment types analyzed include several types of ASHPs — split and packaged unitary ducted heat pumps, ductless mini- and multi-splits, and ducted mini-splits — as well as AWHPs.

For both the baseline and measure cases, our analysis considered anticipated federal efficiency standards that are either completed or in progress, and assumed in the case of furnaces and boilers that baseline equipment meets proposed or recently finalized federal efficiency standards. Market insights support this assumption, as about two-thirds of furnaces and boilers currently installed will meet this future compliance efficiency. Table 3 provides a summary of efficiency assumptions for baseline and measure equipment.

Cold-climate heat pumps were not included in the equipment cost or operating cost analysis, although the report does offer some general considerations for cold-climate heat pumps and their potential impacts on cost. The definition of "cold-climate" heat pumps varies,[8] and while heat pumps that perform well at low temperatures are an optimal choice in New England states and northern New York, we decided not to formally include "cold-climate" heat pumps for several reasons. First, we wanted to use consistent assumptions for equipment efficiencies across the OTR, which also includes Mid-Atlantic states with milder climates. Second, heat pump performance has improved significantly such that ASHPs meeting federal efficiency standards perform reasonably well in cold climates. Third, we determined that the cost impacts of cold-climate equipment were relatively minor, with lower operating costs roughly balancing out higher equipment costs. For equipment cost, a three-ton cold-climate heat pump is approximately $270 more than a minimum federally compliant heat pump.[9] For operating cost, a cold-climate heat pump that meets the

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[8] For example, DOE's Cold Climate Heat Pump challenge requires 100% capacity at 5°F or -15°F, whereas NEEP and EPA rely on coefficient of performance thresholds at 5°F. The recently updated industry test procedure, AHRI 1600, defines cold climate heat pumps as those that maintain at least 70% of their capacity at 5°F. See: https://www.energy.gov/eere/buildings/residential-cold-climate-heat-pump-challenge, https://neep.org/heating-electrification/ccashp-specification-product-list, https://www.energystar.gov/products/spec/central_air_conditioner_and_air_source_heat_pump_specification_version_6_0_pd, per https://www.federalregister.gov/documents/2024/04/05/2024-04784/energy-conservation-program-test-procedure-for-central-air-conditioners-and-heat-pumps, https://neea.org/img/documents/NEEA-Cold-Climate-DHP-Spec-and-Recommendations.pdf

[9] https://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/full.pdf

ENERGY STAR Cold Climate Criteria[10] has a SEER2 rating six percent higher and an HSPF2 rating eight percent higher than minimum federally compliant equipment, which could decrease operating cost approximately eight percent.

This analysis sought to compare whole-home space heating systems for both fossil-fuel space heating (baseline) and ASHP and AWHP technologies. Auxiliary heat use varies by location, sizing methods, and heat loss/gain balance, and was not considered for the report. Hybrid or dual-fuel heat pump systems were likewise not included in our analysis. Fossil fuel heating equipment normally averages around 100,000 input Btu/hr (~85,000 output Btu/hr) while residentially sized heat pumps can range from 24,000-65,000 output Btu/hr per unit. To facilitate consistent comparison between fossil fuel and ASHP heating systems, equipment capacity for both baseline and measure heating equipment is based on an assumed output heating load of 65,000 Btu/hr for single-family homes. For the fossil fuel heating equipment, efficiency was multiplied by the input Btu/hr to convert to output Btu/hr. Then $/output kBtu/hr was calculated for the equipment cost portions of installation cost for each equipment type. Then these costs were multiplied by 65, to arrive at the heating equivalent size of 65,000 Btu/hr. This heating size represents the upper size limit for residentially sized heat pumps. Equipment capacity for cooling equipment is assumed to be 36,000 Btu/hr. This assumption is supported by EIA.[11]

Table 3 summarizes the assumptions related to equipment efficiency and installation type used in this study.

TABLE 3. EFFICIENCY ASSUMPTIONS FOR BASELINE AND MEASURE EQUIPMENT

Equipment Type	Installation Configuration to Provide Whole-Home Heating	Equipment Efficiency Assumption
Furnace	One unit per home	95% AFUE
Boiler	One unit per home	95% AFUE
Zonal Electric Resistance	Three zones per home	~100%
Split Unitary AC	One unit per home	13.7 SEER2
Ducted Mini-Split Heat Pump	One outdoor unit connected to one indoor unit in series with ducting.	15.2 SEER2, 7.6 HSPF2
Ductless Multi-Split Heat Pump	One outdoor unit connected to three indoor units	15.2 SEER2, 7.6 HSPF2
Packaged Unitary Heat Pump	One outdoor unit connected to one indoor unit, attached to ducting.	14.3 SEER2, 7.5 HSPF2

[10] https://www.energystar.gov/products/heat_pump_water_heaters/key-product-criteria#:~:text=Cold%20Climate%20Heat%20Pumps%20Low,with%20Appendix%20M15%20H42%20test.

[11] https://www.eia.gov/analysis/studies/buildings/equipcosts/f

Equipment Type	Installation Configuration to Provide Whole-Home Heating	Equipment Efficiency Assumption
Split Unitary Heat Pump	One outdoor unit connected to one indoor unit, attached to ducting.	14.3 SEER2, 7.5 HSPF2
Air to Water Heat Pump	One unit attached to one or more distribution systems, including radiant floor heating, low-temperature radiators, etc.	2.83 COP @5°F, 9.4 EER

Utility Infrastructure Costs

Utility Infrastructure costs are not included in this cost analysis for methane gas or electricity. This cost analysis does not incorporate any costs to avoided infrastructure, stranded assets, or other utility infrastructure costs that may be impacted by converting customers from one fuel type to another. It does include estimates for electrical upgrades, such as panels and wiring, that are needed in some homes to enable heat pump installation.

Rounding and Number Accuracy

Values calculated from report methodologies are rounded to the nearest integer and represent an estimated value. Results of the analysis are presented in current (2024) dollars.

Methods and Approaches

Literature Review

Energy Solutions conducted a thorough review of literature and content relating to the costs and impacts of residential electrification ranging from academic economic papers to utility program evaluations. Information on specific costs, regional variations, installation, and operational details were used as a source for study costs and to inform major assumptions on installation costs. We also compared cost data from the literature review to the costs developed through this analysis, to “ground truth” the results against state-specific data sources. More detail on the literature review can be found in the installation cost sources section and the annotated bibliography, in Appendix A.

Installation Cost Analysis

Methodology

We calculated installation costs for both baseline equipment (propane, oil, methane gas, and electric resistance space heaters) and measure equipment (ASHPs and AWHPs). Assumptions and methods are defined in detail in the section below. As noted above, all heating equipment was sized to an equivalent heating load of 65,000 Btu/hr and assumed to provide whole-home heating. Installation cost depends on the existing heat distribution system in the home,[12] the state the equipment is installed in, the age of the building,[13] and the type of distribution system is being installed. This methodology will be referred to as the "Ozone Transport Region (OTR) Cost Methodology" throughout the report.

Installation Cost Sources

This report uses publicly available data sources for equipment and labor costs, aside from a few outliers where costs are derived from RS Means construction cost estimates[14] due to public data limitations. For each equipment category, we consulted multiple data sources for installation cost, evaluating each source based on equipment type efficiency assumptions, how recently it was published, and how conservative the cost estimates were compared to other sources. Table 4 outlines the primary installation cost data sources for each equipment type.

Across all sources, we used the US EIA Updated Building Sector Appliance and Equipment Costs and Efficiencies Report[15] most frequently due to its wide span of equipment types included, availability of efficiencies and costs for multiple years, and relatively recent publication date of March 2023. This source was used for nine of the equipment cost inputs and six of the labor cost inputs shown in Table 4, including split and unitary heat pumps. We then compared EIA values to real-world data from the MassCEC Whole Home Pilot and Mass Save Program datasets and found that equipment costs were generally similar to the EIA values (see "Massachusetts Installation Cost Results" for more discussion).

We also utilized the US Department of Energy's (DOE) Technical Support Documents (TSDs) for boilers[16] and furnaces.[17] These documents, published in 2023, provided detailed cost-efficiency[18] data and technical context for boilers and furnaces. We used DOE TSD figures for two equipment cost inputs and five labor cost inputs. Comparison to MassCEC Whole Home Pilot and Mass Save data showed some differences in labor costs, which we discuss further in the "Massachusetts Installation Cost Results" section.

The DOE TSD for central air conditioners and heat pumps[19] was considered for the source of split and unitary heat pump costs. However, the document was published in 2016, which

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[12] For new construction projects, assume no panel upgrade and no compatible existing distribution system.

[13] Building age only applies to retrofit scenarios. This variable affects cost through the likelihood of a panel upgrade being necessary. Studies have found that panel upgrades are more likely to be necessary for older homes.

[14] RS Means is a database of construction equipment, material, and labor costs offered by private company Gordian. https://www.rsmeans.com/info/contact/about-us.

[15] https://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/full.pdf

[16] https://www.regulations.gov/document/EERE-2019-BT-STD-0036-0021

[17] https://www.regulations.gov/document/EERE-2021-BT-STD-0031-0011

[18] Cost-efficiency refers to the relationship between the manufacturing production cost (MPC) of an appliance and the energy efficiency of an appliance. As efficiency levels increase, so too may the MPC, as a whole, or for subcomponents of an appliance.

[19] https://www.regulations.gov/document/EERE-2014-BT-STD-0048-0098

was too out-of-date for assessing equipment manufactured under current and future efficiency standards. Additionally, the DOE TSD for central air conditioners and heat pumps used outdated test procedure efficiency ratings[20] and the cost-efficiency tables included in the document were based on cooling efficiency. Although we did not use the DOE TSD for heat pumps as an input cost metric, we did use the ratio of installation costs for packaged unitary heat pumps to split unitary heat pumps to scale down EIA installation costs for packaged unitary heat pumps.

Mini/multi-split cost data was more complicated to locate since these units are regulated as ASHPs but do not align exactly with traditional split or packaged unitary heat pump costs. The systems also vary in number of zones and ducting configurations, which significantly impacts cost. To provide a more comprehensive source for costs for these units, we used Navigant's Massachusetts Ductless Mini-Split Heat Pump Cost Study[21] for both equipment and labor cost inputs. Navigant's report provided various tables presenting total installed cost for mini/multi-splits at different capacities, cooling and heating efficiencies, number of zones, and cold climate designations, aiding in the customization of the two mini/multi-split measure equipment cases.

AWHPs are an emerging technology to retrofit boiler hydronics in existing homes. However, while intended to be a turnkey solution for homes with hydronic heating, this equipment type is still gaining traction and is currently less affordable than other measure equipment considered. While AWHP nascency means there is little publicly available cost data, a detailed retrofit case study published by Efficiency Vermont[22] enabled our analysis. The case study presents a real-world application of the AWHP installation in an existing hydronic-heated home. The study provides an itemized list of parts, equipment, and labor costs associated with the installation example. These costs were aggregated based on whether the cost was associated with the unit itself (e.g., equipment cost) or the process of installing the AWHP (e.g., labor cost). We referenced the Vermont TRM[23] and Efficiency Vermont qualifying product list (QPL)[24] to determine an average heating and cooling efficiency for this equipment type. More research is required to determine the cost-to-efficiency relationship for the AWHP equipment category.

Electric zonal resistance baseline costs were derived from RS Means database values based on the heating load assumption of 65,000 Btu/hr. Costs labeled "Extended Labor O&P" from RS Means were used for the labor costs. "Extended Material O&P" costs were used as

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[20] 10 CFR Part 430, Subpart B, Appendix M

[21] https://ma-eeac.org/wp-content/uploads/RES28_Assembled_Report_2018-10-05.pdf

[22] https://www.efficiencyvermont.com/Media/Default/bbd/2020/docs/presentations/fossil-fuel-free-at-last-bbd-2020.pdf

[23] https://puc.vermont.gov/document/ev-technical-reference-manual

[24]https://qualifiedproducts.efficiencyvermont.com/evt/products/browse?search.searchGroup=Heat%20Pumps%20-%20Air%20to%20Water&search.IncomeQualified=False

the input for the equipment cost portion of install cost. Efficiency was assumed to be 100 percent since electricity is directly converted to heat.

Where cost, efficiency, and size data were available at the desired level of granularity for multiple data sources, we selected the highest cost for each cost category (e.g., labor cost, equipment cost) to derive the uppermost installation cost estimate for each equipment type analyzed in this report. This results in conservative estimates of installation costs.

Due to the variety of data sources used for equipment and labor costs, all prices were adjusted to the current year, 2024, using the US Sticky Price Consumer Price Index (CPI).[25] The Sticky Price CPI is more accurate for inflating costs of space heating equipment, as the typical frequency of price adjustment in this category of goods is 5.3 months.[26] This adjustment accounts for the expected effects of inflation on both equipment and labor costs. For equipment costs, we also applied equipment-specific learning rates, due to downward cost trends associated with "learning" or gaining experience in producing a technology over time.[27] The learning rate is the reduction in price that results from a doubling in cumulative production (or increasing economies of scale). To capture this effect, we adjusted all equipment costs in this analysis using equipment-specific learning rates derived from DOE analyses of historical cost trends. Notably, due to lack of heat-pump-specific pricing history, we used the learning rate for unitary air conditioning equipment as a proxy for the learning rate for heat pump equipment. This approach is similar to that used in the National Renewable Energy Laboratory (NREL) Electrification Futures Study: End-Use Electric Technology Cost and Performance Projections through 2050.[28]

The following formulas describe the adjustments applied to bring all externally sourced cost data into 2024 dollars.

$$Equipment\ Cost_{2024} = Equipment\ Cost_{Source} \times i \times LR$$

$$Labor\ Cost_{2024} = Labor\ Cost_{Source} \times i$$

Where:

i is the cumulative factor of inflation between the source year and 2024

LR is the learning rate between the source year and 2024

[25] https://fred.stlouisfed.org/series/CORESTICKM159SFRBATL

[26] https://www.clevelandfed.org/publications/economic-commentary/2010/ec-201002-are-some-prices-in-the-cpi-more-forward-looking-than-others-we-think-so

[27] https://www.federalregister.gov/documents/2011/02/22/2011-3873/equipment-price-forecasting-in-energy-conservation-standards-analysis

[28] https://www.nrel.gov/docs/fy18osti/70485.pdf

TABLE 4. PRIMARY COST DATA SOURCES BY EQUIPMENT TYPE

Base/ Measure Case	Fuel Type	HVAC Unit Type	Distribution System	Equipment Cost Source[29]	Labor Cost Source
Base	Methane Gas	Boiler	Hydronic Low T Radiant	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiencies – March 2023	DOE TSD - Consumer Boilers – April 2022
Base	Propane	Boiler	Hydronic Low T Radiant	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiencies – March 2023	DOE TSD - Consumer Boilers – April 2022
Base	Fuel Oil	Boiler	Hydronic High T	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiencies – March 2023	DOE TSD - Consumer Boilers – April 2022
Base	Methane Gas	Boiler	Hydronic High T	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiencies – March 2023	DOE TSD - Consumer Boilers – April 2022
Base	Propane	Boiler	Hydronic High T	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiencies – March 2023	DOE TSD - Consumer Boilers – April 2022
Base	Fuel Oil	Furnace	Ducted	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiencies – March 2023	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiencies – March 2023
Base	Methane Gas	Furnace	Ducted	DOE TSD - Oil, Electric, and Weatherized Gas Consumer Furnaces – November 2022	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiencies – March 2023
Base	Propane	Furnace	Ducted	DOE TSD - Oil, Electric, and Weatherized Gas Consumer Furnaces – November 2022	EIA Updated Buildings Sector Appliance and Equipment Costs

[29] Efficiency levels for each baseline case product shown in Table 4 are based on recently proposed or finalized federal energy conservation standards.

Base/ Measure Case	Fuel Type	HVAC Unit Type	Distribution System	Equipment Cost Source[29]	Labor Cost Source
					and Efficiencies — March 2023
Base	Electric	Zonal Electric Resistance	Radiant Baseboard	RS Means Database	RS Means Database
Base	Electric	Split Unitary Air Conditioner	Ducted	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiencies — March 2023	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiencies — March 2023
Measure	Electric	AWHP	Hydronic Low T Radiant	Efficiency Vermont - Air-to-Water Heat Pump and Ventilation Retrofit Case Study – 2020	Efficiency Vermont - Air-to-Water Heat Pump and Ventilation Retrofit Case Study
Measure	Electric	Mini-Multi Split (one-zone)	Ducted	Navigant MSHP Study — 2017	Navigant MSHP Study — 2017
Measure	Electric	Mini-Multi Split (three-zones)	Ductless	Navigant MSHP Study — 2017	Navigant MSHP Study — 2017
Measure	Electric	Packaged Unitary Heat Pump	Ducted	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiencies — March 2023	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiencies — March 2023
Measure	Electric	Split Unitary HP	Ducted	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiencies - March 2023	EIA Updated Buildings Sector Appliance and Equipment Costs and Efficiencies – March 2023

Equipment Cost

Equipment efficiency and representative input capacity were extracted from the sources outlined in Table 4. Subsequent Equipment Cost $ per Btu/hr curves were developed from current RS Means data to scale prices for each equipment type based on the equipment size needed to fulfill varying heating demands from different building types, replacement scenarios, or vintages. These representative size-versus-equipment-type costs were then scaled to state-specific costs based on the state-weighted average material cost index.

CALCULATION

Equipment costs account for the retail cost (inclusive of any markup or shipping costs) of the HVAC system being installed. The inflation- and learning-rate-adjusted equipment costs from the literature were national or state averages. The "material" City Cost Indexes provided by RS Means were used to create state-specific equipment costs for the baseline and measure cases. RS Means generates these indexes to compare equipment and labor costs from city to city. Each included city was weighted based on US Census population data to derive the state material cost index. 2024 RS Means material and labor indexes were developed for each state; these can be found in Table 5. 2024 factors were applied to average equipment costs using the equation below:

$$\frac{Material\ Cost\ Index\ A}{100} x\ Equipment\ Cost = Equipment\ Cost\ in\ State\ A$$

For input equipment costs that were state averages rather than national averages, such as the mini/multi-split heat pumps, the 100 in the equation was replaced by the state cost index.

Labor Cost

Labor costs comprise the hourly work performed by HVAC contractors and the installation materials required to install the respective HVAC unit. For the costs developed in this study, the bundled total cost of installation materials and labor was scaled based on the state population-weighted average labor index. The state labor index was developed in the same manner as the state material index and can be found in Table 6.

Labor costs can be distilled down to the cost categories presented in Table 5. Not all bullets apply to all types of HVAC equipment. This list is not comprehensive but serves as a detailed example of cost sources for an HVAC installation project. Some distribution systems are less characterized in publicly available sources than others. Most of the labor cost category descriptions are sourced from the DOE lifecycle analysis workbooks.[30,31]

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[30] DOE HP/CAC Final Rule Analytical Spreadsheets: Life-Cycle Cost (LCC) Analysis: https://www.regulations.gov/document/EERE-2014-BT-STD-0048-0100

[31] DOE Consumer Furnace Life-Cycle Cost (LCC) and Payback Period Analysis (NOPR) Spreadsheet: https://www.regulations.gov/document/EERE-2014-BT-STD-0031-0352

Propane and methane gas units are assumed to have the same labor costs since propane units are often compatible with methane gas.

TABLE 5. LABOR COST CATEGORIES

Labor Cost Category	Description
Basic	• Hours and average contractor rates for wholesale equipment purchases • Commute to the installation site (commonly included in contractor charges) • Removal of the old HVAC system • Installation of the new HVAC system
Distribution System	• Gas/oil/refrigerant/water piping • Ductwork labor and materials • Ventilation for air intake and flue venting • Radiators/floor radiators • Demolition of internal structures to implement floor radiative heat distribution
Other (if applicable)	• Condensate drainage systems (only applicable to condensing units) • Asbestos abatement • Minor electrical costs that are commonly required for HVAC systems (separate from electric panel upgrades) • Electric panel upgrade often needed for homes built before 1970[32] • Permit fees passed on from contractor • Additional labor needed to set up venting or mounting using existing configurations

DISTRIBUTION SYSTEMS

Costs associated with installation and upgrades to distribution systems are accounted for in the labor cost portion of the installed cost. This study uses the term "compatible distribution system" to describe cases in which a home's existing distribution system (e.g., ductwork) that was used for the baseline equipment can also be used for the measure equipment. All heat pump installations include some labor costs associated with the distribution system, even when there is a compatible distribution system. Both baseline and measure equipment types include labor costs for connecting the new HVAC system to the distribution system and minor modifications to the distribution system, such as replacing connecting components, e.g., plenums and manifolds. Cases where the existing distribution system is not compatible with the new heat pump incur additional costs, which are also accounted for under the labor cost category.

For fossil-fuel space heating technologies, furnaces with ductwork and boilers with high-temperature hydronic distribution systems are the most common system types found in the Northeast and Mid-Atlantic. Within hydronic distribution systems, there are high-temperature and low-temperature systems. High-temperature distribution systems are designed for non-

[32] DOE Furnace TSD: https://www.regulations.gov/document/EERE-2021-BT-STD-0031-0012

condensing boilers and run water temperatures around 180°F, utilizing baseboard radiators as the primary equipment for heat distribution. Low-temperature distribution systems are used for condensing boilers and run water temperatures around 120°F to 130°F. There are several different types of low-temperature distribution systems, including low-temperature baseboard radiators, radiant panels, and radiant floors. Condensing boilers will eventually become code minimum efficiency, as federal appliance standards requiring condensing boiler efficiencies are currently under development. These appliance efficiency standards will not require low-temperature distributions systems, as condensing boilers can also operate high-temperature distribution systems. Electric resistance heating systems serve as their own distribution system.

For heat pump technologies, there are three primary distribution systems:

1. Ductless heat pumps, where refrigerant lines act as the distribution system, running from the outdoor condensing unit to the indoor unit.
2. Ducted systems, where ductwork distributes conditioned air, as in furnace distribution systems.
3. Low-temperature hydronic distribution systems used for AWHPs, similar to the low-temperature hydronic systems used for condensing boilers. AWHPs have limited adoption currently, but they are a notable technology for future hydronic retrofit applications as an alternative to ductless mini-splits.

Major differences in distribution systems required for equipment types may create a significant financial burden for consumers. When needed, installation of new ductwork is a significant contributor to labor costs in HVAC installations. Labor costs can be lowered by thoughtful selection of heat pump systems. For example, homes that have ducts used for furnaces and central ACs can select ducted ASHPs that will use the same ductwork. When a compatible distribution system is not present, ductless mini-splits using refrigerant lines instead of ductwork can help avoid the need for a new distribution system and its associated costs.

Currently, retrofits for low-temperature hydronic systems tend to follow this model, circumventing the hydronic distribution system by installing ductless mini-splits. However, AWHPs are a newer technology that might eventually become a preferred solution for homes with hydronic heating since AWHPs enable reuse of existing low-temperature hydronic distribution systems and provide radiative heat like that from a boiler, rather than heated air. Currently AWHPs are too expensive upfront for most consumers, but cost-effective installations may become more common over time as this technology continues to increase in market volume. However, it's worth noting that customers with hydronic distribution systems that install AWHPs will also need to install water-to-air coils if they want to use the AWHP for cooling.

Cost Sources and Assumptions

Distribution system costs were sourced from two separate sources. Low-temperature hydronic distribution system input costs were collected from the Efficiency Vermont AWHP case study. Ducting input costs were collected from the RS Means database, assuming that 200 lbs of aluminum was used. Costs were adjusted to a US average value using the RS Means state weighted average indices and were escalated to 2024 dollars using an inflation conversion factor, such as an equipment and labor cost conversion factor.

For scenarios where low-temperature hydronic distribution systems exist in the home, the labor cost was discounted to account for the savings associated with installing equipment compatible with existing functional distribution systems. The research team selected a 60 percent discount as the anticipated reduction in labor was significant.

For scenarios where ducting exists in the home, the labor cost was also discounted to account for the existing infrastructure. The research team selected a 40 percent discount to account for frequent instances when ductwork needs some modification when switching heating system types. For example, ductwork designed for furnaces often needs some redesign to work for the lower temperature air that heat pumps provide.

ELECTRICAL INFRASTRUCTURE UPGRADES

When shifting from residential fossil-fuel equipment to electric heat pumps, electrical infrastructure upgrades may be necessary to accommodate the increased electric load. Older buildings are more likely to need electrical panel upgrades due to lower panel capacities. Energy Solutions estimated state-specific electrical upgrade costs for all measure equipment scenarios to account for this possible expense.

Electrical upgrade costs were determined via TECH Clean California program data, a program that collects detailed project costs for HVAC and installations in California.[29] Of all HVAC heat pump installation projects in the TECH program dataset, only 2,284 of 29,802 projects (7.7 percent) needed an "electrical service upgrade," as of 8/31/24. This is generally consistent with findings from a recent survey of residential homes which found that 27 percent of homes in the Northeast and 12 percent of homes in the South have 100 Amps or less. Not all of these homes would necessitate electrical service upgrades to convert to a heat pump. While that study's methodology differs from the TECH dataset, they found that approximately 4 percent of all homes adopting heat pumps would trigger a panel upgrade.[33]

These costs were then customized to individual states via the state labor cost index. Electrical infrastructure upgrades focused on the customer-sited electrical infrastructure and did not include grid infrastructure upgrades such as transformers and sub-stations.

Cost Sources and Assumptions

For scenarios with a panel upgrade, we added $2,351 to the labor cost portion of the installation cost, for both the labor and materials associated with installing HVAC equipment. This cost was determined by adjusting the cost of materials and labor needed for a panel upgrade from the TECH Clean California program, using the California labor index. Costs did not need to be adjusted to 2024 dollars since these projects were recent enough to reflect current costs and come from a range of program years. We did not include front-of-meter electricity service upgrades in this analysis, which can add to electrification costs but vary greatly from household to household.

[33] Defining the Electrical Panel Barrier to Residential Electrification, EPRI, ACEEE Summer Study 2024 Proceedings: https://www.aceee.org/sites/default/files/proceedings/ssb24/pdfs/Defining%20the%20Electrical%20Panel%20Barrier%20to%20Residential%20Electrification.pdf

Calculation

Average consumer labor costs included all materials necessary to install the baseline or measure equipment. To adjust labor costs to state-specific rates, the Labor City Cost Indexes in the RS Means Database were averaged for each state. As with the material cost indexes, population weighting was used for each city within each state to derive the state labor cost indexes. The state averaged labor indexes are shown in Table 7. 2024 state labor indexes were applied to the calculated US average labor costs using the equation below:

$$\frac{Labor\ Cost\ Index\ A}{100} x\ Labor\ Cost = Labor\ Cost\ in\ State\ A$$

For input labor costs that are state averages rather than national averages, such as the mini/multi-split heat pumps, the 100 in the equation was replaced by the applicable state index.

TABLE 6. STATE MATERIAL CITY COST INDEXES — 2024

States	Material Cost Index	Cities Included
Connecticut	100.3	Bridgeport, Bristol, Hartford, Meriden, New Britain, New Haven, New London, Norwalk, Stamford, Waterbury, and Willimantic
Delaware	101.5	Dover, Newark, and Wilmington
District of Columbia	100.1	
Maine	97.9	Augusta, Bangor, Bath, Houlton, Kittery, Lewiston, Machias, Portland, Rockland, and Waterville
Maryland	99.6	Annapolis, Baltimore, College Park, Cumberland, Easton, Elkton, Hagerstown, Salisbury, Silver Spring, and Waldorf
Massachusetts	98.4	Boston, Brockton, Buzzards Bay, Fall River, Fitchburg, Framingham, Greenfield, Hyannis, Lawrence, Lowell, New Bedford, Pittsfield, Springfield, and Worcester
New Hampshire	99.0	Charleston, Claremont, Concord, Keene, Littleton, Manchester, Nashua, and Portsmouth
New Jersey	97.8	Atlantic City, Camden, Dover, Elizabeth, Hackensack, Jersey City, Long Branch, New Brunswick, Newark, Paterson, Point Pleasant, Summit, Trenton, and Vineland
New York	99.3	Albany, Binghamton, Bronx, Brooklyn, Buffalo, Elmira, Far Rockaway, Flushing, Glens Falls, Hicksville, Jamaica, Jamestown, Kingston, Long Island City, Monticello, Mount Vernon, New Rochelle, New York, Niagara Falls, Plattsburgh, Poughkeepsie, Queens, Riverhead, Rochester, Schenectady, Staten Island, Suffern, Syracuse, Utica, Watertown, White Plains, and Yonkers

States	Material Cost Index	Cities Included
Pennsylvania	98.3	Allentown, Altoona, Bedford, Bradford, Butler, Chambersburg, Doylestown, Dubois, Erie, Greensburg, Harrisburg, Hazleton, Indiana, Johnstown, Kittanning, Lancaster, Lehigh, Montrose, New Castle, Norristown, Oil City, Philadelphia, Pittsburgh, Pottsville, Reading, Scranton, State College, Stroudsburg, Sunbury, Uniontown, Washington, Wellsboro, Westchester, Wilkes-Barre, Williamsport, and York
Rhode Island	101.2	Newport and Providence
Vermont	97.7	Bellows Falls, Bennington, Brattleboro, Burlington, Guildhall, Montpelier, Rutland, St. Johnsbury, and White River Junction
Virginia	100.2	Alexandria, Arlington, Bristol, Charlottesville, Culpeper, Fairfax, Farmville, Fredericksburg, Grundy, Harrisonburg, Lynchburg, Newport News, Norfolk, Petersburg, Portsmouth, Pulaski, Richmond, Roanoke, Staunton, and Winchester

Source: RS Means 2024, Q2

TABLE 7. STATE LABOR COST INDEXES — 2024

States	Labor Cost Index	Cities Included
Connecticut	115.4	Bridgeport, Bristol, Hartford, Meriden, New Britain, New Haven, New London, Norwalk, Stamford, Waterbury, and Willimantic
Delaware	108.7	Dover, Newark, and Wilmington
District of Columbia	88.7	
Maine	86.1	Augusta, Bangor, Bath, Houlton, Kittery, Lewiston, Machias, Portland, Rockland, and Waterville
Maryland	81.8	Annapolis, Baltimore, College Park, Cumberland, Easton, Elkton, Hagerstown, Salisbury, Silver Spring, and Waldorf
Massachusetts	122.0	Boston, Brockton, Buzzards Bay, Fall River, Fitchburg, Framingham, Greenfield, Hyannis, Lawrence, Lowell, New Bedford, Pittsfield, Springfield, and Worcester
New Hampshire	90.6	Charleston, Claremont, Concord, Keene, Littleton, Manchester, Nashua, and Portsmouth
New Jersey	135.5	Atlantic City, Camden, Dover, Elizabeth, Hackensack, Jersey City, Long Branch, New Brunswick, Newark, Paterson, Point Pleasant, Summit, Trenton, and Vineland

States	Labor Cost Index	Cities Included
New York	161.4	Albany, Binghamton, Bronx, Brooklyn, Buffalo, Elmira, Far Rockaway, Flushing, Glens Falls, Hicksville, Jamaica, Jamestown, Kingston, Long Island City, Monticello, Mount Vernon, New Rochelle, New York, Niagara Falls, Plattsburgh, Poughkeepsie, Queens, Riverhead, Rochester, Schenectady, Staten Island, Suffern, Syracuse, Utica, Watertown, White Plains, and Yonkers
Pennsylvania	115.7	Allentown, Altoona, Bedford, Bradford, Butler, Chambersburg, Doylestown, Dubois, Erie, Greensburg, Harrisburg, Hazleton, Indiana, Johnstown, Kittanning, Lancaster, Lehigh, Montrose, New Castle, Norristown, Oil City, Philadelphia, Pittsburgh, Pottsville, Reading, Scranton, State College, Stroudsburg, Sunbury, Uniontown, Washington, Wellsboro, Westchester, Wilkes-Barre, Williamsport, and York
Rhode Island	112.7	Newport and Providence
Vermont	87.3	Bellows Falls, Bennington, Brattleboro, Burlington, Guildhall, Montpelier, Rutland, St. Johnsbury, and White River Jct.
Virginia	72.2	Alexandria, Arlington, Bristol, Charlottesville, Culpeper, Fairfax, Farmville, Fredericksburg, Grundy, Harrisonburg, Lynchburg, Newport News, Norfolk, Petersburg, Portsmouth, Pulaski, Richmond, Roanoke, Staunton, and Winchester

Source: RS Means 2024, Q2

Massachusetts – Installation Costs

In addition to the OTR Cost Methodology, we conducted an in-depth review of residential heat pump installation costs from two programs in Massachusetts, the MassCEC Whole Home Pilot and the Mass Save program, for which we had access to anonymized data from hundreds of heat pump installations throughout Massachusetts. These program cost datasets were broken down in greater detail, allowing for comparison between the estimated results from the OTR Cost Methodology to real-world installation costs. The MassCEC Whole Home Pilot dataset includes installation costs of whole-home heat pump retrofits from 2019 through 2021. The Mass Save dataset includes full and partial displacement heat pump installations from 2022 through 2023. Results of this supplemental analysis can be found in the Massachusetts Installation Cost Results section of the report.

Operating Cost Analysis

Methodology

Annual operating costs were generated using the energy savings methodology found in the Residential/Multifamily HVAC heat pump measure in the New Jersey Technical Reference Manual (TRM).[34] We specifically selected New Jersey's TRM for this analysis because it includes many system types, building types, and efficiencies, and is intended for ASHPs and central ACs.

[34] https://nj.gov/bpu/pdf/publicnotice/4.%20EE%20T2%20Technical%20Reference%20Manual%202023.pdf

Baseline heating equipment in the TRM includes boilers and furnaces using fossil fuels or electric resistance. The formulas used for baseline and measure cases are summarized in this section.

Operating costs were provided for each state and savings were calculated based on several factors. Energy savings were established based on system type, efficiency, location, building vintage, and presence of cooling equipment. Fuel types and costs were applied to the energy savings numbers with multiple rate structures modeled for each state. Variables for equivalent full load hours (EFLH) were used in the energy savings formulas to account for differences in building location and age. Equivalent full load hours represent the number of hours an HVAC system needs to operate to meet the heating and cooling requirements of a building for one year and vary from state to state based on climate zone. For example, an old home located in Maine uses more heating fuel annually than a new home located in Maryland.

Variables used in the TRM entry's formulas are HVAC system capacity, efficiency, and EFLH. Equipment capacity was determined by the average system size of a representative residential building. Efficiency levels for each product were selected based on future anticipated appliance standards and current market efficiency trends, as shown in Table 3. EFLH assumptions were based on each state's TRM. Energy consumption was calculated for baseline and measure systems, with differences between the two representing the resulting energy savings. Total heating and cooling energy savings were combined and converted to monetary values based on state fossil fuel and electricity prices, to illustrate the operating cost impact of switching from fossil fuels to electric heat pumps.

While New Jersey's TRM was best suited to provide the energy savings methodology needed for our analysis, TRM methodologies vary across states. The NJ TRM does not include cold-climate performance adjustments or hourly energy consumption calculations, as it uses annual effective full load hours and heat pump performance rated at 47°F. As such, our use of the New Jersey TRM is one limitation of this study and may affect operating cost results for some states.

Annual Energy and Cost Savings

We developed an Operating Cost Calculator[35] to determine annual energy use and associated operating costs for each baseline and measure HVAC system evaluated in this study. Calculator inputs include HVAC system, building age and location, and utility cost, which users can find in the tables of this report. Once the inputs are selected, the calculator generates energy consumption and operating costs. This section describes each required user input.

CALCULATING BASELINE AND MEASURE ENERGY CONSUMPTION

To determine operating cost differences, we first estimated changes in annual energy consumption between baseline and measure equipment. In this analysis, energy demand for each unit depends on the annual heating and cooling requirements per household, building vintage, and the efficiency of the equipment. Table 8 shows annual energy consumption by baseline equipment type per state. Some key highlights include:

[35] Email elevin@nescaum.org to request access to the calculator.

- Maine's heating EFLH in its TRM is higher than other states, resulting in higher energy consumption for heating and in many cases, higher operating costs.
- New Jersey has the lowest energy consumption for heating, due to a lower EFLH in its TRM.
- Oil furnaces have the highest energy consumption and therefore present the greatest opportunity for net energy savings by transitioning to heat pumps.

TABLE 8. BASELINE EQUIPMENT ANNUAL ENERGY CONSUMPTION (THERMS) BY STATE

	Boiler		Furnace	
	Fuel Oil	MG and Propane	Fuel Oil	MG and Propane
CT	680.3	630.2	688.1	630.2
DC	696.1	644.8	704.1	644.8
DE	737.9	683.6	746.4	683.6
MA	947.1	877.3	958.0	877.3
MD	666.0	616.9	673.6	616.9
ME	1191.8	1103.9	1205.5	1103.9
NH	805.0	745.7	814.3	745.7
NJ	621.1	575.4	628.3	575.4
NY	704.6	652.7	712.7	652.7
PA	755.9	700.2	764.6	700.2
RI	897.4	831.2	907.7	831.2
VA	760.0	704.0	768.8	704.0
VT	1153.9	1068.8	1167.1	1068.8

Annual Therms: 575.4 – 1205.5

Table 9. illustrates the annual energy consumption per state for the various measure equipment types, also assuming average building vintage. We show split unitary and packaged ASHPs as having the same efficiency levels, in alignment with federal minimum efficiency requirement assumptions. Some key highlights include:

- The heating EFLH assumptions drive annual energy consumption values.
- Maine, Vermont, and Rhode Island heating equipment have the highest annual energy consumption, indicating that cold-climate heat pumps may be a preferred option in those and other cold states to improve operating efficiency.
- Mini- and multi-splits consume the least energy because they often have variable-speed compressors that increase efficiency compared to standard-efficiency unitary ASHPs; their federal minimum efficiency requirements are higher than packaged and split unitary ASHPs.

TABLE 9. MEASURE EQUIPMENT ANNUAL ENERGY CONSUMPTION (KWH) BY STATE

	Average Building Vintage			
	Air to Water Heat Pump	Mini-Multi Split	Packaged Unitary HP	Split Unitary HP
CT	8941	8398	9498	9498
DC	11124	9570	10812	10812
DE	10401	9457	10692	10692
MA	10773	10864	12298	12298
MD	9874	8776	9919	9919
ME	12042	12922	14637	14637
NH	8768	9042	10238	10238
NJ	8243	7707	8716	8716
NY	8246	8196	9276	9276
PA	11697	10203	11529	11529
RI	12355	11356	12840	12840
VA	9938	9358	10584	10584
VT	12433	12894	14599	14599

Annual kWh

7707 14637

ENERGY CONSUMPTION FORMULAS

Annual energy consumption was calculated using a base formula that applies to all heating and cooling equipment. The formula uses different input values to generate the energy consumption of each type of system modeled in the report. Annual energy consumption calculations are utilized for estimating operating costs for the purposes of this report. This methodology does not provide hourly granularity needed to calculate seasonal fluctuations in energy rates or time-of-use rate structures, as this would have significantly expanded the project scope. The EIA annual energy rates utilized are weighted to represent an average weighted cost throughout the year. Calculations of further granularity could be a future area of study building on this report.

$$\textbf{\textit{Annual Energy Consumption}} = \left(\frac{Equipment\ Capacity}{Efficiency\ \times Conversion\ Factor}\right) \times EFLH$$

Annual Energy Consumption: The total energy consumed by the HVAC system during a typical weather year.

Equipment Capacity: The average HVAC system size for a residential single-family dwelling. To evenly compare system and operating costs from state to state, the same capacity for heating and cooling equipment was used in these calculations.

Efficiency: The rated efficiency of the heating or cooling equipment. Each of the system types shown in Table 4 has an associated efficiency used in the calculations. Cooling equipment is rated by seasonal energy-efficiency rating (SEER) and heating equipment is rated by heating seasonal performance factor (HSPF).

Conversion Factor: This constant allows for the standardization of measurement format for different fuel types. For electric heat pumps and air conditioners, the conversion factor is 1,000 to have energy use rated in kWh. For a fossil fuel furnace or boiler, the conversion factor is 100,000 to have energy use rated in therms.

EFLH: Equivalent Full Load Hours are the number of hours an HVAC system operates at full load to satisfy the heating and cooling requirements of a building for a one-year period. They were used to account for building location and age in calculating annual energy usage. For example, an old home located in Maine uses more heating fuel annually than a new home located in Maryland.

This report provides a comparison of the energy consumption for multiple baseline heating and cooling systems. The energy consumption for each of these systems was modeled using the following formulas:

Fossil Fuel Furnace or, Boiler $$AEC_{htg_{base}} = \left(\frac{Cap_{htg}}{Eff_{htg} \times 100{,}000}\right) \times EFLH_{htg}$$

Electric Resistance Heat $$AEC_{htg_{base}} = \left(\frac{Cap_{htg}}{Eff_{htg} \times 1{,}000}\right) \times EFLH_{htg}$$

Central Air Conditioner $$AEC_{clg_{base}} = \left(\frac{Cap_{clg}}{Eff_{clg} \times 1{,}000}\right) \times EFLH_{clg}$$

Air Source Heat Pump $$AEC_{htg_{meas}} = \left(\frac{Cap_{htg}}{Eff_{htg} \times 1{,}000}\right) \times EFLH_{htg}$$

$$AEC_{clg_{meas}} = \left(\frac{Cap_{clg}}{Eff_{clg} \times 1{,}000}\right) \times EFLH_{clg}$$

$AEC_{htg_{base}}$	Annual Energy Consumption of baseline heating system
$AEC_{clg_{base}}$	Annual Energy Consumption of baseline cooling system
$AEC_{htg_{meas}}$	Annual Energy Consumption of measure heating system
$AEC_{clg_{meas}}$	Annual Energy Consumption of measure cooling system
Cap_{htg}	Capacity of heating equipment (Btu/hr)
Cap_{clg}	Capacity of cooling equipment (Btu/hr)
Eff_{htg}	Efficiency of heating equipment (AFUE or HSPF)
Eff_{clg}	Efficiency of cooling equipment (SEER)
$EFLH_{htg}$	Equivalent Full Load Hours during heating season
$EFLH_{clg}$	Equivalent Full Load Hours during cooling season

ENERGY CONSUMPTION INPUTS

Energy consumption is the primary driver of operating cost, and we applied electricity and fuel cost data to annual energy consumption estimates to determine annual operating costs. The energy consumption calculations require inputs unique to each HVAC system modeled. The options available for those inputs were set using the baseline and measure systems being compared. The selections determined the equipment efficiencies used in the operating cost formulas. Options available for each equipment type input are shown in Table 10.

TABLE 10. EQUIPMENT INPUT SELECTIONS

Operating Cost Calculation Inputs: Equipment Types			
Baseline Heating Systems	**Baseline Cooling Systems**	**Measure Systems**	**Equipment Capacity**
Boiler **Furnace** **Electric** **Radiant**	Split Unitary A/C No A/C	Split Heat Pump Mini-Multi Split Heat Pump Packaged Heat Pump Air to Water Heat Pump	Determined by average system size

Once energy consumption is generated, HVAC operating costs are calculated. This requires values for each fuel type, utility type, and state. The calculator selects the correct fuel rate based on these inputs. State selection determines the EFLH and the utility rates available as shown in the Fuel Price section of the report. Gas and Electric Utility Size selections account for different rates within each state, and Building Vintage adjusts the EFLH. Table 11 lists the options available for each input.

TABLE 11. SCENARIO INPUT SELECTIONS

Operating Cost Calculation Inputs: Scenarios				
State	**Building Vintage**	**Heating Fuel Types**	**Gas Utility Size**	**Electric Utility Size**
CT, DC, DE, MA, ME, MD, NH, NJ, NY, PA, RI, VT, VA	New (2007 and newer) Average (1979 – 2006) Old (Prior to 1979)	Methane Gas Propane Fuel Oil Electricity	Largest Utility Second Largest Utility Small Utility EIA State Average	Largest Utility Second Largest Utility Small Utility EIA State Average

Operating costs were determined for many scenarios of baseline and measure heating and cooling systems, creating numerous permutations to compare the annual operating cost of one specific system to another.

The baseline heating systems were broken down by equipment and fuel type. They included furnaces, boilers, and electric resistance systems. Each of the appropriate fuel types was applied to each of the heating system types to generate a list of permutations for baseline heating comparisons. The baseline cooling system permutations consisted of either no air conditioning equipment or a central air conditioner.

The measure heat pump systems were broken down by equipment type. These included split unitary heat pumps, mini/multi split heat pumps, packaged unitary heat pumps, and AWHPs. The current average efficiencies and sizes of the equipment are included in Table 12.

TABLE 12. EQUIPMENT SPECIFICATION ASSUMPTIONS

Base/Measure Case	Fuel Type	HVAC Unit Type	Distribution System	Efficiency	Output Btu/hr
Baseline	Methane Gas	Boiler	Hydronic Low T Radiant	95% AFUE	65,000
Baseline	Propane	Boiler	Hydronic Low T Radiant	95% AFUE	65,000
Baseline	Electric	Zonal Electric Resistance	Radiant Baseboard	100% AFUE	65,000
Baseline	Electric	Split Unitary Air Conditioner	Ducted	13.7 SEER2	36,000
Baseline	Fuel Oil	Boiler	Hydronic High T	88% AFUE	65,000
Baseline	Methane Gas	Boiler	Hydronic High T	95% AFUE	65,000
Baseline	Propane	Boiler	Hydronic High T	95% AFUE	65,000
Baseline	Fuel Oil	Furnace	Ducted	85% AFUE	65,000
Baseline	Methane Gas	Furnace	Ducted	95% AFUE	65,000
Baseline	Propane	Furnace	Ducted	95% AFUE	65,000
Measure	Electric	AWHP	Hydronic Low-T Radiant	9.4 EER, 2.83 COP @5 °F	65,000
Measure	Electric	Mini/multi split (one-zone)	Ducted	15.2 SEER2, 7.6 HSPF2	65,000
Measure	Electric	Mini/multi split (three-zones)	Ductless	15.2 SEER2, 7.6 HSPF2	65,000
Measure	Electric	Packaged unitary heat pump	Ducted	14.3 SEER2, 7.5 HSPF2	65,000
Measure	Electric	Split unitary heat pump	Ducted	14.3 SEER2, 7.5 HSPF2	65,000

Overall, conversions from fossil fuel-powered heating equipment to ASHPs result in decreased fossil fuel use and increased electricity use. Conversions from electric resistance baseboard heaters to heat pumps result in significant kWh savings and zero therm savings.

Annual Operating Cost Impacts

Operating costs are calculated by multiplying energy consumption for the baseline and measure-case equipment by the price of fuel for each state. Fuel price data for each fuel type can be found in the Fuel Price section of the report.

$$Operating\ Cost\left(\frac{\$}{yr}\right)_{Baseline\ or\ Measure} = \frac{kWh}{Therms}_{Baseline\ or\ Measure} \times Fuel\ Price_{\$/_{kWh} or \$/_{Therm}}$$

To calculate operating cost impacts, the cost to operate measure equipment was subtracted from the cost to operate baseline equipment.

$$Operating\ Cost\ Savings\left(\frac{\$}{yr}\right) = Operating\ Cost\left(\frac{\$}{yr}\right)_{Baseline} - Operating\ Cost\left(\frac{\$}{yr}\right)_{Measure}$$

Accounting for the number of permutations based on each state's utility rates and fuel consumption, along with options for system type, fuel type, and building age, results in a high number of system configurations. The current number of variables make possible more than 44,000 individual permutations. Because of that, the calculator tool allows for specific inputs to be used to represent a desired data set of information. The information presented in the tables in Appendix E: Operating Cost Tables by State is set up to represent typical systems for each state. To limit the amount of data displayed in the tables, assumptions were made for building vintage and the existence of central air conditioning on the baseline system. The Operating Cost Calculator allows users to examine results for other scenarios.

Key Assumptions

EQUIVALENT FULL LOAD HOURS

Equivalent Full Load Hours (EFLH) approximate annual home heating and cooling loads and are used to calculate annual operating savings. Each state has EFLH data from their respective TRM that is used in the savings calculations to account for geographical location. In this analysis, EFLH also accounts for home type and approximate age of the structure. Table 13 summarizes the heating and cooling EFLH values by state and building vintage. These EFLH assumptions are a key driver of operating cost results.

TABLE 13. HEATING AND COOLING EFLH BY STATE AND BUILDING VINTAGE

State	Heating EFLH			Cooling EFLH		
	New (2007 and newer)	Average (1979 to 2006)	Old (prior to 1979)	New	Average	Old
Connecticut	862	921	981	536	602	624
Delaware	935	999	1064	719	808	837
District of Columbia	882	942	1004	935	1050	1088
Maine	1510	1613	1719	231	260	269
Maryland	844	902	961	744	836	866
Massachusetts	1200	1282	1366	419	471	488
New Hampshire	1020	1090	1161	280	315	326
New Jersey	787	841	896	505	567	588
New York	893	954	1016	357	401	415
Pennsylvania	958	1023	1090	940	1057	1094
Rhode Island	1137	1215	1294	817	918	951
Vermont	1462	1562	1664	375	421	436
Virginia	963	1029	1096	589	662	685

EQUIPMENT CAPACITY

As previously noted, this analysis uses a standard heating load assumption to enable comparison of heat pumps and fossil fuel equipment for whole-home heating. Operating costs show the differences between equipment sized to handle a home's full heating and cooling load. The use of auxiliary heat can vary by location, sizing methods, and heat loss/gain balance, and was not considered for the report. Equipment capacity for heating equipment was based on an assumed heating load of 65,000 Btu/hr for single family homes. Equipment capacity for cooling equipment is assumed to be 36,000 Btu/hr. This assumption is supported by EIA.[36]

FUEL PRICE

Fuel price data was collected from the US EIA website and utility websites. To account for the wide range in prices and sizes of utilities operating in each state, this analysis incorporated four representative categories of utility rates for electricity[37,38] and methane gas:[39,40] Largest Utility, Second Largest Utility, Sample "Small" Utility/Co-op, and EIA State Average. Prices from 2022 were used for the analysis. Some states, such as Rhode Island or the District of Columbia, do not

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36 https://www.eia.gov/analysis/studies/buildings/equipcosts/f

37 https://www.eia.gov/electricity/state/

38 https://www.eia.gov/electricity/sales_revenue_price/

39 https://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm

40 https://www.eia.gov/naturalgas/ngqs/#?report=RP4&year1=2021&year2=2021&company=Name

have more than one utility for methane gas service. EIA State Average values were used for these scenarios.

For fuel oil and propane price data,[41] weekly prices were available for all territories except the District of Columbia. Weekly fuel oil and propane prices are only recorded during the heating season, which runs from October through March. The price of delivered fuels like fuel oil and propane can fluctuate significantly from year to year based on geopolitics, weather, and other factors. This analysis did not factor in that price volatility; it used the average weekly price for each fuel type over the most recent heating period for which data was available: October 2022 to March 2023. District of Columbia's fuel oil and propane prices were assumed to be the same as Maryland's.

The price of fuel varies based on fuel type, utility size, and the state in which it is sold. Delivered fuels like propane and fuel oil tend to be more expensive with greater price volatility compared to regulated fuels like methane gas and electricity. Utility size also affects prices for methane gas and electricity. Larger electric utilities often charge more than smaller electric utilities in the OTR, although there are notable exceptions. Individual utilities chosen for the various sample utility sizes can be found in the Operating Cost Calculator, and this calculator can be provided upon request. Conversely, larger methane gas utilities tend to charge less than smaller methane gas utilities. Rate data is provided in Tables 14-16.

TABLE 14. ELECTRIC UTILITY RATES ($/KWH) — 2022

State	Largest Utility	Second Largest Utility	Sample "Small" Utility/Co-op	EIA State Average[42]
Connecticut	$0.25	$0.24	$0.16	$0.25
Delaware	$0.13	$0.13	$0.14	$0.13
District of Columbia	$0.13	$0.13*	$0.13*	$0.13
Maine	$0.22	$0.23	$0.17	$0.22
Maryland	$0.14	$0.15	$0.10	$0.14
Massachusetts	$0.29	$0.29	$0.15	$0.26
New Hampshire	$0.26	$0.26	$0.26	$0.26
New Jersey	$0.17	$0.14	$0.17	$0.17
New York	$0.29	$0.19	$0.22	$0.23
Pennsylvania	$0.14	$0.17	$0.12	$0.15
Rhode Island	$0.23	$0.16	$0.36	$0.23
Vermont	$0.20	$0.20	$0.24	$0.20
Virginia	$0.13	$0.13	$0.13	$0.13

* EIA State Average was used for utility categories that were not applicable to the state

[41] https://www.eia.gov/dnav/pet/pet_pri_wfr_a_EPD2F_PRS_dpgal_w.htm

[42] EIA defines residential electricity prices as the average price of electricity delivered to residential customers. Prices are total prices paid by residential end-users, inclusive of tax, delivery, commodity, demand, and other charges.

TABLE 15. METHANE GAS UTILITY RATES ($/THERM) — 2022

State	Largest Utility	Second Largest Utility	Sample "Small" Utility/Co-op	EIA State Average[43]
Connecticut	$2.37	$1.81	$2.17	$2.03
Delaware	$1.17	$1.52	$1.28*	$1.28
District of Columbia	$2.02	$2.02*	$2.02*	$2.02
Maine	$1.66	$1.17	$1.88	$1.64
Maryland	$2.62	$1.80	$1.07	$2.25
Massachusetts	$2.59	$2.15	$3.80	$2.43
New Hampshire	$1.46	$1.92	$1.58*	$1.58
New Jersey	$1.36	$2.00	$1.63	$1.68
New York	$2.00	$2.90	$3.24	$2.00
Pennsylvania	$1.75	$1.77	$0.55	$2.00
Rhode Island	$1.56	$1.56*	$1.56*	$1.56
Vermont	$1.35	$1.35*	$1.35*	$1.35
Virginia	$1.71	$1.43	$0.83	$1.78

* EIA State Average was used for utility categories that were not applicable to the state

[43] EIA defines residential natural gas prices as the average price of natural gas delivered to residential customers. Prices are total prices paid by residential end-users, inclusive of tax, delivery, commodity, demand, and other charges.

TABLE 16. PROPANE AND FUEL OIL RATES ($/THERM) — 2022 TO 2023

State	Propane[44]	Fuel Oil[45]
Connecticut	$4.09	$3.37
Delaware	$3.76	$3.73
District of Columbia	$3.75*	$3.58*
Maine	$3.62	$3.28
Maryland	$3.75	$3.58
Massachusetts	$3.87	$3.45
New Hampshire	$4.11	$3.50
New Jersey	$3.69	$3.62
New York	$3.70	$3.59
Pennsylvania	$3.22	$3.33
Rhode Island	$4.08	$3.38
Vermont	$3.78	$3.38
Virginia	$3.65	$3.39

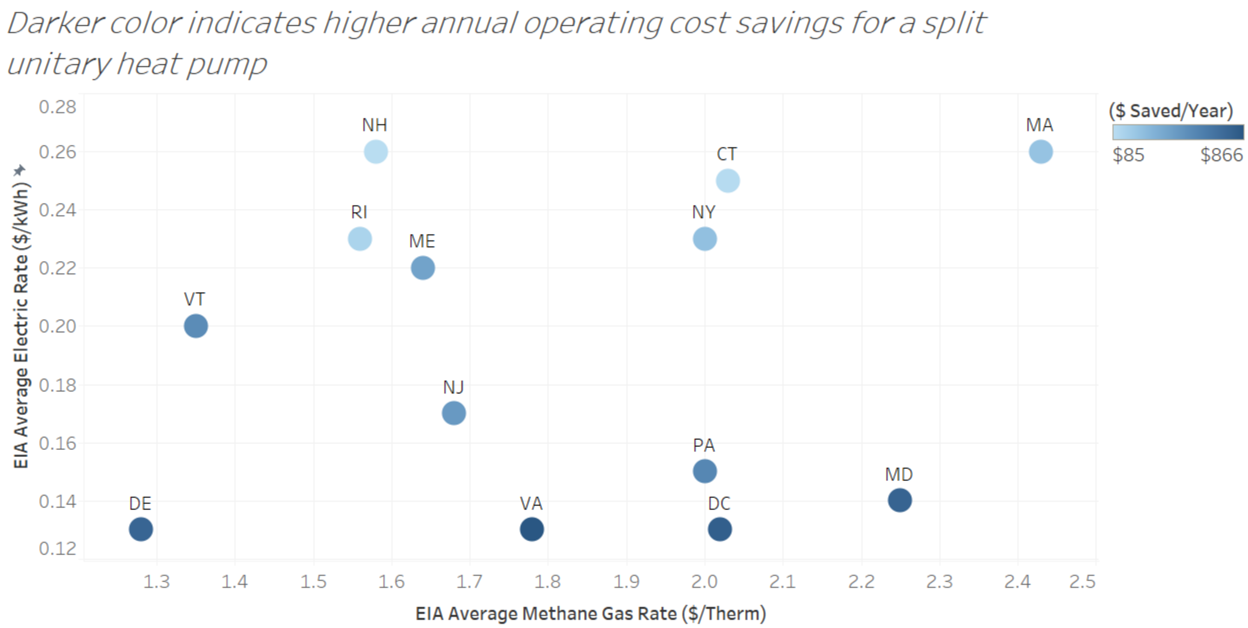
* District of Columbia propane and fuel oil rates were assumed to be the same as Maryland.

Figure 1 illustrates the impact that electricity and methane gas rates have on operating costs for conversions from methane gas heating with central air conditioning to electric heat pump systems. The primary assumptions utilized for this analysis were the Equivalent Full Load Hours for Average Building Vintages (1979 to 2006) as listed by state in Table 13 and split unitary heat pumps as the measure technology. The EIA Average Utility size was used for electric utility rates per state and the fuel oil and propane prices were based on a straight average of EIA residential weekly propane and fuel oil rate price reports for the months of October to March to represent pricing during a full heating season. Maine and Vermont have limited methane gas territory, so they were outliers to the general trend of higher gas rates and lower electricity rates leading to more cost savings.

[44] EIA defines residential propane price as the price charged for home delivery of consumer grade propane intended for use in space heating, cooking, or hot water heaters in residences.

[45] EIA defines residential heating oil price as the price charged for home delivery of No. 2 heating oil, exclusive of any discounts such as those for prompt cash payment. Prices do not include taxes paid by the consumer.

FIGURE 1. METHANE GAS RATES VS. ELECTRIC RATES AND IMPACT ON OPERATING COST SAVINGS



Average of Natural Gas Rate ($/Therm) vs. average of Electric Rate ($/kWh). Color shows average of Annual Operating Cost Savings. The marks are labeled by State Abbrevations. The data is filtered on Electric Utility Size and Gas Utility Size. The Electric Utility Size filter keeps EIA State Average (Elec). The Gas Utility Size filter keeps EIA State Average (Gas).

VT and ME have limited NG distribution. These states are outliers

Results

Cost Analysis Results

Here we present results of the installation and operating cost analyses for conversions from baseline space heating equipment to ASHP and AWHPs, based on the methodologies described above. The summary includes results for the following topics:

1. Equipment cost based on OTR Cost Methodology
2. Labor cost based on OTR Cost Methodology
3. Total installation cost (equipment and labor cost) based on OTR Cost Methodology
4. Massachusetts installation costs
5. Operating cost

Equipment Cost Analysis Results

Table 17 shows the US average cost of a single equipment unit by fuel and HVAC unit type, normalized to 65,000 Btu/h as described in the methodology. Table 17 costs assume that the heating unit is attached to an existing compatible distribution system and do not include any extra fees for distribution system installation or panel upgrades. Cell color corresponds to equipment cost, with darker colors indicating higher cost. All the ASHPs cost more on a per-unit basis than the baseline equipment. However, the cost differential becomes less dramatic after factoring in labor costs, as described below. As discussed in the Installation Cost Sources section of the report, equipment costs were sourced from DOE TSDs and represent US average prices. Those prices were then multiplied by cost adjustment factors per state to derive the state equipment cost estimates. State-specific equipment cost details can be found in Appendix C: Supporting Data Tables.

TABLE 17. US AVERAGE EQUIPMENT COSTS BY EQUIPMENT TYPE AND INSTALLATION SCENARIO

Measure	Electric	AWHP	N/A	$24,594
		Mini-Multi Split (1-zone)	N/A	$8,816
		Mini-Multi Split (3-zones)	N/A	$11,861
		Packaged Unitary HP	N/A	$9,809
		Split Unitary HP	N/A	$8,174
Baseline	Electric	Zonal Electric Resistance	With AC	$7,138
			Without AC	$4,098
	Fuel Oil	Boiler	With AC	$5,254
			Without AC	$2,214
		Furnace	With AC	$5,837
			Without AC	$2,797
	MG & Propane	Boiler	With AC	$5,241
			Without AC	$2,201
		Furnace	With AC	$5,273
			Without AC	$2,233

Equipment Cost

$2,201 14K

Labor Cost Analysis Results

Table 18 and Table 19 show the costs of labor and associated materials to install each equipment type for seven installation scenarios. AWHPs are shown separately since their labor costs are significantly higher than any other type of equipment. Of ASHP types, low-temperature radiant HVAC units have the highest labor costs for installation, while packaged unitary heat pumps have the lowest due to their lack of refrigerant lines. For retrofit projects where compatible existing ductwork is available and no panel upgrade is needed, labor costs for ASHPs are lower than for baseline fossil-fuel equipment.

A key observation from the labor cost analysis is that labor cost indices vary widely across OTR states, from 72.2 percent (VA) to 161.4 percent (NY) of the US average labor rate. This can cause significant differences in overall installation cost by state. Other cost assumptions that were included in the labor cost analysis include electrical infrastructure upgrades increasing heat pump installation costs by $2,351 and replacing insufficient ductwork costing $4,500.

State-specific labor cost details can be found in Appendix C: Supporting Data Tables.

TABLE 18. US AVERAGE LABOR COSTS BY EQUIPMENT TYPE AND INSTALLATION SCENARIO

				Includes New Distribution System Costs	Excludes New Distribution System Costs
Measure	Electric	Mini-Multi Split (1-zone)	With Panel Upgrade	$8,868	$7,081
			Without Panel Upgrade	$6,516	$4,730
		Mini-Multi Split (3-zone..	With Panel Upgrade	$6,308	
			Without Panel Upgrade	$3,957	
		Packaged Unitary HP	With Panel Upgrade	$4,545	$2,758
			Without Panel Upgrade	$2,194	$407
		Split Unitary HP	With Panel Upgrade	$5,356	$3,570
			Without Panel Upgrade	$3,005	$1,219
Baseline	Electric	Zonal Electric Resistance	With AC	$7,780	
			Without AC	$4,898	
	Fuel Oil	Boiler	With AC	$6,060	
			Without AC	$3,178	
		Furnace	With AC	$6,589	$3,016
			Without AC	$3,706	$1,920
	MG & Propane	Boiler	With AC	$6,232	
			Without AC	$3,349	
		Furnace	With AC	$6,143	$2,571
			Without AC	$3,261	$1,474

Labor Cost

$407 9K

TABLE 19. US AVERAGE LABOR COSTS OF AWHPS BY INSTALLATION SCENARIO

Measure			Includes New Distribution System Costs	Excludes New Distribution System Costs
Electric	AWHP	With Panel Upgrade	$33,817	$30,010
		Without Panel Upgrade	$31,466	$27,658

Labor Cost
28K 34K

Total Installation Cost Results

Table 20 shows US-average total installation costs (equipment cost plus labor cost) for each equipment type, except AWHPs. These are presented separately (Table 21) since AWHPs are much more expensive than ASHPs and obfuscated the color difference for lower-priced equipment.

Total installation costs trend similarly to labor costs, with hydronic low-temperature HVAC systems priced the highest. Baseline equipment generally costs less upfront than measure equipment. Split unitary heat pumps cost the least of all heat pumps, with a minimum price of $9,400 when no panel upgrade or ductwork is necessary, followed by packaged unitary heat pumps, which cost about $800 more. Ductless, 3-zone mini/multi-splits cost slightly more than ducted single-zone mini/multi-splits for each installation scenario due to the higher number of zones. State-specific equipment cost details can be found in Appendix C: Supporting Data Tables.

TABLE 20. US AVERAGE INSTALLATION COSTS BY EQUIPMENT TYPE AND INSTALLATION SCENARIO

				Includes New Distribution System Costs	Excludes New Distribution System Costs
Measure	Electric	Mini-Multi Split (1-zone)	With Panel Upgrade	$17,684	$15,898
			Without Panel Upgrade	$15,333	$13,546
		Mini-Multi Split (3-zone..	With Panel Upgrade	$18,170	
			Without Panel Upgrade	$15,818	
		Packaged Unitary HP	With Panel Upgrade	$14,353	$12,567
			Without Panel Upgrade	$12,002	$10,216
		Split Unitary HP	With Panel Upgrade	$13,530	$11,744
			Without Panel Upgrade	$11,179	$9,392
Baseline	Electric	Zonal Electric Resistance	With AC	$14,918	
			Without AC	$8,996	
	Fuel Oil	Boiler	With AC	$11,314	
			Without AC	$5,392	
		Furnace	With AC	$12,426	$8,853
			Without AC	$6,503	$4,717
	MG & Propane	Boiler	With AC	$11,472	
			Without AC	$5,550	
		Furnace	With AC	$11,416	$7,844
			Without AC	$5,494	$3,707

Installed Cost

$3,707 18K

TABLE 21. US AVERAGE INSTALLATION COSTS OF AWHPS BY INSTALLATION SCENARIO

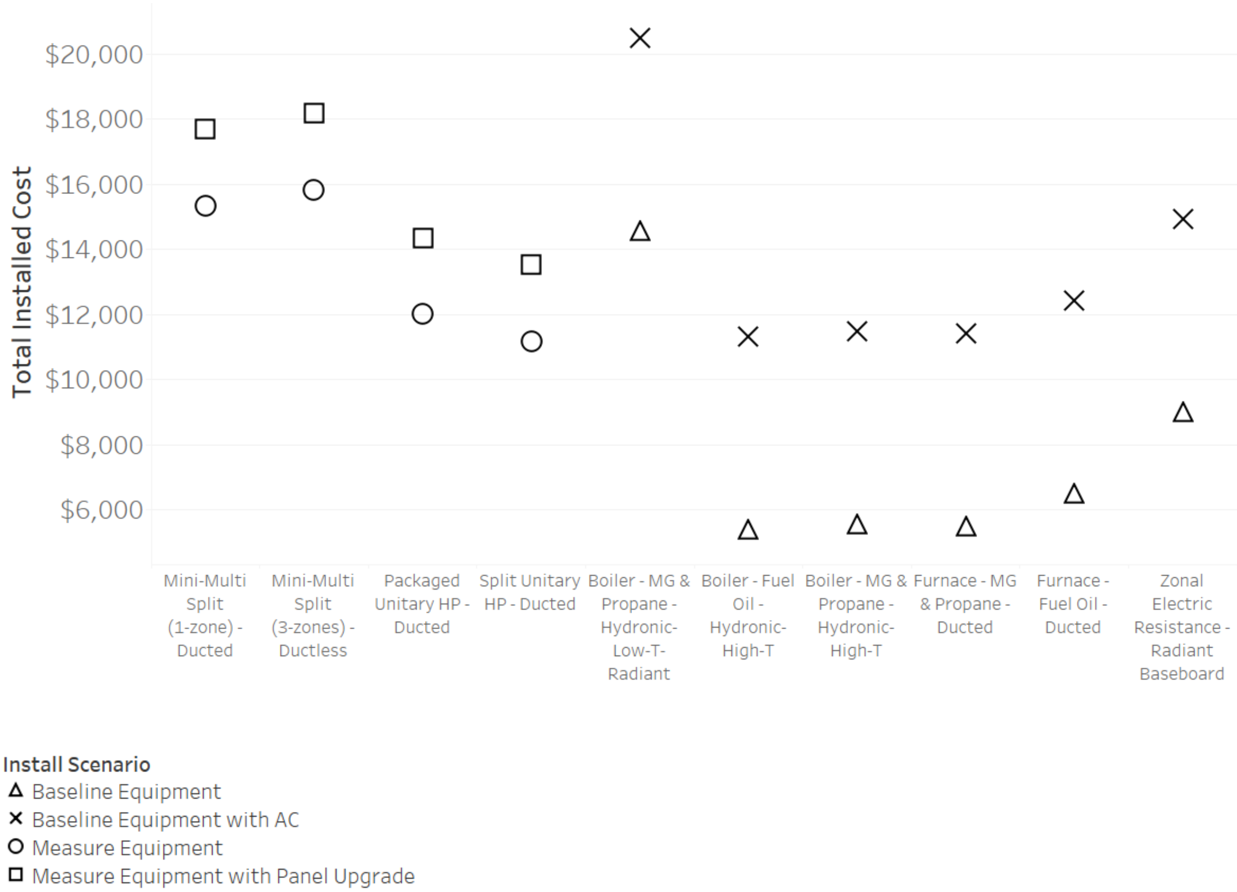
				Includes New Distribution System Costs	Excludes New Distribution System Costs
Measure	Electric	AWHP	With Panel Upgrade	$58,411	$54,603
			Without Panel Upgrade	$56,060	$52,252

Install Cost

52K 58K

Figure 2 shows US average total installation costs for measure equipment with and without a panel upgrade and baseline equipment with and without central AC installed. Costs assume there was no compatible heating distribution system in the home at the time of installation and apply to both retrofit and new construction projects. These costs represent the maximum cost on average for HVAC equipment installations since they exclude discounts associated with compatible distribution systems.

FIGURE 2. US AVERAGE HVAC EQUIPMENT TOTAL INSTALLATION COST BY EQUIPMENT TYPE*



*All costs assume no compatible distribution system and include the cost of a new distribution system.

Figure 3 shows US average total installation costs for measure equipment with a panel upgrade and baseline equipment with central AC installed by state. Costs assume there was no compatible heating distribution system in the home at the time of installation and apply to both retrofit and new construction projects. Costs without panel upgrades can be seen in Appendix C: Supporting Data Tables.

Results are similar to Figure 2 but account for the differences in material and labor across each state considered. The impact of higher labor costs for some states raise costs for measure equipment utilizing ducting, like ducted mini-splits with a panel upgrade.

Figure 3. HVAC Equipment Total Installation Cost by State and Equipment Type*

	CT	DC	DE	MA	MD	ME	NH	NJ	NY	PA	RI	VA	VT
Mini-Multi Split (1-zone) - Ducted	$19.1K	$16.7K	$18.6K	$19.5K	$16.0K	$16.3K	$16.8K	$20.6K	$23.1K	$18.9K	$18.9K	$15.2K	$16.4K
Mini-Multi Split (3-zones) - Ductless	$19.2K	$17.5K	$18.9K	$19.4K	$17.0K	$17.1K	$17.5K	$20.1K	$22.0K	$19.0K	$19.1K	$16.4K	$17.1K
Packaged Unitary HP - Ducted	$15.1K	$13.8K	$14.9K	$15.2K	$13.5K	$13.5K	$13.8K	$15.7K	$17.1K	$14.9K	$15.0K	$13.1K	$13.5K
Split Unitary HP - Ducted	$14.4K	$12.9K	$14.1K	$14.6K	$12.5K	$12.6K	$12.9K	$15.2K	$16.8K	$14.2K	$14.3K	$12.1K	$12.7K
Zonal Electric Resistance - Radiant Baseboard	$16.1K	$14.0K	$15.7K	$16.5K	$13.5K	$13.7K	$14.1K	$17.5K	$19.7K	$16.0K	$16.0K	$12.8K	$13.8K
Furnace - Fuel Oil - Ducted	$13.5K	$11.7K	$13.1K	$13.8K	$11.2K	$11.4K	$11.7K	$14.6K	$16.4K	$13.4K	$13.3K	$10.6K	$11.5K
Furnace - MG & Propane - Ducted	$12.4K	$10.7K	$12.0K	$12.7K	$10.3K	$10.5K	$10.8K	$13.5K	$15.2K	$12.3K	$12.3K	$9.7K	$10.5K
Boiler - Fuel Oil - Hydronic-High-T	$12.3K	$10.6K	$11.9K	$12.6K	$10.2K	$10.4K	$10.7K	$13.3K	$15.0K	$12.2K	$12.1K	$9.6K	$10.4K
Boiler - MG & Propane - Hydronic-High-T	$12.4K	$10.8K	$12.1K	$12.8K	$10.3K	$10.5K	$10.8K	$13.6K	$15.3K	$12.4K	$12.3K	$9.7K	$10.6K
Boiler - MG & Propane - Hydronic-Low-T-Radiant	$22.8K	$18.8K	$21.9K	$23.8K	$17.7K	$18.3K	$19.0K	$25.8K	$29.8K	$22.8K	$22.5K	$16.3K	$18.4K

Install Cost

$9.6K $29.8K

*Baseline costs include air conditioning. Measure costs include a panel upgrade. All costs include new distribution system added costs.

The installation cost analysis resulted in the following key observations:

Increased Installation Costs for Heat Pumps: Across all OTR states and most HVAC equipment configurations, heat pump systems have a higher installation cost than fossil fuel heating systems. Average fossil fuel system plus AC total installation cost ranged from $10,000-$13,000, whereas ASHP total installation cost ranged from $12,000-$23,000. These results highlight the importance of supplemental incentive programs to offset heat pumps' higher installation costs, as well as the potential to promote heat pumps to households installing central ACs – particularly as cooling needs increase with warming temperatures.

Impact of Ductwork Costs: Ductwork adds significant cost to central heat pump system installations. On average, adding new or replacing insufficient ductwork added about $4,500 in material cost to heat pump installations. Where existing ductwork is already in place, typically in homes with forced air furnaces and/or central air conditioners, installing ducted heat pumps that use existing ductwork can significantly reduce retrofit costs, getting heat pump installation cost closer to parity with replacing an existing furnace and air conditioner. In cases where there is no existing ductwork, ductless mini- and multi-splits may be a more economical choice, and AWHPs are an emerging technology that will provide another option for homes with hydronic heating systems in the coming years.

Impacts of Electrical Infrastructure Upgrades: When necessary, electrical infrastructure upgrades such as replacing panels and running new circuits increase heat pump installation costs by an average of $2,400. This points to the importance of using load management strategies to support electrification within existing electric panel capacity, as well as incorporating electrical upgrade costs into incentive programs.

High Labor Cost Variance: Labor cost indices vary widely across OTR states, from 72.2 percent (VA) to 161.4 percent (NY) of the US average labor rate. This can cause significant differences in overall installation cost by state. Labor costs are also highly variable due to other factors, such as installation complexity and varying levels of contractor training on and comfort with heat pumps.

Low Equipment Cost Variance: Material cost indices, measuring the cost of the HVAC equipment itself, are relatively consistent from state to state, from 97.7 percent (VT) to 101.5 percent (DE) of the US average material cost index.

High AWHP Installation Cost: An emerging technology that is widely adopted in Europe but currently uncommon in the US, AWHPs cost significantly more than any other type of heat pump, with total installation cost in the range of $50,000. This price is expected to come down as the industry matures and more products are manufactured in the US.

Massachusetts Installation Cost Results

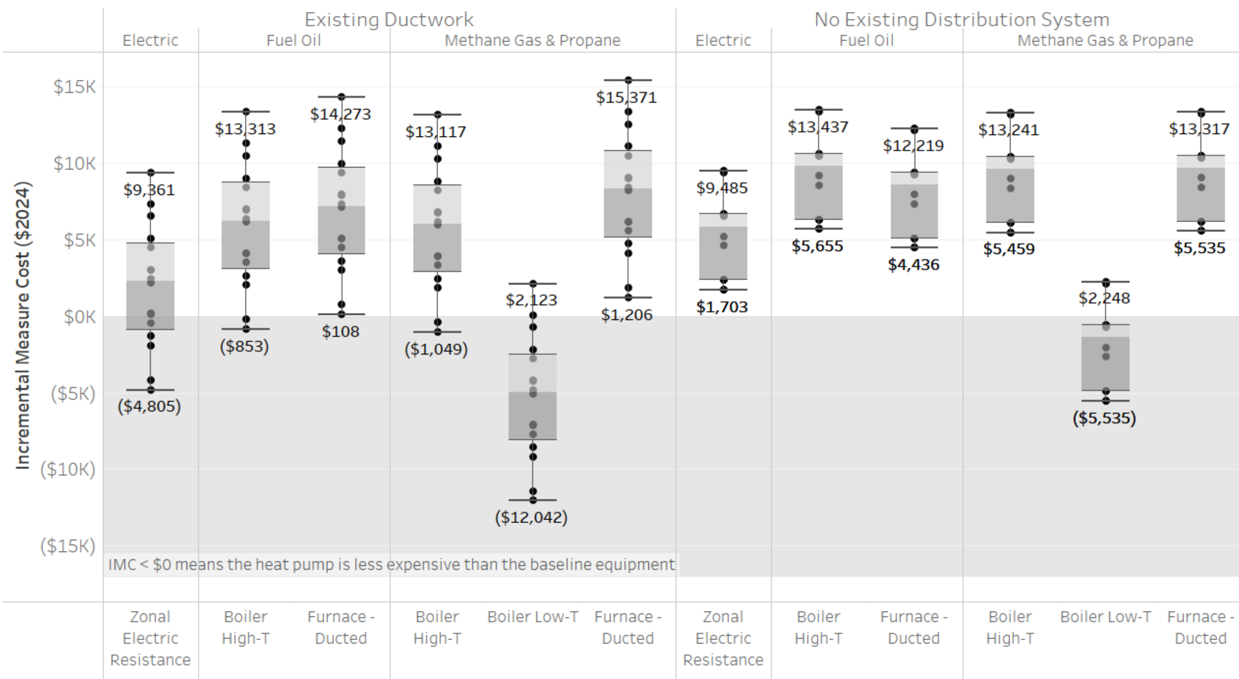
We reviewed anonymized residential heat pump installation cost data from two programs in Massachusetts, the MassCEC Whole Home Pilot and the Mass Save program, to compare installation costs with the OTR Cost Methodology and gain a deeper understanding of cost drivers. Based on this Massachusetts-specific data, Figure 4 shows Incremental Measure Costs (IMC) for various installation scenarios, comparing calculated baseline and measure equipment costs. Positive IMC represents the cost a consumer will pay to adopt the measure equipment instead of the baseline equipment. Negative IMC represents the dollar amount a consumer will save if they install measure equipment instead of baseline equipment. IMC is calculated by subtracting the cost of installation for the baseline equipment (e.g., methane gas furnace) from the measure equipment (e.g., heat pumps).

For almost all Massachusetts homes with central AC and no compatible heat distribution system, consumers will pay more money upfront to install a heat pump instead of their original heating system type due to the cost of a new distribution system and potential need for electrical upgrades. This is demonstrated by the higher cost ranges on the right side of Figure 4. However, methane gas and propane low-temperature boilers are an exception to this trend due to higher costs associated with installing low-temperature hydronic heat distribution.

Cost savings are still possible for consumers adopting ASHPs instead of baseline equipment, as demonstrated in Figure 4. Consumer-facing costs decrease when the consumer is replacing both their heating and air conditioning equipment with a heat pump. Additionally, for ducted heat pumps, the presence of existing ductwork lowers costs compared to new construction or retrofit scenarios where ductwork does not already exist.

Installation cost savings are greatest for split unitary heat pumps installed without a panel upgrade in homes with methane gas or propane fired low-temperature boilers and air conditioning. IMC is the highest for ductless mini/multi splits (three-zones) installed with a panel upgrade in homes with a methane gas or propane furnace and no intention to install central AC.

FIGURE 4. MASSACHUSETTS INCREMENTAL MEASURE COST OF AIR SOURCE HEAT PUMPS



MASSCEC WHOLE-HOME PILOT INSTALLATION COST RESULTS

MassCEC provided over 150 data points from the Massachusetts Whole-Home Heat Pump Pilot from 2019-2021, which enabled the study team to analyze the main cost components for HVAC equipment in Massachusetts. This pilot sought to identify and inform the market about cost-effective and efficient design strategies for whole-home ASHP solutions that provide stand-alone full-winter heating.[46] The Mass Save program also provided aggregate data from over 3,000 partial and full displacement heat pump projects. Average costs per installation cost type are aggregated in Table 22.

Centrally ducted heat pumps in the pilot program were assumed to be split unitary heat pumps since these are significantly more common in residential settings than packaged heat pumps. Equipment cost accounted for about 40 percent of the installation cost for this equipment type. Aside from the equipment, labor and ductwork materials contributed to overall installation cost.

Mini-splits and multi-splits comprised the majority of installs in the MassCEC pilot, with 113 total installations. Most installations (95 of 113) were multi-zone splits with multiple indoor units per

[46] https://www.masscec.com/program/whole-home-air-source-heat-pump-pilot

home, which increased equipment cost $4,000 higher on average than the mini-split category. Labor was the second highest cost category for both mini- and multi-splits.

Ductwork is not required for all mini- or multi-splits and ductwork costs are less common for these systems. However, some mini/multi-split projects were ducted in the MassCEC Pilot, which may have driven up average costs for these equipment types. Multi-split installation labor costs averaged more than double mini-splits, most likely due to more labor hours. The average mini- and multi-split costs differed from the estimates generated by the Energy Solutions team, and the results can be seen in Table 23. The labor and materials portion of the mini- and multi-split install costs also varied significantly from project to project in the MassCEC Whole-Home Pilot. Figure 5 displays the range of labor costs incurred for mini- and multi-split MassCEC Whole-Home Pilot projects.

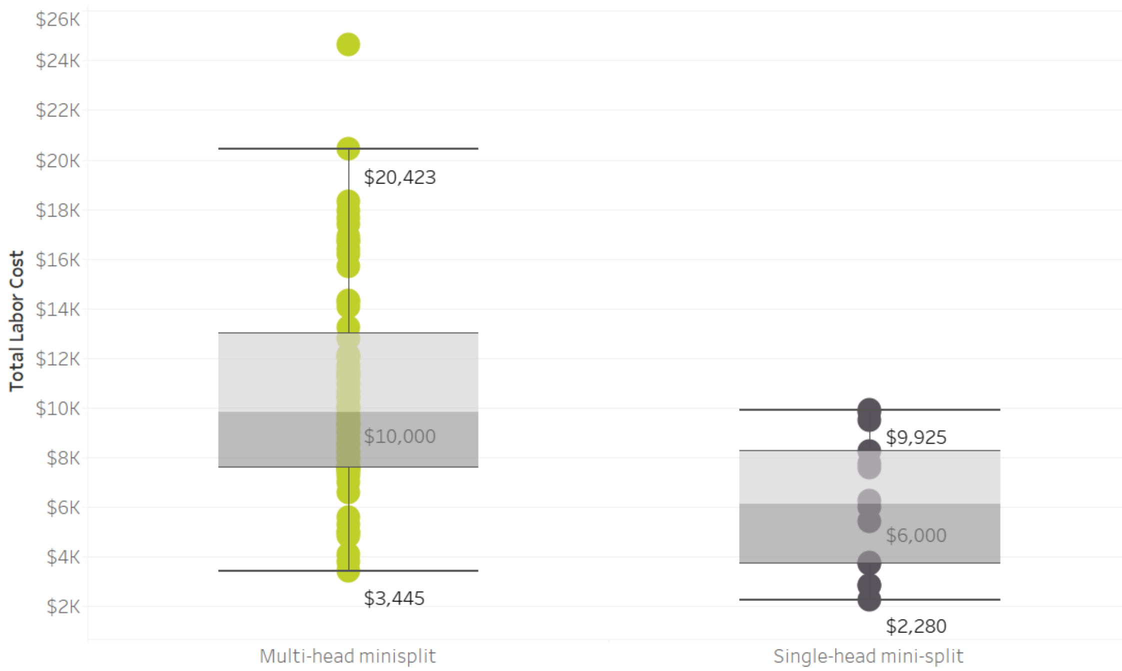
MassCEC's dataset included few AWHP installations, only four out of the 156 heat pumps reported over the two-year period, because AWHPs are a newer technology. AWHPs were by far the most expensive heat pump to install, averaging $42,000 per home. Labor and materials needed for installation made up $33,000 of the cost. This aligns with our independent finding that the cost of labor and materials for installing an AWHP in Massachusetts would equate to about $33,000. Although MassCEC reported 47 percent of the cost as "other parts and equipment," it can be reasonably assumed that majority of the costs incurred for this installation type apply to the low-temperature radiant distribution system needed for an AWHP. A case study presented by Efficiency Vermont demonstrated the extensive building deconstruction that is often needed to implement such a distribution system for an AWHP retrofit project.[47]

[47] Efficiency Vermont, Fossil Fuel Free at Last: Air-to-Water Heat Pump and Ventilation Retrofit Case Study, 2020: https://www.efficiencyvermont.com/Media/Default/bbd/2020/docs/presentations/fossil-fuel-free-at-last-bbd-2020.pdf

TABLE 22. AVERAGE INSTALLATION COSTS BY TYPE FROM MASSCEC WHOLE-HOME PILOT (2019-2021)

Installation Cost Type	Centrally Ducted Heat Pump	Multi-Zone Mini-Split	Single-Zone Mini-Split	Air-to-Water Heat Pump
Total count of outdoor units	39	95	18	4
Ductwork costs (if applicable)	$2,720	$1,280	$1,129	$0
Heat pump equipment	$7,745	$9,253	$5,229	$9,108
Other parts and equipment	$1,396	$1,696	$1,378	$6,591
Heat pump installation labor	$4,879	$6,969	$3,445	$8,312
Electrician costs	$1,077	$1,273	$1,268	$2,700
Removal of previous heating system (if applicable)	$356	$164	$104	$1,430
Other (if applicable)	$387	$163	$620	$13,290
Permitting	$122	$176	$96	$166
Tax (if applicable)	$111	$167	$163	$445
Total Project Cost	$18,792	$21,140	$13,431	$42,040

FIGURE 5. MASSCEC WHOLE-HOME PILOT LABOR COSTS FOR MINI- AND MULTI-SPLITS



INSTALLATION COST COMPARISONS BETWEEN MA PROGRAM DATA AND OTR COST METHODOLOGY

Installation costs for ASHPs and AWHPs are summarized in Table 23 for the MassCEC Whole Home Pilot, the Mass Save Program dataset, and the Massachusetts costs generated using the OTR Cost Methodology.

The agreement on total installation costs for multi-splits and centrally ducted heat pumps among both the MassCEC and Mass Save program datasets indicates that higher-than-average costs are experienced by Massachusetts residents participating in these pilots. A comparison of MassCEC and OTR Cost Methodology labor and equipment costs reveals that the discrepancy between Massachusetts costs and OTR Cost Methodology is due to the labor costs, not equipment cost.

For centrally ducted heat pumps, the reported MassCEC Whole Home Pilot average total installation cost was higher than the cost reported by EIA adjusted for MA,[48] with an average totaling approximately $19,000 versus the $13,000 determined by the OTR Cost Methodology,[49] assuming that retrofit projects included a panel upgrade. The cause of this $6,000 discrepancy remains unclear. Some potential factors may be installation complications due to older building stock in Massachusetts, as well as the need for both electricians and HVAC technicians. Other plausible causes of the cost disparity may be markup due to high cost of living in Massachusetts or limitations and assumptions of the OTR Cost Methodology.

[48] https://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/full.pdf

[49] Assumes a retrofit project with a panel upgrade installation

Single-zone mini-split equipment cost discrepancies came from the equipment cost portion of total installation cost, when comparing MassCEC costs to the OTR Cost Methodology. The OTR Cost Methodology's total cost estimate was higher than the weighted average total cost of MassCEC sales.[50] However, the Mass Save Program Administrator average total cost was higher than the OTR Cost Methodology. Discrepancies may be due to differences in energy efficiencies of installed equipment across datasets. Delving into the program requirements for MassCEC and Mass Save might reveal if the more expensive heat pumps sold through the Mass Save Program Administrator program were higher efficiency than the MassCEC Whole Home Pilot.

The MassCEC and OTR Cost Methodology had similar labor costs for AWHPs, validating the higher installation cost of this measure type. In contrast, the AWHP equipment costs estimated by the OTR Cost Methodology were about $10,000 more than the MassCEC program average cost. Because AWHPs are an emerging technology, it is difficult to say why the OTR Cost Methodology estimate is much higher. There is no Mass Save Program Administrator AWHP program data to compare to the other cost sources.

TABLE 23. INSTALLATION COST COMPARISON OF MASSACHUSETTS PROGRAM DATA TO CALCULATED COSTS

Cost Source	Cost Type	Centrally Ducted Heat Pump	Multi-Zone Mini-Split	Single-Zone Mini-Split[51]	Air-to-Water Heat Pump
OTR Cost Methodology	Labor Cost[52]	$5,271	$6,209	$8,727	$33,281
MassCEC	Labor Cost	$11,048	$11,887	$8,202	$32,932
OTR Cost Methodology	Equipment Cost	$8,044	$11,673	$8,677	$24,204
MassCEC	Equipment Cost	$7,745	$9,253	$5,229	$9,108
OTR Cost Methodology	Total Installation Cost	$13,316	$17,882	$17,404	$57,486
MassCEC	Total Installation Cost	$18,792	$21,140	$13,431	$42,040
Mass Save*	Total Installation Cost	$20,188	$20,746	$19,649	N/A

*Mass Save data was only provided at an aggregated level as a total of equipment and labor cost.

[50] MassCEC Project Costs were not adjusted for inflation

[51] Energy Solutions calculated costs for a ducted single zone mini-split while mini-splits in the MassCEC program may have been installed in the ductless configuration.

[52] Labor costs assume no existing distribution system is in usable condition and a panel upgrade was required.

Through interviews with Massachusetts-specific market actors including manufacturers, distributors, and contractors, we identified key installation cost drivers that may also be relevant in other jurisdictions. Below, we provide an overview of these cost drivers and potential program delivery and design considerations to address them. Energy Solutions determined these cost drivers based on qualitative market interviews combined with professional judgement; they do not reflect the results of quantitative analysis beyond what is reported in this study.

1) The biggest single driver of costs is the relative complexity of a heat pump project. Projects that require distribution system upgrades will include more labor costs. Similarly, projects that require more engineering or a complex design (such as a mix of a central system and ductless heat pumps) may require more labor hours and may result in contractors increasing costs to address greater perceived risk. One way to address this barrier may be to have a program hotline, similar to an approach implemented by Efficiency Vermont, where consumers can ask an expert what questions they should be asking their contractor, and where to look for unnecessary cost inflation.[53] Another way to address this issue is to encourage homeowners to receive multiple quotes from contractors to help identify situations where installation is challenging.
2) HVAC contractors are seeing robust business and thus demand is high, resulting in higher prices. This trend is particularly relevant for heat pump installations, which are increasing in popularity as the heat pump contractor pool remains small. Some contractors may be pricing projects with the mindset of "I do not necessarily need this job, but if they are willing to pay a premium, I will take it on." One way to specifically address this factor is listing of pricing information in a publicly available database, similar to the TECH Clean California database, to provide price transparency to consumers.[54]
3) Massachusetts has a higher percentage of hydronic heating and a relatively lower rate of central systems, meaning that more projects are likely to include more complex installations or multiple-technology systems with both ducted and ductless elements. Greater emphasis on addressing centrally ducted systems and training and support for contractors installing those systems may help to bring overall costs down.
4) Related to both #1 and #3, many contractors are still not comfortable with heat pump technology and may be charging a premium to offset perceived risk. Increased contractor training can both help them feel more comfortable with those risks and more efficient in installing these systems, leading to reductions in labor hours as they gain proficiency. Advertising a list of qualified contractors, or those who perform a high volume of projects (such as the Mass Save Heat Pump Installer Network (HPIN)) may also help address this issue by directing customers to experienced contractors who may not be as likely to set risk premiums.[55]
5) Massachusetts has a relatively high cost of living. While RS Means labor rates should help account for relative cost-of-living comparisons between states and incorporate some

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[53] https://www.efficiencyvermont.com/services/project-support/technical-support

[54] https://techcleanca.com/heat-pump-data/

[55] https://www.efficiencymaine.com/at-home/vendor-locator/

aspect of variables such as housing, transportation, permitting, taxes and other cost drivers, an HVAC market index was not readily available. Higher actual costs than our estimates may indicate that the cost of doing business for HVAC professionals is greater than what is accounted for in generalized labor rate indices.

Operating Cost Analysis Results

Table 24 shows annual operating costs by baseline heating equipment type using EIA State Average utility rates, New Building Vintage (2007-current) and central AC as the baseline cooling equipment. The operating cost savings are based on average efficiencies of equipment currently sold in the market. For the operating cost comparisons, the efficiencies of methane gas and propane boilers were assumed to be the same, although operating costs will differ based on the cost of fuel for each respective fuel type. The same holds true for both methane gas and propane furnaces. For measure-case heat pump equipment, split and packaged equipment types will have similar operating costs due to their equivalent projected efficiency level. All operating cost estimates include the combined cost of heating and cooling with central AC. State-specific operating cost details can be found in Appendix E: Operating Cost Tables by State.

Table 24. Average Annual Operating Costs by Equipment Type for Typical New Building

	Methane Gas		Fuel Oil		Propane		Electric			
State (abbrev)	Boiler High Temp & Boiler Low Temp	Furnace	Boiler High Temp & Boiler Low Temp	Furnace	Boiler High Temp & Boiler Low Temp	Furnace	AWHP	Mini-Multi Split	Packaged Unitary HP & Split Unitary HP	Zonal Electric Resistance
CT	$1,535	$1,535	$2,486	$2,510	$2,748	$2,748	$2,060	$1,949	$2,205	$4,445
DC	$1,525	$1,525	$2,636	$2,663	$2,566	$2,566	$1,325	$1,150	$1,300	$2,492
DE	$1,054	$1,054	$2,813	$2,843	$2,643	$2,643	$1,244	$1,140	$1,289	$2,552
MA	$2,269	$2,269	$3,331	$3,367	$3,454	$3,454	$2,596	$2,631	$2,978	$6,221
MD	$1,561	$1,561	$2,492	$2,517	$2,425	$2,425	$1,269	$1,138	$1,286	$2,514
ME	$1,822	$1,822	$3,791	$3,833	$3,869	$3,869	$2,467	$2,655	$3,007	$6,460
NH	$1,286	$1,286	$2,819	$2,849	$3,050	$3,050	$2,117	$2,192	$2,482	$5,238
NJ	$1,121	$1,121	$2,323	$2,347	$2,201	$2,201	$1,291	$1,216	$1,376	$2,766
NY	$1,428	$1,428	$2,572	$2,599	$2,466	$2,466	$1,756	$1,755	$1,986	$4,120
PA	$1,666	$1,666	$2,712	$2,739	$2,465	$2,465	$1,609	$1,416	$1,600	$3,094
RI	$1,687	$1,687	$3,314	$3,347	$3,644	$3,644	$2,615	$2,423	$2,739	$5,458
VA	$1,366	$1,366	$2,605	$2,633	$2,599	$2,599	$1,191	$1,130	$1,278	$2,579
VT	$1,539	$1,539	$3,841	$3,883	$3,968	$3,968	$2,310	$2,405	$2,723	$5,762

Operating Cost

$1,054 $6,460

*Operating costs for new buildings using EIA State Average energy prices, with central AC assumed for baseline heating equipment.

When accounting for AC use (e.g., baseline heating equipment plus central AC), heat pumps cost less to operate than propane, oil, and electric resistance heating systems in every state for new buildings. Heat pumps are also more affordable to operate than methane gas heating in Virginia, Maryland, Pennsylvania, and Washington, DC, and approach price parity with methane gas in several other states. Colder states with the highest heating and lowest cooling loads show the greatest discrepancies between heat pump and methane gas heating operating costs, potentially pointing to the importance of utilizing more efficient cold-climate heat pumps in those areas.

Further analysis could assess the higher installation and lower operating cost trade-offs of using cold-climate heat pumps in these states. Across every state, operating electric resistance heating in conjunction with central AC is the most expensive option. In most cases, customers who install heat pumps rather than electric resistance heaters could cut their annual operating costs in half.

Table 25 summarizes the maximum operating cost savings achievable for each fuel type for typical new buildings, using EIA State Average energy prices. Results for new buildings are presented here and represent the maximum annual heating bill savings achievable for each state, given the measure and baseline equipment types considered. For this cost matrix, building vintage was assumed to be new, the baseline equipment scenario includes air conditioning operation, and EIA weighted average utility rates for electricity and methane gas were used. Costs were aggregated based on state and fuel type, taking the maximum operating cost savings per fuel type vs. state, of all generated permutations across all types of equipment. The orange colors were incorporated because cost savings in some cases are negative. Therefore, these costs represent the best-case operating cost savings scenario by fuel type and state.

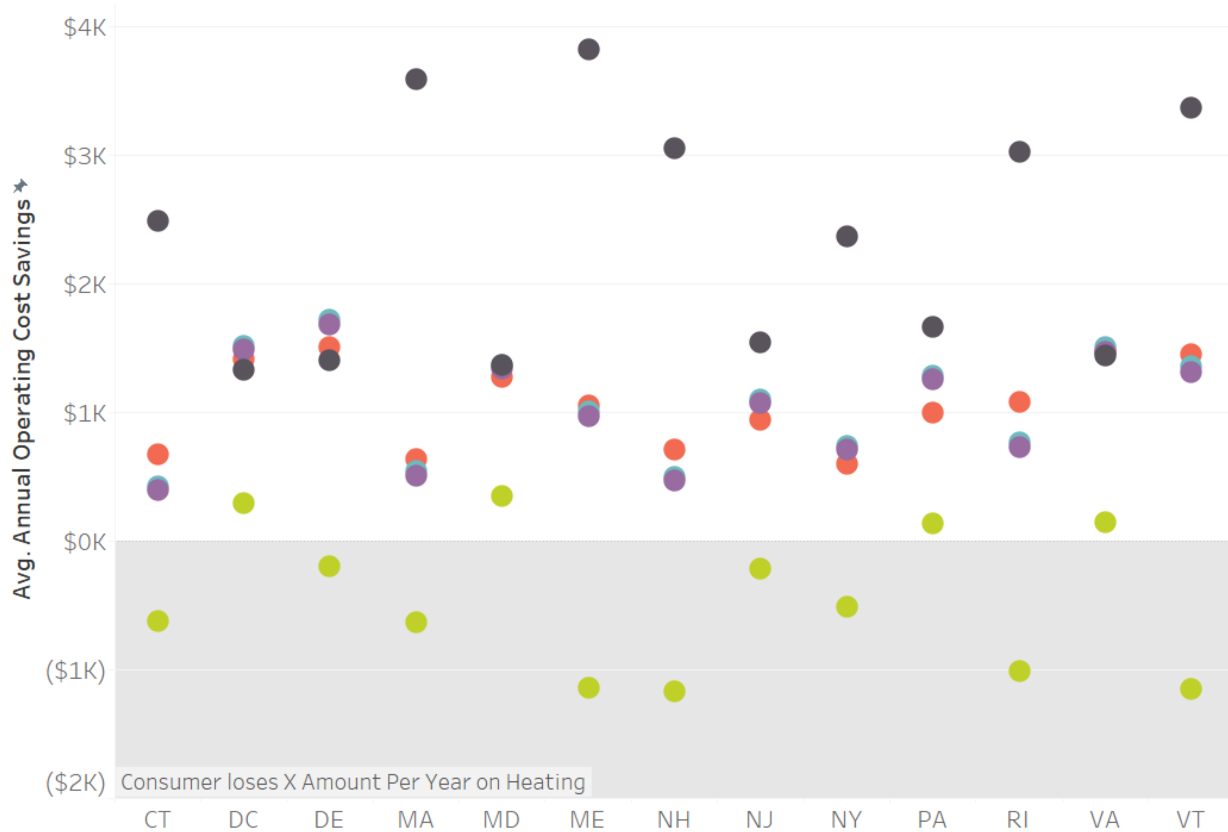
TABLE 25. MAXIMUM ANNUAL OPERATING COST SAVINGS AFTER INSTALLING A HEAT PUMP BY FUEL TYPE FOR A TYPICAL NEW BUILDING

	Baseline Fuel Type			
State	Electric	Fuel Oil	Methane Gas	Propane
Connecticut	$2,496	$561	($415)	$799
Delaware	$1,412	$1,703	($86)	$1,504
District of Columbia	$1,341	$1,513	$375	$1,416
Maine	$3,993	$1,365	($645)	$1,402
Maryland	$1,376	$1,379	$424	$1,287
Massachusetts	$3,625	$771	($327)	$858
New Hampshire	$3,122	$733	($831)	$934
New Jersey	$1,550	$1,131	($96)	$985
New York	$2,366	$844	($327)	$711
Pennsylvania	$1,678	$1,323	$250	$1,049
Rhode Island	$3,035	$924	($736)	$1,221
Vermont	$3,453	$1,573	($770)	$1,659
Virginia	$1,449	$1,503	$236	$1,469

Cost Savings ($)
($831) $3,993

Figure 6 shows the range of operating cost savings (or added costs, represented by negative values) for the various equipment and fuel types analyzed, with central AC included in the baseline scenario.

FIGURE 6. ANNUAL OPERATING COST SAVINGS BY BASELINE EQUIPMENT TYPE*



*Cost savings calculated at EIA state average utility rates, assuming average building vintage and including air conditioning cost in baseline costs.

Baseline HVAC Unit Type
- Electric - Zonal Electric Resistance
- Fuel Oil - Boiler
- Fuel Oil - Furnace
- Methane Gas - Boiler or Furnace
- Propane - Boiler or Furnace

This analysis shows that fuel type has a large impact on operating costs and resultant savings when switching to ASHPs. The largest operating cost savings come from scenarios where the customer opts for an ASHP over an electric resistance heating system, since ASHPs are much more energy efficient. Households using propane or fuel oil-fired furnaces and boilers will generally see operating cost savings after switching to an ASHP, while customers using methane gas may face an increase in operating costs from making the switch, depending on the state and utility rates in effect. The combination of lower gas rates and higher electricity rates results in the least favorable operating cost scenario; currently southern Mid-Atlantic states are more likely to have this favorable scenario.

The operating cost analysis resulted in the following key observations:

Operating Cost Savings Associated with Electric Resistance Heating System Replacement: In all states, we found significant operating cost savings when converting from electric resistance baseboard to heat pump space heating systems. Annual cost savings for electric resistance baseboard heating replacement are $1,200 to $7,000 per year depending on utility rates, climate, and building vintage. This represents an opportunity for states to help residents who still rely on electric resistance baseboard heating significantly reduce their heating costs.

Operating Cost Savings Associated with Delivered Fuel Heating System Replacement: Switching from fuel oil or propane heating systems to heat pumps results in operating cost savings that average about $1,100 per year, and these fuels are also subject to price volatility. Residents using these expensive delivered fuels should also be targeted for heat pump replacements.

Increased Operating Costs Compared to Methane Gas Heating Systems: With current gas and electric rates, heating loads, and building envelope characteristics, converting from methane gas to heat pump space heating systems would increase operating costs in New England states as well as NY, NJ, and DE, even with the increased efficiency of heat pump systems and accounting for AC use. The average annual operating cost increase ranges from around $100 (NJ) to $2,400 (ME). As noted, these results are subject to change with rising methane gas prices and evolving electricity rate design, such as Massachusetts' upcoming heat pump electricity rate.[56] The risk of higher operating costs for customers who switch from methane gas equipment to heat pumps points to the importance of rate reform as a long-term policy solution. In the near-term, states should implement strategies to ensure the low- and moderate-income (LMI) households that electrify do not experience increased energy burden. Near-term strategies include comprehensive retrofits that bundle heat pumps with weatherization and solar (including community solar), caps on customer bills or enrollment in other low-income rates, and continued access to fuel assistance for households that electrify.

Operating Cost Savings for Methane Gas Heating System Replacement in DC, MD, PA, and VA: Converting from methane gas to heat pump space heating systems would save $50 to $400 per year in operating costs in southern Mid-Atlantic states. The savings in these states are due to a combination of higher methane gas rates and low electric rates.

High Energy Cost Variance: Utility rates and delivered fuel costs vary significantly from state to state and across utilities within a state, and this analysis represents a single point in time in 2024. The "NESCAUM HVAC Operating Cost Calculator" is available to states upon request as a

[56] https://energynews.us/2024/10/01/more-good-news-for-heat-pumps-in-massachusetts-as-regulators-order-national-grid-to-develop-special-rate/

supplemental tool to determine operating costs for specific utility territories or rate structures within their state.[57]

Cost Trends Over Time

Market Actor Interviews

Energy Solutions interviewed 14 heat pump manufacturers, manufacturers' representatives, wholesale distributors, and installation contractors to understand key cost trends over the next decade for ASHP equipment and installation costs. These market actors offered information on AWHPs as well, and the report includes those findings.

Energy Solutions drafted an interview questionnaire to guide discussions with market actors. The questions aimed to better understand the key drivers of cost trends for equipment pricing and installation over the next decade. The full questionnaire is provided in Appendix B: Market Questionnaire.

Key Cost Trends Over Time

Commodity, regulatory, and labor costs were identified as having the greatest impact on heat pump installation costs. Exchange rates and global market realities were also cited as a cost factor. One manufacturer stated that incentives based on capacity should be outlawed because they incentivize inefficiently oversized systems. Another manufacturer stated that states have been identified as "electrification states" and "non-electrification states," and investments will follow those lines in the short- to mid-term. The following sections summarize feedback received in market actor interviews by topic.

MANUFACTURING TRENDS

Commodity costs dictate manufacturing costs and global markets demanding more copper and other key materials are increasing heat pump equipment costs. For example, data centers, electric vehicles, and batteries use similar commodities as heat pumps, including copper. A manufacturer who imports products stated that import tariffs are also increasing equipment costs.

Three manufacturers stated that the ASHP industry will not benefit further from economies of scale in manufacturing, as all major manufacturers have already built out manufacturing for US equipment production and are at capacity.

Another manufacturer stated that the rapid growth of window unit heat pump systems (also called room, window-mounted, saddle window, micro, inverter-driven, or portable heat pumps) creates an opportunity to revolutionize how multifamily apartments heat and cool in a more efficient way. This technology is still developing with only a few manufacturers making inverter-driven units. Projects are currently being completed at large apartment buildings with hundreds of window air conditioners that need replacement.[58] The supplemental and efficient heating

[57] Email elevin@nescaum.org to request access to the calculator.

[58] https://www.governor.ny.gov/news/governor-hochul-announces-installation-window-heat-pumps-new-york-city-public-housing

capabilities of window unit heat pumps are still not fully understood from an energy use or emissions perspective, but efficiently heating only occupied spaces may reduce heating costs and provide a lower cost heat pump retrofit solution. The manufacturer said there is a real business case for single family use, too, as these systems are exponentially less expensive than retrofitting a house's entire heating/cooling system to leverage heat pump efficiencies.

AWHP TRENDS

In contrast to ASHPs, one manufacturer stated that AWHP equipment costs will likely decrease once manufacturing comes to the United States, as European factories are currently supplying the US AWHP market. A distributor said that AWHP demand will increase as prices fall and then they will be more attractive as retrofits. AWHPs will continue to grow in the market, creating additional design and installation training needs.

A manufacturer's representative stated that the prevalence of hydronic heating in the Northeast, especially Massachusetts, leads to a logical transition to AWHP systems, but, presently, the technology has a small market share with low contractor awareness. Needing both plumbers and electricians for AWHP installations creates additional challenges to scaling this promising technology. The representative said that manufacturers are starting to make systems that can produce domestic hot water with indirect water heaters for storage off the same system used for space conditioning.

Another manufacturer's representative described their work with low-temperature radiant AWHP projects (using outlet water temperatures of 90 to 120°F) for affordable housing. They stated that current technology allows new construction to leverage low-temperature radiant AWHPs and that market has been growing for some time. This is distinct from the higher-temperature AWHPs that could be used in conjunction with existing cast iron radiators requiring water outlet temperatures of 130 to 160°F for effective space heating. The representative said that this low-temperature radiant setup is best suited for new construction and is more difficult and much more expensive in retrofits.

Despite the high cost of this technology, it has potential for installation cost savings by allowing retrofits to utilize existing hydronic distribution systems. The labor and material costs to install new piping or ducting is a significant portion of the AWHP total installation cost. A distributor stated that they expect AWHP equipment costs to be a realistic and cost-competitive option for many homes with existing hydronic systems in the future. Further developments in AWHP technology could increase the retrofit applicability of AWHPs, allowing for low-GWP refrigerants and high-temperature distribution system integration.

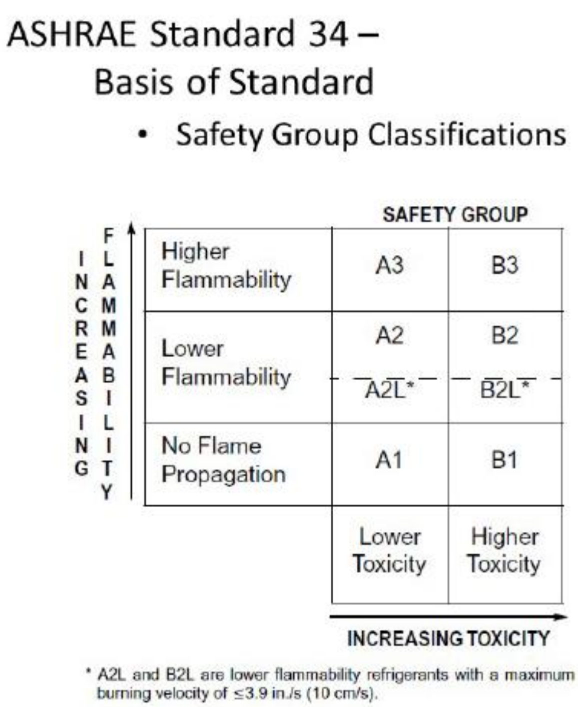
REFRIGERANT TRENDS

Safety regulations associated with the refrigerant transition were cited as a cost driver for heat pumps. A contractor stated that equipment costs might be 20 percent higher with new refrigerants, as discussed further below. One manufacturer described per- and polyfluoroalkyl substances (PFAS) in refrigerants as a significant cost issue, with possible cost increases associated with PFAS-free refrigerants.

New testing standards and refrigerant types affect both manufacturing and workforce costs. To comply with new EPA refrigerant global warming potential (GWP) regulations, which take effect in 2025, new A2L refrigerants (R-32 and R-454B) are currently being introduced across many manufacturers' products.[59] There is a tradeoff between higher-GWP, less-flammable refrigerants currently used in the US and lower-GWP, more-flammable refrigerants, including "natural" refrigerants such as propane.

Figure 7 summarizes ASHRAE safety classifications for refrigerants. A3 refrigerants are currently not legal to use in the US because safety regulations recognized elsewhere, including Europe, have not been adopted. Efforts are underway by manufacturers and other stakeholders to update regulations that are limiting the use of natural refrigerants such as propane, which would allow for a broader range of heat pump products and enable an industry shift to PFAS-free, low-GWP refrigerants.

FIGURE 7. ASHRAE STANDARD 34 REFRIGERANT SAFETY GROUP CLASSIFICATIONS[60]



[59] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-84/subpart-B

[60] Source: ASHRAE. Update on New Refrigerants Designations and Safety Classifications. November 2022.

Table 26 summarizes common refrigerant types and status in the United States.

Table 26. Refrigerant Properties

Use Status	Refrigerant	GWP	ASHRAE Class	Contains PFAS
Not Currently Permitted in US	R-290 / Propane	3	A3	No
Legacy	R-22	1,810	A1	Yes
	R-410A	2,088	A1	Yes
Being Introduced	R-32	675	A2L	No
	R-454B	466	A2L	Yes
	R-744 / CO_2	1	A1	No

Looking ahead, one manufacturer stated that an emerging technology, outdoor monobloc[61] AWHP systems, could significantly reduce operating costs and associated emissions impacts if regulators approve the use of R290 (propane), as propane refrigeration systems have a low GWP and typically have increased operating efficiency. The manufacturer cited "low probability" of fire or explosion incident as this equipment contains only 1 kg of charge, is pre-charged at the factory, and shipped as one unit. This means that the installation contractor does not charge the system with the A3 refrigerant, reducing the fire risk. CO_2 as a refrigerant is another upcoming trend, with this technology currently being deployed in Europe but not yet widely used in the US. One challenge with CO_2 refrigerants are the high operating pressures required and safety concerns associated with high pressure systems.

One Massachusetts-specific challenge is the lack of building code updates allowing for A2L refrigerants. All manufacturers either have updated their equipment to low-GWP refrigerant heat pumps or are currently engineering, manufacturing, and testing new equipment. The EPA has offered guidance on how states can handle the EPA-required transition to low-GWP refrigerants, and only four states have not passed legislation and promulgated regulations to support this transition, including Massachusetts in the OTR. Up-to-date refrigerant legislation progress can be found on the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) website.[62]

WORKFORCE TRENDS

One distributor mentioned significant concern about future heat pump sales growth due to labor shortages throughout the HVAC workforce. The distributor, who sells thousands of heat pumps in Massachusetts and New Hampshire, said there are not enough qualified contractors who can install heat pumps, and that the industry is struggling to train installers on quality installations.

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[61] A monobloc heat pump is a singular unit that contains all components, such as heat exchanger, evaporator, condenser, pumps, etc. within a single system that is typically sited outside the home.

[62] AHRI A2L Refrigerant Building Code Map: https://www.ahrinet.org/a2l-refrigerant-building-code-map?state=AL#map

Good contractors are turning down work because they are too busy. A concern is that heat pump projects do not come to fruition despite customer interest because there are not enough installers, which can also contribute to price increases due to supply and demand effects. Labor shortage issues can also be exacerbated by the additional need for electricians to perform electrical panel upgrades in homes without the capacity to support heat pumps.

Manufacturers are rolling out more trainings and the Mass Save® program requires a contractor to be listed on the [Heat Pump Installer Network (HPIN)] for installations to qualify for incentives. The HPIN requires contractors to show proof-of-attendance at a manufacturer cold-climate sizing training, proof of insurance, and an EPA 608 certification for refrigerant handling. Over 1,300 contractors in Massachusetts are on the HPIN, but a distributor stated that Massachusetts heat pump installation goals will require many more qualified installers.

All of the market actors interviewed view insufficient workforce as an overwhelming risk factor in the residential heat pump market, highlighting the need for substantial workforce development and training. Heat pump installations are generally more complex than a simple "box swap" boiler or furnace replacement, as the electrical capacity and distribution system need to be matched to the heat pump condensing unit. For example, in the case of plug-and-play (or plumb-and-play, as one manufacturer stated), retrofitting an existing oversized boiler system with an identically sized AWHP system would result in a grossly oversized expensive heat pump system that is far more expensive and inefficient to operate than the heat load requirements of the space. A market actor stated that contractors need to understand that each heat pump retrofit is different based on existing infrastructure, heat pump performance, and level of weatherization in the home. Installing a system using an accurate load calculation becomes even more important when promoting weatherization before retrofits, which reduces heating load and often renders existing heating system layouts obsolete.

PRICING TRENDS

In addition to contractor shortages driving up costs, a major manufacturer and a distributor stated that the contractor market, overall, continues to apply risk premiums for heat pump installations, as newer technologies and retrofit applications can create more risk. For example, heat pump installations might require more callbacks to troubleshoot until contractors become familiar with the technology. Additionally, as stated by a distributor, a contractor might be comfortable installing one manufacturer's equipment and then be hired to install another manufacturers' equipment with a different installation set-up. That risk or perceived risk can result in increased prices passed along to consumers.

A manufacturer said regions with the highest incentives have the highest installation costs, and that incentive program pressure to accelerate heat pump adoption may drive demand up and raise overall cost. A distributor said that the Mass Save® residential heat pump incentive, although generous with $1,250 per ton and $10,000 whole-home incentives available if fossil fuel heating is removed, does not cover the full cost of installation and homeowners are still paying "a decent amount" for cold-climate certified heat pumps.

A contractor stated that ducted heat pumps with four zones or more are the most expensive to install. These larger systems require customization to develop a properly sized and balanced system that meets the varied needs of space conditioning across differently sized rooms with varying heating loads. The contractor stated that all full-service contractors have equal costs, and that the availability of zero-percent financing is more important in customer acceptance of higher bid prices than rebates. The longstanding prevalence of the Mass Save® HEAT Loan is an important aspect of the Massachusetts residential heat pump market, and has financed retrofits that otherwise would not have been undertaken.

One contractor noted that their workforce is sufficient because they have invested heavily in their own training for many years, stating that proper planning is key to meeting increases in market scale. The need for electrical upgrades associated with heat pump installations has caused some HVAC installers to hire dedicated electrical upgrade estimators, contributing to the increase in overall heat pump installation costs. As customers have installed more electric technologies at scale, homes' electricity demand has increased, necessitating panel upgrades. Examples include air conditioning where previously there was none or only window AC units, heat pump water heaters (HPWH), more computers, and larger electronics like TVs and induction cooking technologies.

CUSTOMER AND CONTRACTOR TRENDS

A distributor stated that consumers are comfortable and interested in heat pumps overall while a manufacturer said more study would be needed to really understand developing consumer experiences and attitudes.

All contractors interviewed stated they are very busy and scheduling installations months out. Heat pumps are readily available at many distributors with no lead time issues for residentially sized systems. Two contractors stated the best current use case for heat pumps is homes heated with electricity or delivered fuels such as oil and propane, with western Massachusetts specifically cited as a market with strong growing demand. The payback for delivered fuel customers is better than for homes heated with methane gas. Contractors also reported energy security as a factor increasing heat pump demand among delivered fuel customers, since heat pump installation can relieve the stress of waiting for an oil or propane delivery.

Market actors also noted customer interest in gaining air conditioning with heat pumps. One contractor noted that there have been complaints of high utility costs with heat pumps in the cooling season, most likely associated with customers using air conditioning to cool too much and at too low a temperature, highlighting the importance of customer education on the benefits and costs associated with heat pumps.

One contractor noted a significant number of calls to help customers troubleshoot heat pump installations completed by other contractors where the systems were not working, or utility bills were significantly higher than expected. Another contractor noted that many customers prefer to keep their fossil fuel heating system as a backup for security or resiliency reasons, such as in the case of a power outage, and cost hedging. Contractors also identified pre-electrification barriers such as panel upgrade needs, insulation requirements, and electrical code upgrades that may be required in older homes.

Conclusions and Future Work

Installation Cost Challenges and Solutions

Across all OTR states and most HVAC equipment configurations, ASHPs have a higher upfront installation cost than fossil fuel heating systems – although they can begin to reach cost parity for customers that are also installing central ACs. Costs can be even higher when other upgrades, such as new distribution systems or electric panel and wiring updates, are needed to enable whole-home electrification. Installation costs can vary widely due to factors such as the complexity of the installation and the cost of labor in a given state. As noted in the market trends discussion, market actors also see insufficient workforce as an overwhelming risk factor in the residential heat pump market, which is likely contributing to higher installation costs at present.

WORKFORCE DEVELOPMENT

Substantial investments in workforce development and training are needed to increase the number of HVAC technicians, electricians, and plumbers working on ASHP and AWHP installations, as well as their comfort level to correctly size and install these often-complex systems. States can help by establishing networks of qualified contractors and promoting these contractors to customers. For example, the Mass Save program requires a contractor to be listed on the Heat Pump Installer Network (HPIN) for installations to qualify for incentives. The HPIN requires contractors to show proof-of-attendance at a manufacturer cold-climate sizing training, proof of insurance, and an EPA 608 certification for refrigerant handling.

HEAT PUMP INCENTIVE PROGRAMS

Incentive programs are also crucial to reduce the incremental measure cost that customers incur when purchasing a heat pump system. Table 27 provides a list of the currently available incentive programs throughout the OTR states, as of October 2024.[63] These programs are expected to expand in the coming years, particularly for low- and moderate-income (LMI) households that may be eligible for additional incentives from federally funded efforts such as the Inflation Reduction Act's Home Energy Rebates.[64]

TABLE 27. RESIDENTIAL HEAT PUMP HEATING AND COOLING REBATES BY STATE 2024

State	Statewide Program Name	Utilities	Customer Incentives*	Notes
Connecticut	Energize Connecticut	Eversource, United Illuminating (UI)	\$750-\$15,000	Equipment must be installed by contractor participating in utility installer network

[63] Some states include ground-source heat pumps in their residential heat pump incentive programs.

[64] States are beginning to launch federally funded programs that will support heat pump adoption https://www.energy.gov/save/home-upgrades

State	Statewide Program Name	Utilities	Customer Incentives*	Notes
Delaware	Energize Delaware	Delmarva Power, Chesapeake Utilities, Delaware Electric Co-Op, Delaware Municipal Electric Corporation	$550-$3,300	Home Energy Assessment required for qualified customers Equipment must be installed by contractor participating in utility installer network
DC	DC Sustainable Energy Utility	District of Columbia Sustainable Energy Utility	$250-$700	Equipment must be installed by contractor participating in utility installer network
Maine	Efficiency Maine	Central Maine Power, Versant Power, Eastern Maine Electric Cooperative	$2,000-$10,600	Equipment must be installed by contractor participating in the residential registered vendor program
Maryland	EmPOWER Maryland	Baltimore Gas and Electric (BGE), Delmarva Power, Pepco, Potomac Edison, Southern Maryland Electric Cooperative	$300-$1,300	Equipment must be installed by contractor participating in utility installer network
Massachusetts	Mass Save	Berkshire Gas, Cape Light Compact, Eversource, Liberty Utilities, National Grid, Until	$1,250 per ton up to $10,000	Equipment must be installed by contractor participating in utility installer network
New Hampshire	NHSaves	Eversource, Liberty Utilities, Until	Up to $2,500	Equipment must be installed by contractor participating in utility installer network
New Jersey	NA	PSE&G, Atlantic City Electric, Jersey Central Power and Light	$210-$1,500	Equipment must be installed by contractor participating in utility installer network
New York	NYS Clean Heat Rebate Program	New York State Electric and Gas, National Grid, ConEdison	$700-$8,000	Rebates eligible to customers who install qualifying equipment

State	Statewide Program Name	Utilities	Customer Incentives*	Notes
				by participating contractors
Pennsylvania	NA	Duquesne Light, First Energy, PECO, PPL, UGI Electric	$150-$1,250	Rebates eligible to customers who install qualifying equipment by participating contractors
Rhode Island	Clean Heat Rhode Island	Rhode Island Office of Energy Resources, Rhode Island Energy, Pascoag Utility District, Block Island Power	$750-$10,000	Equipment must be installed by a contractor listed on the Clean Heat Rhode Island Heat Pump Installer Network
Vermont	Efficiency Vermont	Green Mountain Power, plus 16 electric distribution utilities	$350-$6,500	Must be installed by an Efficiency Excellence Network contractor

*Rebate varies by eligible equipment and utility offering

HEAT PUMP INCENTIVE DESIGN CONSIDERATIONS

There are several details to consider when designing an energy efficiency or decarbonization program to promote adoption of heat pumps. The following are best practices observed in heat pump programs throughout the United States, based on Energy Solutions' experience as a program implementer for numerous heat pump incentive programs.

- **Set incentives to cover the majority of the incremental cost:** In Energy Solutions' experience, we have observed successful program influence of incentives when the incentive covers over 60 percent of the incremental cost of the equipment, with incremental cost being the difference between baseline efficiency and measure efficiency equipment.
- **Provide incentives per unit instead of per ton for residential equipment:** Manufacturers and distributors have both stated that equipment incentives per ton for residential equipment can encourage oversizing and that providing an incentive per unit instead of per ton will help mitigate oversizing of heat pumps.
- **Include incentives to cover installation cost and infrastructure upgrades for electrification measures:** When incentivizing measures that convert from fossil fuels to heat pumps, it is important to consider the added cost of installation and potential infrastructure upgrades such as new electrical circuits and panels when developing incentives. Installation costs (including labor costs and supporting upgrades such as

panels, wiring, and distribution systems) can be a major component of overall project cost when electrifying, and programs that offer incentives for these associated are more successful at influencing conversions from fossil fuel heating to heat pumps.

- **Ensure delivered fuel customers are eligible for incentives:** Incentive programs that include delivered fuels as eligible baseline equipment can reach a larger portion of the market than programs that require customers to have existing methane gas or electric equipment. Utility programs are often constrained to serving customers with methane gas and electric heating equipment due to regulatory requirements, but some programs have expanded eligibility to include delivered fuel customers.
- **Increase incentives and technical support for LMI customers:** LMI customers are often the last customers to electrify their heating systems without direct program intervention. Existing weatherization programs serving low-income customers can be expanded to include electrification measures such as ASHP installations and associated costs, and programs can also consider enhanced incentives for moderate-income customers. For example, Efficiency Maine offers sliding-scale incentives for residential heat pumps: 80 percent of project cost up to $8,000 for low-income customers, 60 percent of project cost up to $6,000 for moderate-income customers, and 40% of project cost up to $4,000 for all other customers.[65] It is important to include LMI customers in incentive programs to avoid unintended consequences such as subjecting them to higher gas rates as wealthier customers other customers electrify and exit the methane gas system.

Operating Cost Challenges and Solutions

While operating costs vary widely from state to state and across utility service territories, switching from fuel oil, propane, or electric resistance heating systems to ASHPs results in significant operating cost savings across all OTR states. Customers using these expensive heating fuels should be targeted for heat pump replacements.

The picture is more complicated for customers using methane gas. With current gas and electric rates, heating loads, and building envelope characteristics, converting from methane gas to ASHPs generally results in higher operating costs in New England states and NY, NJ, and DE, and slightly lower operating costs in DC, MD, PA, and VA.

The risk of higher operating costs for customers who switch from methane gas equipment to heat pumps points to the importance of rate reform as a policy solution. Several states are considering new rate designs, such as Massachusetts' upcoming heat pump electricity rate, to improve the economics for heat pumps.[66] In the near-term, states should implement strategies to ensure that LMI households that electrify do not experience increased energy burden. Strategies to protect customers against higher operating costs include promoting comprehensive retrofits that bundle heat pumps with weatherization and solar (including community solar), caps on

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65 https://www.efficiencymaine.com/at-home/whole-home-heat-pump-incentives/

66 https://energynews.us/2024/10/01/more-good-news-for-heat-pumps-in-massachusetts-as-regulators-order-national-grid-to-develop-special-rate/

customer bills or enrollment in other low-income rates, and continued access to fuel assistance for households that electrify.

Future Work

This study focused on residential HVAC equipment, specifically replacing fossil-fuel heating equipment with whole-home ASHP systems. Future work could analyze commercial equipment, auxiliary heat sources, cold climate heat pump specification, lifecycle impacts, and/or aggregate statewide impacts:

- A similar analysis of commercial space heating equipment with heat pump technologies could support policies to address air pollution and GHG emissions from commercial HVAC equipment.
- The operating cost analysis generated in this report assumes that the heat pump handles the entire heating load of the building. Many heat pump installations use an auxiliary heat source to supplement the output of the heat pump, often retaining the existing fossil fuel system as a backup. A future study could analyze the operating cost of systems that incorporate auxiliary heat and the factors that affect heat pump sizing in that scenario.
- A similar analysis comparing the installation and operating costs for cold-climate air source heat pumps (ccASHPs) and traditional ASHPs would help understand the impacts ccASHPs may have on the cost comparisons of this report. Including a seasonal operating cost analysis that includes low temperature performance ratings would provide more insight into heat pump operating costs in cold climates.
- While this study focused on upfront costs and first-year operating costs, future work could analyze impacts over the lifecycle of the equipment. Examples of lifecycle metrics could include lifecycle emissions reductions, net present value over the equipment lifetime (from a consumer or societal point of view), and lifecycle net costs per ton of avoided emissions.
- A study of aggregate statewide impacts would consider the prevalence of each existing heating system type for a particular state. This additional analysis would help states understand the potential statewide impacts and costs, relative to their building stock, associated with adopting policies to address building emissions. Aggregate impacts analysis could also be used to develop estimates of statewide aggregate costs per ton of avoided pollution. Aggregate impacts analysis could include lifecycle impact analysis or other statewide impacts analysis that is conducted over a longer time horizon to account for changes over time in equipment costs, energy prices, and the emissions intensity of electricity.

Appendix A: Bibliography

Literature Reviewed	Author	Annotation
Value of Prioritizing Equitable, Efficient Building Electrification	Fadali et al., 2024 American Council for an Energy Efficient Economy	This in-depth study focuses on the impact of prioritizing (vs. not prioritizing) electrification of low and median income (LMI) households. It looks at the effects on the households, on overall savings, on societal benefits and grid impacts and pricing. The benefit of prioritizing LMI is profound, lowering overall costs, increasing overall savings, and showing positive impacts on every metric. Not prioritizing LMI often not only showed less positive impact, but in many cases, had a negative impact (e.g., residential electrification produces $96 billion in net cost savings when LMI is included, but a net cost increase of $88 billion when they are not). The report provides detailed cost analyses of electrification costs and benefits on a national level along with weighted regional data.
Cost of Electrification a State-by-State Analysis and Results	Tanton, 2020 T^2 Associates	The study reports the capital cost associated with "electrification" for states and the US. The study includes estimates of costs to completely electrify households (I.e. no gas appliance) documented by state. This report is a continuation of a prior 2017 study: ""Levelized Cost of Energy: Expanding the Menu to Include Direct Use of Methane Gas." Prior study found that "natural gas has levelized costs significantly less than any electricity option, and often by a factor of two."
The Economics of Building Electrification	Davis, 2022 Kleinman Center for Energy Policy	This short white paper looks at the growth of electric heating since the 1950s and uses linear regression models to explain the growth trends. The paper then uses a Discrete Choice Model to determine by region and state a "Willingness To Pay" scale (WTP), to map how much homeowners would be willing to pay to avoid an electric mandate.

Literature Reviewed	Author	Annotation
		Geography is the largest determinant of WTP with colder northern states with gas and oil as predominant fuels far more willing to pay to avoid a mandate than warmer southern states where electric heat is already the most common form of space heating.
NY Building Electrification and Decarbonization Costs	Rosen et al., 2022 Rosen Consulting Group	This report summarizes the results of a literature review and subsequent analysis, tailored to New York state, of the costs of whole-home electrification. The authors conducted an extensive review of existing literature related to building electrification and decarbonization costs, nationally and across different states and markets around the country. The report presents typical low-end and high-end costs for retrofits and new construction.
The Electric Ceiling: Limits and Costs of electrification	Rapson et al., 2022 Federal Reserve Bank, Dallas	This paper is an in-depth look at the macro-economics of electrification and decarbonization. It considers both public and private costs and the impacts of increased adoption on costs. The study considers the two major aspects of electrification: converting technologies to electric fuel and decarbonizing the grid. The study looks at the impact of costs and the resulting cost increases of increased adoption. The paper looks at barriers in the market and the challenges they present to policymakers and industry. In the decarbonization aspect, the paper looks at the tremendous impact on the transmission infrastructure, and the drastic rate of cost increases as renewable generation grows. The paper also looks at multiple externalities which impact both financial and social costs.
Ductless Mini-Split Heat Pump Cost Study	Navigant, 2018	The goal of this study was to evaluate the energy-efficiency related total and incremental costs of single-family home installations of DMSHP systems currently rebated through the Massachusetts Residential Heating and Cooling program. This study relied on three main data sources: 1) a survey of HVAC contractors in Massachusetts, 2) retail prices gathered by webscraping, and 3) a sample of scanned invoices for system installations that were rebated through the

Literature Reviewed	Author	Annotation
		program. This study combines data from these three sources to construct cost-efficiency curves that describe the total installed cost of DMSHP systems across a range of different system sizes and efficiency levels.
Heat Pump Friendly Cost Based Designs	Sergici et al., 2023 Energy System Integration Group	This study examines "the role of alternative “cost-based” and “cost-reflective” electricity rate designs in improving the economics of heat pumps by reducing their operating costs."
The Economics of Electrifying Buildings	Billamoria et al., 2017 Rocky Mountain Institute	This paper analyzes the economics and carbon impacts of the electrification of residential space and water heating both with and without demand flexibility the ability to shift energy consumption in time to support grid needs. It compares electric space and water heating to fossil fuels for both new construction and home retrofits under various electric rate structures in four locations: Oakland, California; Houston, Texas; Providence, Rhode Island; and Chicago, Illinois. The report focuses on the residential sector, which makes up the majority of carbon emissions from buildings’ fossil fuel use.
Ductless Mini-Split Heat Pump Impact Evaluation	Cadmus, 2016	The Massachusetts and Rhode Island Program Administrators (PAs) commissioned the authors to conduct an in-situ evaluation of ductless mini-split heat pumps (DMSHPs). The evaluation team studied Massachusetts and Rhode Island homes that participated in local energy-efficiency incentive programs. Research Objectives: the evaluation sought to address many utility and consumer questions about DMSHPs, focusing on power and energy consumption, heat output, efficiency, and interactions with existing HVAC equipment. The specific research questions follow: How much energy is being saved with the average installation of a DMSHP through the programs? What are the relevant baseline equipment configurations and associated energy consumptions and load shapes? During each season, when are DMSHPs operating, how much energy are they consuming, and how

Literature Reviewed	Author	Annotation
		much heating and cooling are they providing? How does DMSHP performance correlate with rated capacity, rated efficiency, and ambient conditions? How do cold-climate DMSHPs and standard unit performances compare? How does unit sizing affect heating performance? How do DMSHPs interact with central heating systems? What factors limit the use and performance of DMSHPs? Are program contractors sizing DMSHPs properly?
Updated Buildings Sector Appliance and Equipment Costs and Efficiencies	Energy Information Administration, 2023	This report is a detailed study of the base costs of residential and commercial HVAC equipment and based on the Energy Information Agencies Residential and Commercial Building Energy Consumption Surveys (RECS and CBECS). The report provides estimates in tables for each equipment type. The tables represent the current and projected efficiencies for residential and commercial building equipment ranging from the installed base in 2012 and 2018 (for commercial products) or 2015 and 2020 (for residential products) to the highest efficiency equipment that is expected to be commercially available by 2050, assuming incremental adoption.
Residential ccASHP Building Electrification Study	Veilleux et al., 2023 Cadmus	The report is a study, in the form of a PowerPoint presentation. Key Objectives of study are: Are ccASHP systems meeting home comfort needs? Are ccASHPs efficiently delivering heating and cooling? How does performance differ between applications? What are the grid impacts of ccASHP market scale up? What continued challenges with customer and contractor experience need to be addressed to scale the market?
Emerging Heat Pump Technologies	Northeast Energy Efficiency Partnerships, 2024	This report discusses air source heat pump technologies that are up-and-coming in functionality and availability for applications in the Northeast and Mid-Atlantic region. Relevant heat pump technologies discussed, i.e., HVAC applications, include: Cold Climate Micro Heat Pumps, Commercial Packaged Heat Pumps (RTU's that replace furnaces), Air to Water Heat Pumps, and Combi Heat Pumps. The report

Literature Reviewed	Author	Annotation
		outline benefits and challenges for each technology type and identifies relevant applications.
Energy Savings, Consumer Economics, and Greenhouse Gas Emissions Reductions from Replacing Oil and Propane Furnaces and Boilers with Air Source Heat Pumps	Nadel, 2018 American Council for an Energy Efficient Economy	This study looks at the energy, financial, and greenhouse gas emissions (GHG) impacts of converting oil and propane furnaces, boilers, and water heaters to high-efficiency electric heat pumps, finding that such replacements will often reduce total source energy use (including energy used at power plants to generate electricity) as long as power comes from an efficient generating plant, such as a combined-cycle methane gas plant, or from renewable energy generation. The study considers four replacement scenarios, with the impacts, barriers, and cost benefits of each addressed.
Home Heat Pumps in Massachusetts	Lopez et al., 2019 Applied Economics Clinic	The study estimates and compares the costs of either a) installing and operating a new electric heat pump system, or b) installing and operating a new gas furnace and electric central AC unit. It explores cost with/without the Mass Save rebate. This study assumes that Massachusetts homeowners replacing their heating systems will consider replacing their room units with central AC or updating an aging central AC system.
Heat Pumps Can Lower Energy Bills in Maryland Today	Rocky Mountain Institute, 2024	This web article highlights Executive Orders by the Governor of Maryland and their impacts. The orders call for a zero-emission heating equipment standard, and a clean heat standard. The article summarizes how heat pumps and heat pump water heaters cost less to operate. The article also notes the impact of incentives on affordability and life cycle costs of Heat Pump Water Heaters. Heat Pump paybacks and affordability are also noted.
Technical Support Document: Energy Efficiency Program for Consumer Products and	US Dept. of Energy, 2022	This report is published by the DOE to support development of energy - efficiency standards and programs. The Technical Support Document (TSD) describes in detail the approaches to and results of preliminary

Literature Reviewed	Author	Annotation
Commercial and Industrial Products: Consumer Boilers		activities that DOE performed in investigating amended energy conservation standards for consumer boilers.
Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Products: Oil, Electric, and Weatherized Gas Furnaces	US Dept. of Energy, 2022	This report is published by the DOE to support development of energy-efficiency standards and programs. The Technical Support Document (TSD) describes in detail the approaches to and results of preliminary activities that the US DOE (DOE) performed in investigating amended energy conservation standards for oil, electric, and weatherized gas furnaces.
Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Products: Residential Central Air Conditioners and Heat Pumps.	US Dept. of Energy, 2022	This report is published by the DOE to support development of energy-efficiency standards and programs. The Technical Support Document (TSD) describes in detail the approaches to and results of preliminary activities that the US DOE (DOE) performed in investigating amended energy conservation standards for residential central air conditioners and heat pumps.

Appendix B: Market Questionnaire

The following questions focus on residential-scale air-source heat pumps, generally less than 5.4-ton air-source heat pumps. We are interested in both near-term trends in the next one to two years and longer-term trends looking ahead to 2030 or beyond.

- Efficiencies: What trends can we expect in heat pump efficiencies over the next decade?
  - Potential prompt: We know that a new test procedure for heat pumps is just being finalized and codified by DOE which should be helpful moving forward to support heat pump efficiency representation, especially in cold climates. Are there other efficiency trends we should be aware of?

- Innovative Product Design: Are there any innovative product designs coming out that could streamline installation and lower installation costs?
  - Any product development that makes use of existing ductwork or distribution systems?
  - Will ductless heat pump replacements have the potential to reuse the existing ductless distribution system?
  - Will any product lines become more plug-and-play?
  - Will there be a greater range of equipment sizes, including smaller equipment, to meet a wider variety of applications?
  - Will heat pump to heat pump replacement as older heat pumps need to be replaced cost less than new heat pump installations? What about AC to HP?
  - Variable capacity heat pumps?
  - Air-to-water heat pumps?

- <u>Equipment costs</u>: What are the primary drivers for equipment costs and equipment pricing?
  - Any regional price differences that are notable?
  - What are you seeing for average distributor markups?
  - What are you seeing for average contractor markups?
  - How do you foresee heat pump equipment costs changing in the next decade?
    - ASHP
    - AWHP
    - Any other differences between equipment types
- <u>Factors that affect equipment costs</u>: What factors in the industry will affect equipment costs over the next decade? (Refrigerants, raw materials, microchips, volume produced per year)
- <u>Component costs</u>: Are there any specific components that may have impacts on overall heat pump equipment costs?
  - Examples: compressors, controls, fan motors, refrigerants, cost of steel
- <u>Current vs Future Market Size</u>: How might increased production volume in the future (due to increased market adoption of heat pumps) affect cost per heat pump?
  - (for those who sell central AC units (CACs) as well) Are you expecting changes in the proportion of sales between CAC and HP?

- Refrigerants: What major advancements in refrigerants can we expect to see in the next decade?
    - How will that affect heat pump costs?
    - How prepared are you to comply with forthcoming low-GWP refrigerant regulations?
    - What low GWP refrigerants are you considering in order to comply with new regulations?
    - Are ultra-low GWP (<10) units coming to the market? If so, when (5-10 years)?
    - What are the major threats/opportunities related to refrigerants that you are looking at in the next 5-10 years?
- Consumer behavior: Do you anticipate any changes to consumer purchasing decisions or patterns based on the greater prevalence of heat pumps?
    - Any equipment choice trends we should note, such as increased interest in a particular equipment type or function?
- Installation considerations: Do you anticipate sufficient workforce development and training to support increased adoption of heat pumps? Are there any anticipated changes to installation costs associated with trends either in the workforce or product development?
- Fail safe improvements: What advancements, whether plug-and-play solutions or improved training and installation practices, are possible and practical to overcome poor sizing and installation and still deliver expected efficiencies/useful life?
- Hydronic retrofits: What advancements will be made in AWPHs to allow for easier and broader retrofit opportunities for hydronic systems to heat pumps? When (by what year) do you anticipate more plug-and-play replacements for boilers to be available in the market?

Contractor Questions

- Installation cost impacts: What are the primary drivers of installation costs?
    - Discuss with contractor how they approach pricing with the customer.
    - Seeing any major price differences across states?
    - How do factors like permits/inspections, fees, and historical building retrofits affect installation costs?
    - What types of homes or installations are the costliest?
    - Do you design your own systems, or do you hire out a design engineer / design firm?
    - Do design costs decrease as you become more familiar with heat pump system configuration?
    - How competitive is the market for pricing?
    - How do prices vary between ducted and ductless installations?
    - Are there any business costs associated with customer acquisition?
    - Are there any major trends or strategies that are likely to affect installation cost of heat pumps over the next decade?
    - How do rebates affect your prices?
    - Does rebate paperwork factor into pricing?
    - Do rebates help customers accept higher bid prices?
- Workforce education and training: Are there any workforce training and education factors that could impact installation cost of heat pumps over the next decade?

  - Do you have sufficient workforce? If not, how does this impact pricing?
  - If the market increases in scale 2-10x, how would this impact workforce availability and pricing?
  - What effects does limited workforce availability have on costs?
- Refrigerant regulations: How might upcoming refrigerant regulations impact installation cost? Is this something you are tracking?
- Technology changes: Do you anticipate any major shifts or changes in technology that would increase or decrease installation costs?
  - Examples: more sophisticated commissioning, quicker install, longer install, variable capacity equipment

Massachusetts-Specific Costs
Prompt by asking about major costs that affect their business, then list some of these as examples. Try to touch on as many as possible.

- Equipment
  - Heat pump cost (outdoor unit)
  - Indoor unit costs/air handlers, and more.
  - Other distribution costs, such as ducting
- Labor
  - Outdoor unit installation
  - Indoor unit installation
  - Distribution system installation
  - System commissioning
  - Travel
- Permitting costs (direct cost as well as labor cost)
- Design costs
  - External (e.g., manual J analysis)
  - Internal (layout planning, and more)
- Soft costs
  - Customer identification (e.g., advertising, outreach, and more)
  - Cost to provide quotes, follow-up, and more
  - Business overhead
  - Profit
  - Temporary inflation due to pandemic, supply chain delays, and more
  - Rebate effect on pricing (i.e., do rebates add any gross costs to project?)
  - High demand price effects (i.e., if consumer demand exceeds contractor availability, does this increase project costs?)
- Related action costs
  - Electrical upgrades (wiring and panel upgrades necessary to accommodate ASHP installation)

Appendix C: Supporting Data Tables

Measure Equipment Unit Costs

CT	AWHP	$24,670
	Mini-Multi Split (1-zone)	$8,844
	Mini-Multi Split (3-zones)	$11,898
	Packaged Unitary HP	$9,839
	Split Unitary HP	$8,199
DC	AWHP	$24,618
	Mini-Multi Split (1-zone)	$8,825
	Mini-Multi Split (3-zones)	$11,873
	Packaged Unitary HP	$9,818
	Split Unitary HP	$8,182
DE	AWHP	$24,952
	Mini-Multi Split (1-zone)	$8,945
	Mini-Multi Split (3-zones)	$12,034
	Packaged Unitary HP	$9,952
	Split Unitary HP	$8,293
MA	AWHP	$24,204
	Mini-Multi Split (1-zone)	$8,677
	Mini-Multi Split (3-zones)	$11,673
	Packaged Unitary HP	$9,653
	Split Unitary HP	$8,044
MD	AWHP	$24,494
	Mini-Multi Split (1-zone)	$8,780
	Mini-Multi Split (3-zones)	$11,813
	Packaged Unitary HP	$9,769
	Split Unitary HP	$8,141
ME	AWHP	$24,089
	Mini-Multi Split (1-zone)	$8,635
	Mini-Multi Split (3-zones)	$11,618
	Packaged Unitary HP	$9,607
	Split Unitary HP	$8,006
NH	AWHP	$24,337
	Mini-Multi Split (1-zone)	$8,724
	Mini-Multi Split (3-zones)	$11,737
	Packaged Unitary HP	$9,706
	Split Unitary HP	$8,089
NJ	AWHP	$24,042
	Mini-Multi Split (1-zone)	$8,619
	Mini-Multi Split (3-zones)	$11,595
	Packaged Unitary HP	$9,589
	Split Unitary HP	$7,991
NY	AWHP	$24,431
	Mini-Multi Split (1-zone)	$8,758
	Mini-Multi Split (3-zones)	$11,783
	Packaged Unitary HP	$9,744
	Split Unitary HP	$8,120
PA	AWHP	$24,185
	Mini-Multi Split (1-zone)	$8,670
	Mini-Multi Split (3-zones)	$11,664
	Packaged Unitary HP	$9,646
	Split Unitary HP	$8,038
RI	AWHP	$24,886
	Mini-Multi Split (1-zone)	$8,921
	Mini-Multi Split (3-zones)	$12,002
	Packaged Unitary HP	$9,925
	Split Unitary HP	$8,271

Measure Equipment Unit Costs

VA	AWHP	$24,650
	Mini-Multi Split (1-zone)	$8,837
	Mini-Multi Split (3-zones)	$11,888
	Packaged Unitary HP	$9,831
	Split Unitary HP	$8,192
VT	AWHP	$24,029
	Mini-Multi Split (1-zone)	$8,614
	Mini-Multi Split (3-zones)	$11,588
	Packaged Unitary HP	$9,583
	Split Unitary HP	$7,986

Baseline Equipment Unit Costs

		with AC	without AC
CT	Boiler - Fuel Oil - Hydronic-High-T	$5,270	$2,220
	Boiler - NG & Propane - Hydronic-High-T	$5,257	$2,207
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$5,257	$2,207
	Furnace - Fuel Oil	$5,855	$2,806
	Furnace - NG & Propane	$5,289	$2,240
	Zonal Electric Resistance - Electric	$7,160	$4,111
DC	Boiler - Fuel Oil - Hydronic-High-T	$5,259	$2,216
	Boiler - NG & Propane - Hydronic-High-T	$5,246	$2,203
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$5,246	$2,203
	Furnace - Fuel Oil	$5,843	$2,800
	Furnace - NG & Propane	$5,278	$2,235
	Zonal Electric Resistance - Electric	$7,145	$4,102
DE	Boiler - Fuel Oil - Hydronic-High-T	$5,330	$2,246
	Boiler - NG & Propane - Hydronic-High-T	$5,317	$2,233
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$5,317	$2,233
	Furnace - Fuel Oil	$5,922	$2,838
	Furnace - NG & Propane	$5,350	$2,265
	Zonal Electric Resistance - Electric	$7,242	$4,158
MA	Boiler - Fuel Oil - Hydronic-High-T	$5,171	$2,179
	Boiler - NG & Propane - Hydronic-High-T	$5,158	$2,166
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$5,158	$2,166
	Furnace - Fuel Oil	$5,745	$2,753
	Furnace - NG & Propane	$5,189	$2,198
	Zonal Electric Resistance - Electric	$7,025	$4,033
MD	Boiler - Fuel Oil - Hydronic-High-T	$5,232	$2,205
	Boiler - NG & Propane - Hydronic-High-T	$5,219	$2,192
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$5,219	$2,192
	Furnace - Fuel Oil	$5,813	$2,786
	Furnace - NG & Propane	$5,252	$2,224
	Zonal Electric Resistance - Electric	$7,109	$4,082
ME	Boiler - Fuel Oil - Hydronic-High-T	$5,146	$2,168
	Boiler - NG & Propane - Hydronic-High-T	$5,133	$2,156
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$5,133	$2,156
	Furnace - Fuel Oil	$5,717	$2,740
	Furnace - NG & Propane	$5,165	$2,187
	Zonal Electric Resistance - Electric	$6,992	$4,014
NH	Boiler - Fuel Oil - Hydronic-High-T	$5,199	$2,191
	Boiler - NG & Propane - Hydronic-High-T	$5,186	$2,178
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$5,186	$2,178
	Furnace - Fuel Oil	$5,776	$2,768
	Furnace - NG & Propane	$5,218	$2,210
	Zonal Electric Resistance - Electric	$7,064	$4,056
NJ	Boiler - Fuel Oil - Hydronic-High-T	$5,136	$2,164
	Boiler - NG & Propane - Hydronic-High-T	$5,123	$2,151
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$5,123	$2,151
	Furnace - Fuel Oil	$5,706	$2,734
	Furnace - NG & Propane	$5,155	$2,183
	Zonal Electric Resistance - Electric	$6,978	$4,006
NY	Boiler - Fuel Oil - Hydronic-High-T	$5,219	$2,199
	Boiler - NG & Propane - Hydronic-High-T	$5,206	$2,186
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$5,206	$2,186
	Furnace - Fuel Oil	$5,799	$2,779
	Furnace - NG & Propane	$5,238	$2,218
	Zonal Electric Resistance - Electric	$7,091	$4,071

Baseline Equipment Unit Costs

		with AC	without AC
PA	Boiler - Fuel Oil - Hydronic-High-T	$5,166	$2,177
	Boiler - NG & Propane - Hydronic-High-T	$5,154	$2,164
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$5,154	$2,164
	Furnace - Fuel Oil	$5,740	$2,751
	Furnace - NG & Propane	$5,185	$2,196
	Zonal Electric Resistance - Electric	$7,020	$4,030
RI	Boiler - Fuel Oil - Hydronic-High-T	$5,316	$2,240
	Boiler - NG & Propane - Hydronic-High-T	$5,303	$2,227
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$5,303	$2,227
	Furnace - Fuel Oil	$5,907	$2,830
	Furnace - NG & Propane	$5,336	$2,259
	Zonal Electric Resistance - Electric	$7,223	$4,147
VA	Boiler - Fuel Oil - Hydronic-High-T	$5,266	$2,219
	Boiler - NG & Propane - Hydronic-High-T	$5,253	$2,206
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$5,253	$2,206
	Furnace - Fuel Oil	$5,850	$2,803
	Furnace - NG & Propane	$5,285	$2,238
	Zonal Electric Resistance - Electric	$7,155	$4,108
VT	Boiler - Fuel Oil - Hydronic-High-T	$5,133	$2,163
	Boiler - NG & Propane - Hydronic-High-T	$5,120	$2,150
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$5,120	$2,150
	Furnace - Fuel Oil	$5,703	$2,733
	Furnace - NG & Propane	$5,152	$2,182
	Zonal Electric Resistance - Electric	$6,974	$4,004

Measure Equipment Total Cost of Labor and Materials by State

		Excludes New Distribution System Costs		Includes New Distribution System Costs	
		No Panel Upgrade	With Panel Upgrade	No Panel Upgrade	With Panel Upgrade
CT	AWHP	$31,908	$34,620	$36,300	$39,013
	Mini-Multi Split (1-zone)	$5,457	$8,169	$7,518	$10,230
	Mini-Multi Split (3-zones)			$4,565	$7,278
	Packaged Unitary HP	$470	$3,182	$2,531	$5,243
	Split Unitary HP	$1,406	$4,118	$3,467	$6,179
DC	AWHP	$24,533	$26,618	$27,910	$29,996
	Mini-Multi Split (1-zone)	$4,195	$6,281	$5,780	$7,866
	Mini-Multi Split (3-zones)			$3,510	$5,596
	Packaged Unitary HP	$361	$2,447	$1,946	$4,031
	Split Unitary HP	$1,081	$3,166	$2,665	$4,751
DE	AWHP	$30,074	$32,630	$34,214	$36,770
	Mini-Multi Split (1-zone)	$5,143	$7,700	$7,085	$9,642
	Mini-Multi Split (3-zones)			$4,303	$6,859
	Packaged Unitary HP	$443	$2,999	$2,385	$4,942
	Split Unitary HP	$1,325	$3,881	$3,267	$5,824
MA	AWHP	$33,733	$36,601	$38,377	$41,244
	Mini-Multi Split (1-zone)	$5,769	$8,636	$7,948	$10,815
	Mini-Multi Split (3-zones)			$4,826	$7,694
	Packaged Unitary HP	$497	$3,364	$2,675	$5,543
	Split Unitary HP	$1,486	$4,354	$3,665	$6,532
MD	AWHP	$22,631	$24,555	$25,746	$27,670
	Mini-Multi Split (1-zone)	$3,870	$5,794	$5,332	$7,256
	Mini-Multi Split (3-zones)			$3,238	$5,162
	Packaged Unitary HP	$333	$2,257	$1,795	$3,719
	Split Unitary HP	$997	$2,921	$2,459	$4,383
ME	AWHP	$23,820	$25,845	$27,099	$29,124
	Mini-Multi Split (1-zone)	$4,074	$6,099	$5,612	$7,637
	Mini-Multi Split (3-zones)			$3,408	$5,433
	Packaged Unitary HP	$351	$2,376	$1,889	$3,914
	Split Unitary HP	$1,049	$3,074	$2,588	$4,613
NH	AWHP	$25,057	$27,187	$28,506	$30,636
	Mini-Multi Split (1-zone)	$4,285	$6,415	$5,903	$8,033
	Mini-Multi Split (3-zones)			$3,585	$5,715
	Packaged Unitary HP	$369	$2,499	$1,987	$4,117
	Split Unitary HP	$1,104	$3,234	$2,722	$4,852
NJ	AWHP	$37,465	$40,650	$42,622	$45,807
	Mini-Multi Split (1-zone)	$6,407	$9,592	$8,827	$12,012
	Mini-Multi Split (3-zones)			$5,360	$8,545
	Packaged Unitary HP	$552	$3,736	$2,971	$6,156
	Split Unitary HP	$1,651	$4,835	$4,070	$7,255
NY	AWHP	$44,652	$48,448	$50,799	$54,595
	Mini-Multi Split (1-zone)	$7,636	$11,432	$10,520	$14,316
	Mini-Multi Split (3-zones)			$6,389	$10,185
	Packaged Unitary HP	$657	$4,453	$3,541	$7,337
	Split Unitary HP	$1,967	$5,763	$4,851	$8,647
PA	AWHP	$31,996	$34,716	$36,401	$39,121
	Mini-Multi Split (1-zone)	$5,472	$8,192	$7,538	$10,258
	Mini-Multi Split (3-zones)			$4,578	$7,298
	Packaged Unitary HP	$471	$3,191	$2,538	$5,258
	Split Unitary HP	$1,410	$4,130	$3,476	$6,196

Measure Equipment Total Cost of Labor and Materials by State

		Excludes New Distribution System Costs		Includes New Distribution System Costs	
		No Panel Upgrade	With Panel Upgrade	No Panel Upgrade	With Panel Upgrade
RI	AWHP	$31,174	$33,824	$35,466	$38,116
	Mini-Multi Split (1-zone)	$5,331	$7,981	$7,345	$9,995
	Mini-Multi Split (3-zones)			$4,460	$7,110
	Packaged Unitary HP	$459	$3,109	$2,472	$5,122
	Split Unitary HP	$1,373	$4,023	$3,387	$6,037
VA	AWHP	$19,957	$21,653	$22,704	$24,400
	Mini-Multi Split (1-zone)	$3,413	$5,109	$4,702	$6,398
	Mini-Multi Split (3-zones)			$2,855	$4,552
	Packaged Unitary HP	$294	$1,990	$1,583	$3,279
	Split Unitary HP	$879	$2,576	$2,168	$3,865
VT	AWHP	$24,136	$26,188	$27,459	$29,510
	Mini-Multi Split (1-zone)	$4,128	$6,179	$5,686	$7,738
	Mini-Multi Split (3-zones)			$3,453	$5,505
	Packaged Unitary HP	$355	$2,407	$1,914	$3,966
	Split Unitary HP	$1,063	$3,115	$2,622	$4,674

Baseline Equipment Total Cost of Labor and Materials by State

		Excludes New Distribution System Costs		Includes New Distribution System Costs	
		with AC	without AC	with AC	without AC
CT	Boiler - Fuel Oil - Hydronic-High-T			$6,992	$3,666
	Boiler - NG & Propane - Hydronic-High-T			$7,189	$3,864
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$13,195	$9,870	$17,588	$14,262
	Furnace - Fuel Oil	$3,479	$2,215	$7,601	$4,275
	Furnace - NG & Propane	$2,966	$1,701	$7,087	$3,762
	Zonal Electric Resistance - Electric			$8,975	$5,650
DC	Boiler - Fuel Oil - Hydronic-High-T			$5,376	$2,819
	Boiler - NG & Propane - Hydronic-High-T			$5,527	$2,971
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$10,145	$7,589	$13,523	$10,966
	Furnace - Fuel Oil	$2,675	$1,703	$5,844	$3,287
	Furnace - NG & Propane	$2,280	$1,308	$5,449	$2,892
	Zonal Electric Resistance - Electric			$6,901	$4,344
DE	Boiler - Fuel Oil - Hydronic-High-T			$6,590	$3,455
	Boiler - NG & Propane - Hydronic-High-T			$6,776	$3,642
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$12,437	$9,302	$16,577	$13,442
	Furnace - Fuel Oil	$3,279	$2,087	$7,164	$4,030
	Furnace - NG & Propane	$2,795	$1,603	$6,680	$3,546
	Zonal Electric Resistance - Electric			$8,459	$5,325
MA	Boiler - Fuel Oil - Hydronic-High-T			$7,392	$3,876
	Boiler - NG & Propane - Hydronic-High-T			$7,600	$4,085
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$13,950	$10,434	$18,594	$15,078
	Furnace - Fuel Oil	$3,678	$2,341	$8,036	$4,520
	Furnace - NG & Propane	$3,135	$1,798	$7,493	$3,977
	Zonal Electric Resistance - Electric			$9,489	$5,973
MD	Boiler - Fuel Oil - Hydronic-High-T			$4,959	$2,600
	Boiler - NG & Propane - Hydronic-High-T			$5,099	$2,740
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$9,359	$7,000	$12,474	$10,116
	Furnace - Fuel Oil	$2,468	$1,571	$5,391	$3,032
	Furnace - NG & Propane	$2,103	$1,206	$5,027	$2,668
	Zonal Electric Resistance - Electric			$6,366	$4,007
ME	Boiler - Fuel Oil - Hydronic-High-T			$5,219	$2,737
	Boiler - NG & Propane - Hydronic-High-T			$5,367	$2,884
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$9,851	$7,368	$13,130	$10,647
	Furnace - Fuel Oil	$2,597	$1,653	$5,674	$3,192
	Furnace - NG & Propane	$2,214	$1,270	$5,291	$2,808
	Zonal Electric Resistance - Electric			$6,700	$4,218
NH	Boiler - Fuel Oil - Hydronic-High-T			$5,490	$2,879
	Boiler - NG & Propane - Hydronic-High-T			$5,645	$3,034
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$10,362	$7,751	$13,811	$11,200
	Furnace - Fuel Oil	$2,732	$1,739	$5,969	$3,357
	Furnace - NG & Propane	$2,329	$1,336	$5,565	$2,954
	Zonal Electric Resistance - Electric			$7,048	$4,437
NJ	Boiler - Fuel Oil - Hydronic-High-T			$8,209	$4,305
	Boiler - NG & Propane - Hydronic-High-T			$8,441	$4,537
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$15,493	$11,589	$20,651	$16,746
	Furnace - Fuel Oil	$4,085	$2,600	$8,925	$5,020
	Furnace - NG & Propane	$3,482	$1,997	$8,322	$4,417
	Zonal Electric Resistance - Electric			$10,538	$6,634
NY	Boiler - Fuel Oil - Hydronic-High-T			$9,784	$5,131
	Boiler - NG & Propane - Hydronic-High-T			$10,060	$5,407
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$18,465	$13,812	$24,612	$19,959
	Furnace - Fuel Oil	$4,869	$3,099	$10,637	$5,983

Baseline Equipment Total Cost of Labor and Materials by State

		Excludes New Distribution System Costs		Includes New Distribution System Costs	
		with AC	without AC	with AC	without AC
NY	Furnace - NG & Propane	$4,150	$2,380	$9,918	$5,264
	Zonal Electric Resistance - Electric			$12,560	$7,907
PA	Boiler - Fuel Oil - Hydronic-High-T			$7,011	$3,676
	Boiler - NG & Propane - Hydronic-High-T			$7,209	$3,874
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$13,232	$9,897	$17,636	$14,302
	Furnace - Fuel Oil	$3,489	$2,221	$7,622	$4,287
	Furnace - NG & Propane	$2,974	$1,706	$7,107	$3,772
	Zonal Electric Resistance - Electric			$9,000	$5,666
RI	Boiler - Fuel Oil - Hydronic-High-T			$6,831	$3,582
	Boiler - NG & Propane - Hydronic-High-T			$7,024	$3,775
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$12,892	$9,643	$17,183	$13,934
	Furnace - Fuel Oil	$3,399	$2,164	$7,426	$4,177
	Furnace - NG & Propane	$2,897	$1,662	$6,924	$3,675
	Zonal Electric Resistance - Electric			$8,769	$5,520
VA	Boiler - Fuel Oil - Hydronic-High-T			$4,373	$2,293
	Boiler - NG & Propane - Hydronic-High-T			$4,496	$2,417
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$8,253	$6,173	$11,000	$8,920
	Furnace - Fuel Oil	$2,176	$1,385	$4,754	$2,674
	Furnace - NG & Propane	$1,855	$1,064	$4,433	$2,353
	Zonal Electric Resistance - Electric			$5,614	$3,534
VT	Boiler - Fuel Oil - Hydronic-High-T			$5,289	$2,773
	Boiler - NG & Propane - Hydronic-High-T			$5,438	$2,923
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$9,981	$7,466	$13,304	$10,788
	Furnace - Fuel Oil	$2,632	$1,675	$5,749	$3,234
	Furnace - NG & Propane	$2,243	$1,287	$5,361	$2,846
	Zonal Electric Resistance - Electric			$6,789	$4,274

Measure Equipment Total Installed Cost by State

		Excludes New Distribution System Costs		Includes New Distribution System Costs	
		No Panel Upgrade	With Panel Upgrade	No Panel Upgrade	With Panel Upgrade
CT	AWHP	$56,578	$59,290	$60,970	$63,683
	Mini-Multi Split (1-zone)	$14,300	$17,013	$16,361	$19,074
	Mini-Multi Split (3-zones)			$16,463	$19,175
	Packaged Unitary HP	$10,309	$13,021	$12,369	$15,082
	Split Unitary HP	$9,605	$12,317	$11,666	$14,378
DC	AWHP	$49,151	$51,237	$52,529	$54,614
	Mini-Multi Split (1-zone)	$13,021	$15,106	$14,605	$16,691
	Mini-Multi Split (3-zones)			$15,383	$17,469
	Packaged Unitary HP	$10,180	$12,265	$11,764	$13,850
	Split Unitary HP	$9,263	$11,348	$10,847	$12,933
DE	AWHP	$55,026	$57,583	$59,166	$61,722
	Mini-Multi Split (1-zone)	$14,088	$16,644	$16,030	$18,587
	Mini-Multi Split (3-zones)			$16,337	$18,893
	Packaged Unitary HP	$10,394	$12,951	$12,337	$14,893
	Split Unitary HP	$9,618	$12,174	$11,560	$14,117
MA	AWHP	$57,937	$60,805	$62,581	$65,449
	Mini-Multi Split (1-zone)	$14,446	$17,313	$16,624	$19,492
	Mini-Multi Split (3-zones)			$16,500	$19,367
	Packaged Unitary HP	$10,150	$13,017	$12,329	$15,196
	Split Unitary HP	$9,530	$12,398	$11,709	$14,577
MD	AWHP	$47,125	$49,048	$50,240	$52,164
	Mini-Multi Split (1-zone)	$12,651	$14,574	$14,112	$16,036
	Mini-Multi Split (3-zones)			$15,051	$16,974
	Packaged Unitary HP	$10,102	$12,026	$11,563	$13,487
	Split Unitary HP	$9,138	$11,061	$10,599	$12,523
ME	AWHP	$47,910	$49,935	$51,189	$53,214
	Mini-Multi Split (1-zone)	$12,709	$14,734	$14,248	$16,273
	Mini-Multi Split (3-zones)			$15,026	$17,051
	Packaged Unitary HP	$9,958	$11,983	$11,497	$13,521
	Split Unitary HP	$9,056	$11,080	$10,594	$12,619
NH	AWHP	$49,394	$51,524	$52,843	$54,973
	Mini-Multi Split (1-zone)	$13,009	$15,139	$14,628	$16,758
	Mini-Multi Split (3-zones)			$15,322	$17,452
	Packaged Unitary HP	$10,075	$12,205	$11,694	$13,824
	Split Unitary HP	$9,192	$11,322	$10,811	$12,941
NJ	AWHP	$61,507	$64,692	$66,665	$69,850
	Mini-Multi Split (1-zone)	$15,026	$18,211	$17,445	$20,630
	Mini-Multi Split (3-zones)			$16,955	$20,140
	Packaged Unitary HP	$10,140	$13,325	$12,560	$15,745
	Split Unitary HP	$9,641	$12,826	$12,061	$15,246
NY	AWHP	$69,084	$72,879	$75,230	$79,026
	Mini-Multi Split (1-zone)	$16,394	$20,190	$19,278	$23,074
	Mini-Multi Split (3-zones)			$18,171	$21,967
	Packaged Unitary HP	$10,401	$14,197	$13,285	$17,081
	Split Unitary HP	$10,087	$13,883	$12,971	$16,767
PA	AWHP	$56,182	$58,902	$60,586	$63,306
	Mini-Multi Split (1-zone)	$14,142	$16,862	$16,208	$18,928
	Mini-Multi Split (3-zones)			$16,242	$18,962
	Packaged Unitary HP	$10,117	$12,837	$12,183	$14,903
	Split Unitary HP	$9,448	$12,168	$11,514	$14,234

Measure Equipment Total Installed Cost by State

		Excludes New Distribution System Costs		Includes New Distribution System Costs	
		No Panel Upgrade	With Panel Upgrade	No Panel Upgrade	With Panel Upgrade
RI	AWHP	$56,061	$58,711	$60,352	$63,002
	Mini-Multi Split (1-zone)	$14,252	$16,902	$16,266	$18,916
	Mini-Multi Split (3-zones)			$16,462	$19,112
	Packaged Unitary HP	$10,384	$13,034	$12,398	$15,048
	Split Unitary HP	$9,644	$12,294	$11,658	$14,308
VA	AWHP	$44,607	$46,303	$47,354	$49,050
	Mini-Multi Split (1-zone)	$12,249	$13,946	$13,538	$15,235
	Mini-Multi Split (3-zones)			$14,743	$16,440
	Packaged Unitary HP	$10,125	$11,821	$11,414	$13,110
	Split Unitary HP	$9,072	$10,768	$10,361	$12,057
VT	AWHP	$48,165	$50,216	$51,487	$53,539
	Mini-Multi Split (1-zone)	$12,741	$14,793	$14,300	$16,352
	Mini-Multi Split (3-zones)			$15,042	$17,094
	Packaged Unitary HP	$9,938	$11,990	$11,497	$13,549
	Split Unitary HP	$9,049	$11,101	$10,608	$12,660

Baseline Equipment Total Installed Cost by State

		Excludes New Distribution System Costs		Includes New Distribution System Costs	
		with AC	without AC	with AC	without AC
CT	Boiler - Fuel Oil - Hydronic-High-T			$12,262	$5,887
	Boiler - NG & Propane - Hydronic-High-T			$12,446	$6,071
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$18,452	$12,077	$22,845	$16,470
	Furnace - Fuel Oil	$9,334	$5,020	$13,456	$7,081
	Furnace - NG & Propane	$8,255	$3,941	$12,377	$6,002
	Zonal Electric Resistance - Electric			$16,136	$9,761
DC	Boiler - Fuel Oil - Hydronic-High-T			$10,635	$5,035
	Boiler - NG & Propane - Hydronic-High-T			$10,773	$5,174
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$15,391	$9,791	$18,768	$13,169
	Furnace - Fuel Oil	$8,518	$4,503	$11,687	$6,087
	Furnace - NG & Propane	$7,558	$3,543	$10,727	$5,128
	Zonal Electric Resistance - Electric			$14,046	$8,446
DE	Boiler - Fuel Oil - Hydronic-High-T			$11,920	$5,701
	Boiler - NG & Propane - Hydronic-High-T			$12,093	$5,874
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$17,754	$11,535	$21,894	$15,675
	Furnace - Fuel Oil	$9,201	$4,925	$13,086	$6,868
	Furnace - NG & Propane	$8,145	$3,869	$12,030	$5,811
	Zonal Electric Resistance - Electric			$15,702	$9,483
MA	Boiler - Fuel Oil - Hydronic-High-T			$12,562	$6,055
	Boiler - NG & Propane - Hydronic-High-T			$12,758	$6,250
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$19,108	$12,600	$23,751	$17,244
	Furnace - Fuel Oil	$9,423	$5,094	$13,780	$7,273
	Furnace - NG & Propane	$8,325	$3,996	$12,682	$6,175
	Zonal Electric Resistance - Electric			$16,514	$10,006
MD	Boiler - Fuel Oil - Hydronic-High-T			$10,191	$4,805
	Boiler - NG & Propane - Hydronic-High-T			$10,318	$4,932
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$14,578	$9,192	$17,693	$12,307
	Furnace - Fuel Oil	$8,281	$4,356	$11,204	$5,818
	Furnace - NG & Propane	$7,355	$3,430	$10,278	$4,892
	Zonal Electric Resistance - Electric			$13,475	$8,089
ME	Boiler - Fuel Oil - Hydronic-High-T			$10,365	$4,905
	Boiler - NG & Propane - Hydronic-High-T			$10,500	$5,040
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$14,984	$9,524	$18,263	$12,803
	Furnace - Fuel Oil	$8,315	$4,393	$11,392	$5,931
	Furnace - NG & Propane	$7,379	$3,457	$10,456	$4,996
	Zonal Electric Resistance - Electric			$13,692	$8,232
NH	Boiler - Fuel Oil - Hydronic-High-T			$10,689	$5,070
	Boiler - NG & Propane - Hydronic-High-T			$10,831	$5,212
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$15,548	$9,928	$18,997	$13,378
	Furnace - Fuel Oil	$8,508	$4,507	$11,745	$6,125
	Furnace - NG & Propane	$7,547	$3,545	$10,783	$5,164
	Zonal Electric Resistance - Electric			$14,112	$8,492
NJ	Boiler - Fuel Oil - Hydronic-High-T			$13,345	$6,469
	Boiler - NG & Propane - Hydronic-High-T			$13,564	$6,688
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$20,616	$13,740	$25,774	$18,897
	Furnace - Fuel Oil	$9,791	$5,335	$14,631	$7,754
	Furnace - NG & Propane	$8,637	$4,180	$13,476	$6,600
	Zonal Electric Resistance - Electric			$17,517	$10,640
NY	Boiler - Fuel Oil - Hydronic-High-T			$15,003	$7,330
	Boiler - NG & Propane - Hydronic-High-T			$15,266	$7,593
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$23,672	$15,998	$29,818	$22,145
	Furnace - Fuel Oil	$10,667	$5,878	$16,435	$8,762

Baseline Equipment Total Installed Cost by State

		Excludes New Distribution System Costs		Includes New Distribution System Costs	
		with AC	without AC	with AC	without AC
NY	Furnace - NG & Propane	$9,388	$4,599	$15,156	$7,483
	Zonal Electric Resistance - Electric			$19,651	$11,978
PA	Boiler - Fuel Oil - Hydronic-High-T			$12,177	$5,853
	Boiler - NG & Propane - Hydronic-High-T			$12,363	$6,038
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$18,385	$12,061	$22,790	$16,466
	Furnace - Fuel Oil	$9,229	$4,971	$13,362	$7,038
	Furnace - NG & Propane	$8,159	$3,902	$12,292	$5,968
	Zonal Electric Resistance - Electric			$16,020	$9,696
RI	Boiler - Fuel Oil - Hydronic-High-T			$12,147	$5,822
	Boiler - NG & Propane - Hydronic-High-T			$12,327	$6,002
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$18,195	$11,870	$22,486	$16,161
	Furnace - Fuel Oil	$9,306	$4,994	$13,333	$7,007
	Furnace - NG & Propane	$8,233	$3,921	$12,260	$5,935
	Zonal Electric Resistance - Electric			$15,992	$9,667
VA	Boiler - Fuel Oil - Hydronic-High-T			$9,639	$4,512
	Boiler - NG & Propane - Hydronic-High-T			$9,749	$4,622
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$13,506	$8,379	$16,253	$11,126
	Furnace - Fuel Oil	$8,026	$4,189	$10,604	$5,478
	Furnace - NG & Propane	$7,140	$3,302	$9,718	$4,591
	Zonal Electric Resistance - Electric			$12,768	$7,641
VT	Boiler - Fuel Oil - Hydronic-High-T			$10,422	$4,936
	Boiler - NG & Propane - Hydronic-High-T			$10,558	$5,073
	Boiler - NG & Propane - Hydronic-Low-T-Radiant	$15,101	$9,616	$18,424	$12,938
	Furnace - Fuel Oil	$8,335	$4,408	$11,452	$5,967
	Furnace - NG & Propane	$7,395	$3,468	$10,513	$5,027
	Zonal Electric Resistance - Electric			$13,763	$8,278

Appendix D: Population Weighting for RS Means Analysis – 2024 Q2

State	City	Population (Most Recent Census Data)	Materials Index	Labor Index	Percent Weighting
CONNECTICUT	BRIDGEPORT	148,377	100.5	114.8	14.9%
CONNECTICUT	BRISTOL	61,330	99.9	116.5	6.2%
CONNECTICUT	HARTFORD	120,686	101.2	117	12.2%
CONNECTICUT	MERIDEN	60,242	97.7	114	6.1%
CONNECTICUT	NEW BRITAIN	74,396	99.6	116.5	7.5%
CONNECTICUT	NEW HAVEN	138,915	101	114.6	14.0%
CONNECTICUT	NEW LONDON	27,980	95.7	114	2.8%
CONNECTICUT	NORWALK	91,401	100.7	115.2	9.2%
CONNECTICUT	STAMFORD	136,188	100.7	115.5	13.7%
CONNECTICUT	WATERBURY	115,016	100.7	115.2	11.6%
CONNECTICUT	WILLIMANTIC	18,669	100.2	114	1.9%
DC	DC		100.1	88.7	100.0%
DELAWARE	DOVER	39,421	102.1	109.1	28.0%
DELAWARE	NEWARK	30,622	100.3	108.8	21.7%
DELAWARE	WILMINGTON	70,893	101.6	108.5	50.3%
MAINE	AUGUSTA	18,896	99.2	85.2	9.2%
MAINE	BANGOR	31,740	95.3	83.1	15.4%
MAINE	BATH	8,768	94.1	82.6	4.3%
MAINE	HOULTON	5,763	93.5	82.6	2.8%
MAINE	KITTERY	9,846	93.5	81.5	4.8%
MAINE	LEWISTON	37,127	101.3	89.4	18.1%
MAINE	MACHIAS	2,072	93.4	82.6	1.0%
MAINE	PORTLAND	68,409	100.1	88.7	33.3%
MAINE	ROCKLAND	7,011	92.8	82.6	3.4%
MAINE	WATERVILLE	15,826	94	82.6	7.7%
MARYLAND	ANNAPOLIS	40,807	101.5	84	4.3%
MARYLAND	BALTIMORE	585,693	101.7	84	61.7%
MARYLAND	COLLEGE PARK	34,747	94.8	79.9	3.7%
MARYLAND	CUMBERLAND	19,081	95.9	83.4	2.0%
MARYLAND	EASTON	17,097	97.6	66.5	1.8%
MARYLAND	ELKTON	15,820	95	77	1.7%
MARYLAND	HAGERSTOWN	43,552	97.4	85.9	4.6%

State	City	Population (Most Recent Census Data)	Materials Index	Labor Index	Percent Weighting
MARYLAND	SALISBURY	33,027	97.9	59.6	3.5%
MARYLAND	SILVER SPRING	81,069	94.3	79.1	8.5%
MARYLAND	WALDORF	77,711	94.6	79.1	8.2%
MASSACHUSETTS	BOSTON	675,632	99.2	133.1	38.9%
MASSACHUSETTS	BROCKTON	105,654	98	117	6.1%
MASSACHUSETTS	BUZZARDS BAY	3,208	92.1	111.2	0.2%
MASSACHUSETTS	FALL RIVER	93,984	98	114.8	5.4%
MASSACHUSETTS	FITCHBURG	41,945	94.4	112.3	2.4%
MASSACHUSETTS	FRAMINGHAM	72,381	94.3	118.2	4.2%
MASSACHUSETTS	GREENFIELD	17,763	95.6	108	1.0%
MASSACHUSETTS	HYANNIS	14,089	94.9	113.7	0.8%
MASSACHUSETTS	LAWRENCE	89,153	98.7	125.1	5.1%
MASSACHUSETTS	LOWELL	115,550	98.2	123.4	6.7%
MASSACHUSETTS	NEW BEDFORD	101,089	97.6	113.7	5.8%
MASSACHUSETTS	PITTSFIELD	43,935	98.3	103.4	2.5%
MASSACHUSETTS	SPRINGFIELD	155,931	99.1	107.1	9.0%
MASSACHUSETTS	WORCESTER	206,519	99	113.6	11.9%
NEW HAMPSHIRE	CHARLESTON	4,907	94.8	80.2	1.5%
NEW HAMPSHIRE	CLAREMONT	13,149	94.1	80.2	4.1%
NEW HAMPSHIRE	CONCORD	44,503	100.4	92.7	13.9%
NEW HAMPSHIRE	KEENE	22,774	95	80.6	7.1%
NEW HAMPSHIRE	LITTLETON	6,092	95.3	72.9	1.9%
NEW HAMPSHIRE	MANCHESTER	115,141	100.5	93.6	35.9%
NEW HAMPSHIRE	NASHUA	91,161	99	92	28.4%
NEW HAMPSHIRE	PORTSMOUTH	22,713	96.8	88.6	7.1%
NEW JERSEY	ATLANTIC CITY	38,561	97.3	132.4	2.9%
NEW JERSEY	CAMDEN	70,996	99.1	132.1	5.3%
NEW JERSEY	DOVER	18,422	102.1	109.1	28.0%
NEW JERSEY	ELIZABETH	134,283	95.8	136.8	10.0%
NEW JERSEY	HACKENSACK	45,633	95.1	136.5	3.4%
NEW JERSEY	JERSEY CITY	286,670	97.1	136.4	21.4%
NEW JERSEY	LONG BRANCH	32,434	95.1	133.4	2.4%
NEW JERSEY	NEW BRUNSWICK	55,998	98.9	135.4	4.2%
NEW JERSEY	NEWARK	305,344	100.3	108.8	21.7%
NEW JERSEY	PATERSON	156,661	96.9	136.8	11.7%

State	City	Population (Most Recent Census Data)	Materials Index	Labor Index	Percent Weighting
NEW JERSEY	POINT PLEASANT	19,382	98.3	132.4	1.4%
NEW JERSEY	SUMMIT	22,342	95.4	136.8	1.7%
NEW JERSEY	TRENTON	89,661	100.8	131.2	6.7%
NEW JERSEY	VINELAND	60,491	96.7	132.4	4.5%
NEW YORK	ALBANY	100,826	100.4	108.3	1.0%
NEW YORK	BINGHAMTON	47,115	95.3	98.6	0.4%
NEW YORK	BRONX	1,379,946	93	169.6	13.0%
NEW YORK	BROOKLYN	2,590,516	103	169.5	24.4%
NEW YORK	BUFFALO	276,486	100.9	106.8	2.6%
NEW YORK	ELMIRA	25,852	95.3	99.7	0.2%
NEW YORK	FAR ROCKAWAY	135,919	101.2	169.5	1.3%
NEW YORK	FLUSHING	180,381	101.2	169.5	1.7%
NEW YORK	GLENS FALLS	14,603	94.3	104.5	0.1%
NEW YORK	HICKSVILLE	42,468	100.7	153.3	0.4%
NEW YORK	JAMAICA	133,356	99.9	169.5	1.3%
NEW YORK	JAMESTOWN	28,243	95.2	97.1	0.3%
NEW YORK	KINGSTON	23,916	103	134.4	0.2%
NEW YORK	LONG ISLAND CITY	52,075	102.2	169.5	0.5%
NEW YORK	MONTICELLO	7,285	101.9	137.1	0.1%
NEW YORK	MOUNT VERNON	71,714	91.9	150.4	0.7%
NEW YORK	NEW ROCHELLE	82,288	92.2	153.9	0.8%
NEW YORK	NEW YORK	1,694,251	99.1	168.4	16.0%
NEW YORK	NIAGARA FALLS	47,993	96.2	109.3	0.5%
NEW YORK	PLATTSBURGH	19,904	98.6	99.4	0.2%
NEW YORK	POUGHKEEPSIE	32,010	102.3	138.6	0.3%
NEW YORK	QUEENS	2,309,431	100.8	169.3	21.8%
NEW YORK	RIVERHEAD	35,834	100.7	153.3	0.3%
NEW YORK	ROCHESTER	209,352	100.1	99.4	2.0%
NEW YORK	SCHENECTADY	68,809	99.7	107.8	0.6%
NEW YORK	STATEN ISLAND	475,596	94.5	169.5	4.5%
NEW YORK	SUFFERN	11,338	91.8	141	0.1%
NEW YORK	SYRACUSE	144,451	97.7	100.2	1.4%
NEW YORK	UTICA	64,081	96.3	101.3	0.6%
NEW YORK	WATERTOWN	24,451	96.7	97.8	0.2%

State	City	Population (Most Recent Census Data)	Materials Index	Labor Index	Percent Weighting
NEW YORK	WHITE PLAINS	59,316	94	147.3	0.6%
NEW YORK	YONKERS	208,121	96.6	147.4	2.0%
PENNSYLVANIA	ALLENTOWN	125,094	97.9	101.1	3.8%
PENNSYLVANIA	ALTOONA	43,071	94.5	96.9	1.3%
PENNSYLVANIA	BEDFORD	47,418	98	85.3	1.4%
PENNSYLVANIA	BRADFORD	59,866	96	88.7	1.8%
PENNSYLVANIA	BUTLER	13,176	92.3	92.7	0.4%
PENNSYLVANIA	CHAMBERSBURG	22,172	95.5	94.3	0.7%
PENNSYLVANIA	DOYLESTOWN	8,352	93.5	111.9	0.3%
PENNSYLVANIA	DUBOIS	7,399	98.3	89.7	0.2%
PENNSYLVANIA	ERIE	93,511	95.4	95.6	2.8%
PENNSYLVANIA	GREENSBURG	14,715	97.9	93.4	0.4%
PENNSYLVANIA	HARRISBURG	50,183	99.1	96.3	1.5%
PENNSYLVANIA	HAZLETON	29,993	94.3	84.1	0.9%
PENNSYLVANIA	INDIANA	14,205	96.8	95.1	0.4%
PENNSYLVANIA	JOHNSTOWN	18,091	97.9	96.9	0.5%
PENNSYLVANIA	KITTANNING	3,923	92.8	94.4	0.1%
PENNSYLVANIA	LANCASTER	57,453	94.4	93	1.7%
PENNSYLVANIA	LEHIGH VALLEY	376,317	94.7	97.7	11.3%
PENNSYLVANIA	MONTROSE	1,276	94.1	84.9	0.0%
PENNSYLVANIA	NEW CASTLE	21,532	92.4	95.6	0.6%
PENNSYLVANIA	NORRISTOWN	35,795	96.1	113.7	1.1%
PENNSYLVANIA	OIL CITY	9,459	92.3	87.1	0.3%
PENNSYLVANIA	PHILADELPHIA	1,567,258	100	136.6	47.1%
PENNSYLVANIA	PITTSBURGH	302,898	101.3	103.3	9.1%
PENNSYLVANIA	POTTSVILLE	13,338	94.3	83.8	0.4%
PENNSYLVANIA	READING	94,858	99.2	96.5	2.9%
PENNSYLVANIA	SCRANTON	75,848	97.3	93.1	2.3%
PENNSYLVANIA	STATE COLLEGE	40,745	95.6	99	1.2%
PENNSYLVANIA	STROUDSBURG	5,888	94.1	91.8	0.2%
PENNSYLVANIA	SUNBURY	9,587	94.9	80.6	0.3%
PENNSYLVANIA	UNIONTOWN	9,689	97.4	96.7	0.3%
PENNSYLVANIA	WASHINGTON	13,483	96.5	100.8	0.4%
PENNSYLVANIA	WELLSBORO	3,441	96.6	81.3	0.1%
PENNSYLVANIA	WESTCHESTER	19,531	96.9	111.8	0.6%

State	City	Population (Most Recent Census Data)	Materials Index	Labor Index	Percent Weighting
PENNSYLVANIA	WILKES-BARRE	44,261	94.3	91.7	1.3%
PENNSYLVANIA	WILLIAMSPORT	27,403	93.1	87.8	0.8%
PENNSYLVANIA	YORK	44,845	97.3	91.3	1.3%
RHODE ISLAND	NEWPORT	24,684	96.5	112.8	11.5%
RHODE ISLAND	PROVIDENCE	189,563	101.8	112.7	88.5%
VERMONT	BELLOWS FALLS	2,770	93.8	97.6	2.5%
VERMONT	BENNINGTON	15,312	94.2	90.1	14.1%
VERMONT	BRATTLEBORO	12,106	94.4	97.6	11.1%
VERMONT	BURLINGTON	44,595	100.5	84.5	41.0%
VERMONT	GUILDHALL	256	94.1	81.7	0.2%
VERMONT	MONTPELIER	8,023	97.6	91.6	7.4%
VERMONT	RUTLAND	15,695	98	83.9	14.4%
VERMONT	ST. JOHNSBURY	7,388	95.4	81.7	6.8%
VERMONT	WHITE RIVER JCT.	2,528	95.2	82	2.3%
VIRGINIA	ALEXANDRIA	155,525	100.4	84.6	9.7%
VIRGINIA	ARLINGTON	234,000	100.9	80.7	14.6%
VIRGINIA	BRISTOL	16,975	99.9	116.5	6.2%
VIRGINIA	CHARLOTTESVILLE	45,373	99.4	69.6	2.8%
VIRGINIA	CULPEPER	20,764	98.7	75.2	1.3%
VIRGINIA	FAIRFAX	24,835	99.3	80.1	1.5%
VIRGINIA	FARMVILLE	7,473	98.4	60.8	0.5%
VIRGINIA	FREDERICKSBURG	28,757	98.4	73.6	1.8%
VIRGINIA	GRUNDY	849	97.3	58.2	0.1%
VIRGINIA	HARRISONBURG	51,158	98.9	74.3	3.2%
VIRGINIA	LYNCHBURG	79,287	98.1	70.9	4.9%
VIRGINIA	NEWPORT NEWS	184,306	100.4	67	11.5%
VIRGINIA	NORFOLK	232,995	101.4	68.3	14.5%
VIRGINIA	PETERSBURG	33,394	99.2	70.2	2.1%
VIRGINIA	PORTSMOUTH	97,029	96.8	88.6	7.1%
VIRGINIA	PULASKI	8,904	97.1	63.6	0.6%
VIRGINIA	RICHMOND	229,395	100.8	70.4	14.3%
VIRGINIA	ROANOKE	97,847	100.1	68.8	6.1%
VIRGINIA	STAUNTON	25,904	98	62.9	1.6%
VIRGINIA	WINCHESTER	27,936	98.8	69.9	1.7%

Appendix E: Operating Cost Tables by State

The following tables summarize estimated operating cost savings for single family homes of an average, rather than new or old, building vintage in each state. Positive values indicate a decrease in annual operating costs and negative values indicate an increase in annual operating costs. Operating cost savings estimates are provided for four of the sixteen possible utility rate/size combinations assessed:

- EIA Average Gas Rates and EIA Average Electric Rates
- Sample "Small" Gas Utility/Co-op and Sample "Small" Gas Utility/Co-op
- Second Largest Gas Utility and Second Largest Electric Utility
- Largest Gas Utility and Largest Electric Utility

For additional permutations, please refer to the Operating Costs Calculator.

TABLE 28. OPERATING COST SAVINGS FOR DIFFERENT EQUIPMENT SCENARIOS IN CONNECTICUT FOR AVERAGE BUILDING VINTAGE, 2022 TO 2023

Equipment Combinations				Operating Costs Savings			
Fuel Type	Baseline Heating Equipment	Baseline Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$580	$1,299	$660	$580
Propane	Boiler High Temp	Split Unitary AC	Split Unitary HP	$580	$1,299	$660	$580
Propane	Furnace	Split Unitary AC	Split Unitary HP	$580	$1,299	$660	$580
Methane Gas	Boiler Low Temp	Split Unitary AC	Split Unitary HP	-$716	$90	-$775	-$502
Methane Gas	Boiler High Temp	Split Unitary AC	Split Unitary HP	-$716	$90	-$775	-$502
Methane Gas	Furnace	Split Unitary AC	Split Unitary HP	-$716	$90	-$775	-$502
Fuel Oil	Boiler High Temp	Split Unitary AC	Split Unitary HP	$300	$1,018	$380	$300
Fuel Oil	Furnace	Split Unitary AC	Split Unitary HP	$326	$1,045	$406	$326
Electric	Electric Resistance	Split Unitary AC	Split Unitary HP	$2,394	$1,532	$2,298	$2,394
Propane	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$580	$1,299	$660	$580
Propane	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$580	$1,299	$660	$580
Propane	Furnace	Split Unitary AC	Packaged Unitary HP	$580	$1,299	$660	$580
Methane Gas	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	-$716	$90	-$775	-$502
Methane Gas	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	-$716	$90	-$775	-$502
Methane Gas	Furnace	Split Unitary AC	Packaged Unitary HP	-$716	$90	-$775	-$502
Fuel Oil	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$300	$1,018	$380	$300
Fuel Oil	Furnace	Split Unitary AC	Packaged Unitary HP	$326	$1,045	$406	$326
Electric	Electric Resistance	Split Unitary AC	Packaged Unitary HP	$2,394	$1,532	$2,298	$2,394
Propane	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$855	$1,475	$924	$855

Equipment Combinations				Operating Costs Savings			
Fuel Type	Baseline Heating Equipment	Baseline Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$855	$1,475	$924	$855
Propane	Furnace	Split Unitary AC	Mini-Multi Split	$855	$1,475	$924	$855
Methane Gas	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	-$441	$266	-$511	-$227
Methane Gas	Boiler High Temp	Split Unitary AC	Mini-Multi Split	-$441	$266	-$511	-$227
Methane Gas	Furnace	Split Unitary AC	Mini-Multi Split	-$441	$266	-$511	-$227
Fuel Oil	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$575	$1,194	$644	$575
Fuel Oil	Furnace	Split Unitary AC	Mini-Multi Split	$601	$1,221	$670	$601
Electric	Electric Resistance	Split Unitary AC	Mini-Multi Split	$2,669	$1,708	$2,562	$2,669
Propane	Boiler Low Temp	Split Unitary AC	AWHP	$720	$1,388	$794	$720
Propane	Boiler High Temp	Split Unitary AC	AWHP	$720	$1,388	$794	$720
Propane	Furnace	Split Unitary AC	AWHP	$720	$1,388	$794	$720
Methane Gas	Boiler Low Temp	Split Unitary AC	AWHP	-$577	$180	-$641	-$363
Methane Gas	Boiler High Temp	Split Unitary AC	AWHP	-$577	$180	-$641	-$363
Methane Gas	Furnace	Split Unitary AC	AWHP	-$577	$180	-$641	-$363
Fuel Oil	Boiler High Temp	Split Unitary AC	AWHP	$439	$1,107	$514	$439
Fuel Oil	Furnace	Split Unitary AC	AWHP	$466	$1,134	$540	$466
Electric	Electric Resistance	Split Unitary AC	AWHP	$2,533	$1,621	$2,432	$2,533
Propane	Boiler Low Temp	None	Split Unitary HP	$201	$1,056	$296	$201
Propane	Boiler High Temp	None	Split Unitary HP	$201	$1,056	$296	$201
Propane	Furnace	None	Split Unitary HP	$201	$1,056	$296	$201
Methane Gas	Boiler Low Temp	None	Split Unitary HP	-$1,095	-$152	-$1,139	-$881
Methane Gas	Boiler High Temp	None	Split Unitary HP	-$1,095	-$152	-$1,139	-$881
Methane Gas	Furnace	None	Split Unitary HP	-$1,095	-$152	-$1,139	-$881
Fuel Oil	Boiler High Temp	None	Split Unitary HP	-$79	$776	$16	-$79
Fuel Oil	Furnace	None	Split Unitary HP	-$53	$802	$42	-$53
Electric	Electric Resistance	None	Split Unitary HP	$2,015	$1,289	$1,934	$2,015
Propane	Boiler Low Temp	None	Packaged Unitary HP	$201	$1,056	$296	$201
Propane	Boiler High Temp	None	Packaged Unitary HP	$201	$1,056	$296	$201
Propane	Furnace	None	Packaged Unitary HP	$201	$1,056	$296	$201
Methane Gas	Boiler Low Temp	None	Packaged Unitary HP	-$1,095	-$152	-$1,139	-$881
Methane Gas	Boiler High Temp	None	Packaged Unitary HP	-$1,095	-$152	-$1,139	-$881

Equipment Combinations				Operating Costs Savings			
Fuel Type	Baseline Heating Equipment	Baseline Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Methane Gas	Furnace	None	Packaged Unitary HP	-$1,095	-$152	-$1,139	-$881
Fuel Oil	Boiler High Temp	None	Packaged Unitary HP	-$79	$776	$16	-$79
Fuel Oil	Furnace	None	Packaged Unitary HP	-$53	$802	$42	-$53
Electric	Electric Resistance	None	Packaged Unitary HP	$2,015	$1,289	$1,934	$2,015
Propane	Boiler Low Temp	None	Mini-Multi Split	$476	$1,232	$560	$476
Propane	Boiler High Temp	None	Mini-Multi Split	$476	$1,232	$560	$476
Propane	Furnace	None	Mini-Multi Split	$476	$1,232	$560	$476
Methane Gas	Boiler Low Temp	None	Mini-Multi Split	-$820	$24	-$875	-$606
Methane Gas	Boiler High Temp	None	Mini-Multi Split	-$820	$24	-$875	-$606
Methane Gas	Furnace	None	Mini-Multi Split	-$820	$24	-$875	-$606
Fuel Oil	Boiler High Temp	None	Mini-Multi Split	$196	$952	$280	$196
Fuel Oil	Furnace	None	Mini-Multi Split	$222	$978	$306	$222
Fuel Oil	Furnace	None	Mini-Multi Split	$222	$978	$306	$222
Electric	Electric Resistance	None	Mini-Multi Split	$2,290	$1,465	$2,198	$2,290
Propane	Boiler Low Temp	None	AWHP	$341	$1,146	$430	$341
Propane	Boiler High Temp	None	AWHP	$341	$1,146	$430	$341
Propane	Furnace	None	AWHP	$341	$1,146	$430	$341
Methane Gas	Boiler Low Temp	None	AWHP	-$956	-$63	-$1,005	-$742
Methane Gas	Boiler High Temp	None	AWHP	-$956	-$63	-$1,005	-$742
Methane Gas	Furnace	None	AWHP	-$956	-$63	-$1,005	-$742
Fuel Oil	Boiler High Temp	None	AWHP	$60	$865	$150	$60
Electric	Electric Resistance	None	AWHP	$2,154	$1,379	$2,068	$2,154

Table 29. Operating Cost Savings For Different Equipment Scenarios In Delaware For Average Building Vintage, 2022 to 2023

Equipment Combinations				Operating Costs Savings			
Fuel Type	Baseline Heating Equipment	Baseline Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$1,448	$1,361	$1,448	$1,448
Propane	Boiler High Temp	Split Unitary AC	Split Unitary HP	$1,448	$1,361	$1,448	$1,448
Propane	Furnace	Split Unitary AC	Split Unitary HP	$1,448	$1,361	$1,448	$1,448
Methane Gas	Boiler Low Temp	Split Unitary AC	Split Unitary HP	-$251	-$337	-$87	-$326
Methane Gas	Boiler High Temp	Split Unitary AC	Split Unitary HP	-$251	-$337	-$87	-$326
Methane Gas	Furnace	Split Unitary AC	Split Unitary HP	-$251	-$337	-$87	-$326
Fuel Oil	Boiler High Temp	Split Unitary AC	Split Unitary HP	$1,629	$1,542	$1,629	$1,629
Fuel Oil	Furnace	Split Unitary AC	Split Unitary HP	$1,660	$1,574	$1,660	$1,660
Electric	Electric Resistance	Split Unitary AC	Split Unitary HP	$1,350	$1,454	$1,350	$1,350
Propane	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$1,448	$1,361	$1,448	$1,448
Propane	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$1,448	$1,361	$1,448	$1,448
Propane	Furnace	Split Unitary AC	Packaged Unitary HP	$1,448	$1,361	$1,448	$1,448
Methane Gas	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	-$251	-$337	-$87	-$326
Methane Gas	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	-$251	-$337	-$87	-$326
Methane Gas	Furnace	Split Unitary AC	Packaged Unitary HP	-$251	-$337	-$87	-$326
Fuel Oil	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$1,629	$1,542	$1,629	$1,629
Fuel Oil	Furnace	Split Unitary AC	Packaged Unitary HP	$1,660	$1,574	$1,660	$1,660
Electric	Electric Resistance	Split Unitary AC	Packaged Unitary HP	$1,350	$1,454	$1,350	$1,350
Propane	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$1,608	$1,534	$1,608	$1,608
Propane	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$1,608	$1,534	$1,608	$1,608
Propane	Furnace	Split Unitary AC	Mini-Multi Split	$1,608	$1,534	$1,608	$1,608
Methane Gas	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	-$90	-$164	$74	-$165
Methane Gas	Boiler High Temp	Split Unitary AC	Mini-Multi Split	-$90	-$164	$74	-$165
Methane Gas	Furnace	Split Unitary AC	Mini-Multi Split	-$90	-$164	$74	-$165
Fuel Oil	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$1,789	$1,715	$1,789	$1,789
Fuel Oil	Furnace	Split Unitary AC	Mini-Multi Split	$1,821	$1,747	$1,821	$1,821
Electric	Electric Resistance	Split Unitary AC	Mini-Multi Split	$1,511	$1,627	$1,511	$1,511
Propane	Boiler Low Temp	Split Unitary AC	AWHP	$1,485	$1,402	$1,485	$1,485
Propane	Boiler High Temp	Split Unitary AC	AWHP	$1,485	$1,402	$1,485	$1,485
Propane	Furnace	Split Unitary AC	AWHP	$1,485	$1,402	$1,485	$1,485

Equipment Combinations				Operating Costs Savings			
Fuel Type	Baseline Heating Equipment	Baseline Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Methane Gas	Boiler Low Temp	Split Unitary AC	AWHP	-$213	-$296	-$49	-$288
Methane Gas	Boiler High Temp	Split Unitary AC	AWHP	-$213	-$296	-$49	-$288
Methane Gas	Furnace	Split Unitary AC	AWHP	-$213	-$296	-$49	-$288
Fuel Oil	Boiler High Temp	Split Unitary AC	AWHP	$1,667	$1,583	$1,667	$1,667
Fuel Oil	Furnace	Split Unitary AC	AWHP	$1,698	$1,615	$1,698	$1,698
Electric	Electric Resistance	Split Unitary AC	AWHP	$1,388	$1,495	$1,388	$1,388
Propane	Boiler Low Temp	None	Split Unitary HP	$1,183	$1,076	$1,183	$1,183
Propane	Boiler High Temp	None	Split Unitary HP	$1,183	$1,076	$1,183	$1,183
Propane	Furnace	None	Split Unitary HP	$1,183	$1,076	$1,183	$1,183
Methane Gas	Boiler Low Temp	None	Split Unitary HP	-$515	-$622	-$351	-$590
Methane Gas	Boiler High Temp	None	Split Unitary HP	-$515	-$622	-$351	-$590
Methane Gas	Furnace	None	Split Unitary HP	-$515	-$622	-$351	-$590
Fuel Oil	Boiler High Temp	None	Split Unitary HP	$1,364	$1,258	$1,364	$1,364
Fuel Oil	Furnace	None	Split Unitary HP	$1,396	$1,289	$1,396	$1,396
Electric	Electric Resistance	None	Split Unitary HP	$1,086	$1,169	$1,086	$1,086
Propane	Boiler Low Temp	None	Packaged Unitary HP	$1,183	$1,076	$1,183	$1,183
Propane	Boiler High Temp	None	Packaged Unitary HP	$1,183	$1,076	$1,183	$1,183
Propane	Furnace	None	Packaged Unitary HP	$1,183	$1,076	$1,183	$1,183
Methane Gas	Boiler Low Temp	None	Packaged Unitary HP	-$515	-$622	-$351	-$590
Methane Gas	Boiler High Temp	None	Packaged Unitary HP	-$515	-$622	-$351	-$590
Methane Gas	Furnace	None	Packaged Unitary HP	-$515	-$622	-$351	-$590
Fuel Oil	Boiler High Temp	None	Packaged Unitary HP	$1,364	$1,258	$1,364	$1,364
Fuel Oil	Furnace	None	Packaged Unitary HP	$1,396	$1,289	$1,396	$1,396
Electric	Electric Resistance	None	Packaged Unitary HP	$1,086	$1,169	$1,086	$1,086
Propane	Boiler Low Temp	None	Mini-Multi Split	$1,344	$1,249	$1,344	$1,344
Propane	Boiler High Temp	None	Mini-Multi Split	$1,344	$1,249	$1,344	$1,344
Propane	Furnace	None	Mini-Multi Split	$1,344	$1,249	$1,344	$1,344
Methane Gas	Boiler Low Temp	None	Mini-Multi Split	-$354	-$449	-$190	-$430
Methane Gas	Boiler High Temp	None	Mini-Multi Split	-$354	-$449	-$190	-$430
Methane Gas	Furnace	None	Mini-Multi Split	-$354	-$449	-$190	-$430
Fuel Oil	Boiler High Temp	None	Mini-Multi Split	$1,525	$1,430	$1,525	$1,525

Equipment Combinations				Operating Costs Savings			
Fuel Type	Baseline Heating Equipment	Baseline Cooling Equipment	Measure Equipment	EAI State Avg.	Sample “Small” Utility / Co-op	Second Largest Utility	Largest Utility
Fuel Oil	Furnace	None	Mini-Multi Split	$1,557	$1,462	$1,557	$1,557
Fuel Oil	Furnace	None	Mini-Multi Split	$1,557	$1,462	$1,557	$1,557
Electric	Electric Resistance	None	Mini-Multi Split	$1,246	$1,342	$1,246	$1,246
Propane	Boiler Low Temp	None	AWHP	$1,221	$1,117	$1,221	$1,221
Propane	Boiler High Temp	None	AWHP	$1,221	$1,117	$1,221	$1,221
Propane	Furnace	None	AWHP	$1,221	$1,117	$1,221	$1,221
Methane Gas	Boiler Low Temp	None	AWHP	-$477	-$581	-$313	-$552
Methane Gas	Boiler High Temp	None	AWHP	-$477	-$581	-$313	-$552
Methane Gas	Furnace	None	AWHP	-$477	-$581	-$313	-$552
Fuel Oil	Boiler High Temp	None	AWHP	$1,402	$1,298	$1,402	$1,402
Electric	Electric Resistance	None	AWHP	$1,124	$1,210	$1,124	$1,124

Table 30. Operating Cost Savings For Different Equipment Scenarios In Washington, DC For Average Building Vintage, 2022 to 2023

Equipment Combinations				Operating Costs Savings			
Fuel Type	Baseline Heating Equipment	Baseline Cooling Equipment	Measure Equipment	EAI State Avg.	Sample “Small” Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$1,353	$1,353	$1,353	$1,353
Propane	Boiler High Temp	Split Unitary AC	Split Unitary HP	$1,353	$1,353	$1,353	$1,353
Propane	Furnace	Split Unitary AC	Split Unitary HP	$1,353	$1,353	$1,353	$1,353
Methane Gas	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$241	$241	$241	$241
Methane Gas	Boiler High Temp	Split Unitary AC	Split Unitary HP	$241	$241	$241	$241
Methane Gas	Furnace	Split Unitary AC	Split Unitary HP	$241	$241	$241	$241
Fuel Oil	Boiler High Temp	Split Unitary AC	Split Unitary HP	$1,428	$1,428	$1,428	$1,428
Fuel Oil	Furnace	Split Unitary AC	Split Unitary HP	$1,457	$1,457	$1,457	$1,457
Electric	Electric Resistance	Split Unitary AC	Split Unitary HP	$1,274	$1,274	$1,274	$1,274
Propane	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$1,353	$1,353	$1,353	$1,353
Propane	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$1,353	$1,353	$1,353	$1,353
Propane	Furnace	Split Unitary AC	Packaged Unitary HP	$1,353	$1,353	$1,353	$1,353
Methane Gas	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$241	$241	$241	$241
Methane Gas	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$241	$241	$241	$241

Equipment Combinations				Operating Costs Savings			
Fuel Type	Baseline Heating Equipment	Baseline Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Methane Gas	Furnace	Split Unitary AC	Packaged Unitary HP	$241	$241	$241	$241
Fuel Oil	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$1,428	$1,428	$1,428	$1,428
Fuel Oil	Furnace	Split Unitary AC	Packaged Unitary HP	$1,457	$1,457	$1,457	$1,457
Electric	Electric Resistance	Split Unitary AC	Packaged Unitary HP	$1,274	$1,274	$1,274	$1,274
Propane	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$1,515	$1,515	$1,515	$1,515
Propane	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$1,515	$1,515	$1,515	$1,515
Propane	Furnace	Split Unitary AC	Mini-Multi Split	$1,515	$1,515	$1,515	$1,515
Methane Gas	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$402	$402	$402	$402
Methane Gas	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$402	$402	$402	$402
Methane Gas	Furnace	Split Unitary AC	Mini-Multi Split	$402	$402	$402	$402
Fuel Oil	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$1,590	$1,590	$1,590	$1,590
Fuel Oil	Furnace	Split Unitary AC	Mini-Multi Split	$1,618	$1,618	$1,618	$1,618
Electric	Electric Resistance	Split Unitary AC	Mini-Multi Split	$1,435	$1,435	$1,435	$1,435
Propane	Boiler Low Temp	Split Unitary AC	AWHP	$1,313	$1,313	$1,313	$1,313
Propane	Boiler High Temp	Split Unitary AC	AWHP	$1,313	$1,313	$1,313	$1,313
Propane	Furnace	Split Unitary AC	AWHP	$1,313	$1,313	$1,313	$1,313
Methane Gas	Boiler Low Temp	Split Unitary AC	AWHP	$200	$200	$200	$200
Methane Gas	Boiler High Temp	Split Unitary AC	AWHP	$200	$200	$200	$200
Methane Gas	Furnace	Split Unitary AC	AWHP	$200	$200	$200	$200
Fuel Oil	Boiler High Temp	Split Unitary AC	AWHP	$1,388	$1,388	$1,388	$1,388
Fuel Oil	Furnace	Split Unitary AC	AWHP	$1,416	$1,416	$1,416	$1,416
Electric	Electric Resistance	Split Unitary AC	AWHP	$1,233	$1,233	$1,233	$1,233
Propane	Boiler Low Temp	None	Split Unitary HP	$1,009	$1,009	$1,009	$1,009
Propane	Boiler High Temp	None	Split Unitary HP	$1,009	$1,009	$1,009	$1,009
Propane	Furnace	None	Split Unitary HP	$1,009	$1,009	$1,009	$1,009
Methane Gas	Boiler Low Temp	None	Split Unitary HP	-$103	-$103	-$103	-$103
Methane Gas	Boiler High Temp	None	Split Unitary HP	-$103	-$103	-$103	-$103
Methane Gas	Furnace	None	Split Unitary HP	-$103	-$103	-$103	-$103
Fuel Oil	Boiler High Temp	None	Split Unitary HP	$1,084	$1,084	$1,084	$1,084
Fuel Oil	Furnace	None	Split Unitary HP	$1,113	$1,113	$1,113	$1,113
Electric	Electric Resistance	None	Split Unitary HP	$930	$930	$930	$930
Propane	Boiler Low Temp	None	Packaged Unitary HP	$1,009	$1,009	$1,009	$1,009
Propane	Boiler High Temp	None	Packaged Unitary HP	$1,009	$1,009	$1,009	$1,009

Equipment Combinations				Operating Costs Savings			
Fuel Type	Baseline Heating Equipment	Baseline Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Furnace	None	Packaged Unitary HP	$1,009	$1,009	$1,009	$1,009
Methane Gas	Boiler Low Temp	None	Packaged Unitary HP	-$103	-$103	-$103	-$103
Methane Gas	Boiler High Temp	None	Packaged Unitary HP	-$103	-$103	-$103	-$103
Methane Gas	Furnace	None	Packaged Unitary HP	-$103	-$103	-$103	-$103
Fuel Oil	Boiler High Temp	None	Packaged Unitary HP	$1,084	$1,084	$1,084	$1,084
Fuel Oil	Furnace	None	Packaged Unitary HP	$1,113	$1,113	$1,113	$1,113
Electric	Electric Resistance	None	Packaged Unitary HP	$930	$930	$930	$930
Propane	Boiler Low Temp	None	Mini-Multi Split	$1,171	$1,171	$1,171	$1,171
Propane	Boiler High Temp	None	Mini-Multi Split	$1,171	$1,171	$1,171	$1,171
Propane	Furnace	None	Mini-Multi Split	$1,171	$1,171	$1,171	$1,171
Methane Gas	Boiler Low Temp	None	Mini-Multi Split	$58	$58	$58	$58
Methane Gas	Boiler High Temp	None	Mini-Multi Split	$58	$58	$58	$58
Methane Gas	Furnace	None	Mini-Multi Split	$58	$58	$58	$58
Fuel Oil	Boiler High Temp	None	Mini-Multi Split	$1,246	$1,246	$1,246	$1,246
Fuel Oil	Furnace	None	Mini-Multi Split	$1,274	$1,274	$1,274	$1,274
Fuel Oil	Furnace	None	Mini-Multi Split	$1,274	$1,274	$1,274	$1,274
Electric	Electric Resistance	None	Mini-Multi Split	$1,091	$1,091	$1,091	$1,091
Propane	Boiler Low Temp	None	AWHP	$969	$969	$969	$969
Propane	Boiler High Temp	None	AWHP	$969	$969	$969	$969
Propane	Furnace	None	AWHP	$969	$969	$969	$969
Methane Gas	Boiler Low Temp	None	AWHP	-$144	-$144	-$144	-$144
Methane Gas	Boiler High Temp	None	AWHP	-$144	-$144	-$144	-$144
Methane Gas	Furnace	None	AWHP	-$144	-$144	-$144	-$144
Fuel Oil	Boiler High Temp	None	AWHP	$1,044	$1,044	$1,044	$1,044
Electric	Electric Resistance	None	AWHP	$889	$889	$889	$889

TABLE 31. OPERATING COST SAVINGS FOR DIFFERENT EQUIPMENT SCENARIOS IN MAINE FOR AVERAGE BUILDING VINTAGE, 2022 TO 2023

Equipment Combinations				Operating Costs Savings			
Fuel Type	Baseline Heating Equipment	Baseline Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$1,652	$2,904	$1,401	$1,652
Propane	Boiler High Temp	Split Unitary AC	Split Unitary HP	$1,652	$2,904	$1,401	$1,652
Propane	Furnace	Split Unitary AC	Split Unitary HP	$1,652	$2,904	$1,401	$1,652
Methane Gas	Boiler Low Temp	Split Unitary AC	Split Unitary HP	-$2,268	-$541	-$3,449	-$2,229
Methane Gas	Boiler High Temp	Split Unitary AC	Split Unitary HP	-$2,268	-$541	-$3,449	-$2,229
Methane Gas	Furnace	Split Unitary AC	Split Unitary HP	-$2,268	-$541	-$3,449	-$2,229
Fuel Oil	Boiler High Temp	Split Unitary AC	Split Unitary HP	$1,500	$2,753	$1,250	$1,500
Fuel Oil	Furnace	Split Unitary AC	Split Unitary HP	$1,581	$2,834	$1,330	$1,581
Electric	Electric Resistance	Split Unitary AC	Split Unitary HP	$6,612	$5,109	$6,913	$6,612
Propane	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$1,652	$2,904	$1,401	$1,652
Propane	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$1,652	$2,904	$1,401	$1,652
Propane	Furnace	Split Unitary AC	Packaged Unitary HP	$1,652	$2,904	$1,401	$1,652
Methane Gas	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	-$2,268	-$541	-$3,449	-$2,229
Methane Gas	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	-$2,268	-$541	-$3,449	-$2,229
Methane Gas	Furnace	Split Unitary AC	Packaged Unitary HP	-$2,268	-$541	-$3,449	-$2,229
Fuel Oil	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$1,500	$2,753	$1,250	$1,500
Fuel Oil	Furnace	Split Unitary AC	Packaged Unitary HP	$1,581	$2,834	$1,330	$1,581
Electric	Electric Resistance	Split Unitary AC	Packaged Unitary HP	$6,612	$5,109	$6,913	$6,612
Propane	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$2,315	$3,417	$2,095	$2,315
Propane	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$2,315	$3,417	$2,095	$2,315
Propane	Furnace	Split Unitary AC	Mini-Multi Split	$2,315	$3,417	$2,095	$2,315
Methane Gas	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	-$1,605	-$28	-$2,755	-$1,565
Methane Gas	Boiler High Temp	Split Unitary AC	Mini-Multi Split	-$1,605	-$28	-$2,755	-$1,565
Methane Gas	Furnace	Split Unitary AC	Mini-Multi Split	-$1,605	-$28	-$2,755	-$1,565
Fuel Oil	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$2,164	$3,266	$1,944	$2,164
Fuel Oil	Furnace	Split Unitary AC	Mini-Multi Split	$2,245	$3,347	$2,025	$2,245
Electric	Electric Resistance	Split Unitary AC	Mini-Multi Split	$7,276	$5,622	$7,607	$7,276
Propane	Boiler Low Temp	Split Unitary AC	AWHP	$2,766	$3,766	$2,566	$2,766
Propane	Boiler High Temp	Split Unitary AC	AWHP	$2,766	$3,766	$2,566	$2,766
Propane	Furnace	Split Unitary AC	AWHP	$2,766	$3,766	$2,566	$2,766

Equipment Combinations				Operating Costs Savings			
Fuel Type	Baseline Heating Equipment	Baseline Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Methane Gas	Boiler Low Temp	Split Unitary AC	AWHP	-$1,154	$321	-$2,283	-$1,114
Methane Gas	Boiler High Temp	Split Unitary AC	AWHP	-$1,154	$321	-$2,283	-$1,114
Methane Gas	Furnace	Split Unitary AC	AWHP	-$1,154	$321	-$2,283	-$1,114
Fuel Oil	Boiler High Temp	Split Unitary AC	AWHP	$2,615	$3,615	$2,415	$2,615
Fuel Oil	Furnace	Split Unitary AC	AWHP	$2,696	$3,695	$2,496	$2,696
Electric	Electric Resistance	Split Unitary AC	AWHP	$7,727	$5,971	$8,078	$7,727
Propane	Boiler Low Temp	None	Split Unitary HP	$1,508	$2,793	$1,251	$1,508
Propane	Boiler High Temp	None	Split Unitary HP	$1,508	$2,793	$1,251	$1,508
Propane	Furnace	None	Split Unitary HP	$1,508	$2,793	$1,251	$1,508
Methane Gas	Boiler Low Temp	None	Split Unitary HP	-$2,412	-$652	-$3,599	-$2,373
Methane Gas	Boiler High Temp	None	Split Unitary HP	-$2,412	-$652	-$3,599	-$2,373
Methane Gas	Furnace	None	Split Unitary HP	-$2,412	-$652	-$3,599	-$2,373
Fuel Oil	Boiler High Temp	None	Split Unitary HP	$1,357	$2,642	$1,100	$1,357
Fuel Oil	Furnace	None	Split Unitary HP	$1,437	$2,723	$1,180	$1,437
Electric	Electric Resistance	None	Split Unitary HP	$6,469	$4,998	$6,763	$6,469
Propane	Boiler Low Temp	None	Packaged Unitary HP	$1,508	$2,793	$1,251	$1,508
Propane	Boiler High Temp	None	Packaged Unitary HP	$1,508	$2,793	$1,251	$1,508
Propane	Furnace	None	Packaged Unitary HP	$1,508	$2,793	$1,251	$1,508
Methane Gas	Boiler Low Temp	None	Packaged Unitary HP	-$2,412	-$652	-$3,599	-$2,373
Methane Gas	Boiler High Temp	None	Packaged Unitary HP	-$2,412	-$652	-$3,599	-$2,373
Methane Gas	Furnace	None	Packaged Unitary HP	-$2,412	-$652	-$3,599	-$2,373
Fuel Oil	Boiler High Temp	None	Packaged Unitary HP	$1,357	$2,642	$1,100	$1,357
Fuel Oil	Furnace	None	Packaged Unitary HP	$1,437	$2,723	$1,180	$1,437
Electric	Electric Resistance	None	Packaged Unitary HP	$6,469	$4,998	$6,763	$6,469
Propane	Boiler Low Temp	None	Mini-Multi Split	$2,172	$3,306	$1,945	$2,172
Propane	Boiler High Temp	None	Mini-Multi Split	$2,172	$3,306	$1,945	$2,172
Propane	Furnace	None	Mini-Multi Split	$2,172	$3,306	$1,945	$2,172
Methane Gas	Boiler Low Temp	None	Mini-Multi Split	-$1,748	-$139	-$2,905	-$1,709
Methane Gas	Boiler High Temp	None	Mini-Multi Split	-$1,748	-$139	-$2,905	-$1,709
Methane Gas	Furnace	None	Mini-Multi Split	-$1,748	-$139	-$2,905	-$1,709
Fuel Oil	Boiler High Temp	None	Mini-Multi Split	$2,021	$3,155	$1,794	$2,021

Equipment Combinations				Operating Costs Savings			
Fuel Type	Baseline Heating Equipment	Baseline Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Fuel Oil	Furnace	None	Mini-Multi Split	$2,101	$3,236	$1,874	$2,101
Fuel Oil	Furnace	None	Mini-Multi Split	$2,101	$3,236	$1,874	$2,101
Electric	Electric Resistance	None	Mini-Multi Split	$7,132	$5,511	$7,457	$7,132
Propane	Boiler Low Temp	None	AWHP	$2,623	$3,655	$2,416	$2,623
Propane	Boiler High Temp	None	AWHP	$2,623	$3,655	$2,416	$2,623
Propane	Furnace	None	AWHP	$2,623	$3,655	$2,416	$2,623
Methane Gas	Boiler Low Temp	None	AWHP	-$1,297	$210	-$2,434	-$1,258
Methane Gas	Boiler High Temp	None	AWHP	-$1,297	$210	-$2,434	-$1,258
Methane Gas	Furnace	None	AWHP	-$1,297	$210	-$2,434	-$1,258
Fuel Oil	Boiler High Temp	None	AWHP	$2,472	$3,504	$2,265	$2,472
Electric	Electric Resistance	None	AWHP	$7,583	$5,860	$7,928	$7,583

TABLE 32. OPERATING COST SAVINGS FOR DIFFERENT EQUIPMENT SCENARIOS IN MARYLAND FOR AVERAGE BUILDING VINTAGE, 2022 TO 2023

Equipment Combinations				Operating Costs Savings			
Fuel Type	Baseline Heating Equipment	Baseline Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$1,217	$1,529	$1,138	$1,217
Propane	Boiler High Temp	Split Unitary AC	Split Unitary HP	$1,217	$1,529	$1,138	$1,217
Propane	Furnace	Split Unitary AC	Split Unitary HP	$1,217	$1,529	$1,138	$1,217
Methane Gas	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$294	-$121	-$62	$522
Methane Gas	Boiler High Temp	Split Unitary AC	Split Unitary HP	$294	-$121	-$62	$522
Methane Gas	Furnace	Split Unitary AC	Split Unitary HP	$294	-$121	-$62	$522
Fuel Oil	Boiler High Temp	Split Unitary AC	Split Unitary HP	$1,288	$1,601	$1,210	$1,288
Fuel Oil	Furnace	Split Unitary AC	Split Unitary HP	$1,316	$1,628	$1,237	$1,316
Electric	Electric Resistance	Split Unitary AC	Split Unitary HP	$1,312	$937	$1,406	$1,312
Propane	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$1,217	$1,529	$1,138	$1,217
Propane	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$1,217	$1,529	$1,138	$1,217
Propane	Furnace	Split Unitary AC	Packaged Unitary HP	$1,217	$1,529	$1,138	$1,217
Methane Gas	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$294	-$121	-$62	$522
Methane Gas	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$294	-$121	-$62	$522

Equipment Combinations				Operating Costs Savings			
Fuel Type	Baseline Heating Equipment	Baseline Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Methane Gas	Furnace	Split Unitary AC	Packaged Unitary HP	$294	-$121	-$62	$522
Fuel Oil	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$1,288	$1,601	$1,210	$1,288
Fuel Oil	Furnace	Split Unitary AC	Packaged Unitary HP	$1,316	$1,628	$1,237	$1,316
Electric	Electric Resistance	Split Unitary AC	Packaged Unitary HP	$1,312	$937	$1,406	$1,312
Propane	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$1,377	$1,643	$1,310	$1,377
Propane	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$1,377	$1,643	$1,310	$1,377
Propane	Furnace	Split Unitary AC	Mini-Multi Split	$1,377	$1,643	$1,310	$1,377
Methane Gas	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$454	-$7	$110	$682
Methane Gas	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$454	-$7	$110	$682
Methane Gas	Furnace	Split Unitary AC	Mini-Multi Split	$454	-$7	$110	$682
Fuel Oil	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$1,448	$1,715	$1,381	$1,448
Fuel Oil	Furnace	Split Unitary AC	Mini-Multi Split	$1,476	$1,742	$1,409	$1,476
Electric	Electric Resistance	Split Unitary AC	Mini-Multi Split	$1,472	$1,052	$1,577	$1,472
Propane	Boiler Low Temp	Split Unitary AC	AWHP	$1,223	$1,534	$1,145	$1,223
Propane	Boiler High Temp	Split Unitary AC	AWHP	$1,223	$1,534	$1,145	$1,223
Propane	Furnace	Split Unitary AC	AWHP	$1,223	$1,534	$1,145	$1,223
Methane Gas	Boiler Low Temp	Split Unitary AC	AWHP	$300	-$117	-$55	$529
Methane Gas	Boiler High Temp	Split Unitary AC	AWHP	$300	-$117	-$55	$529
Methane Gas	Furnace	Split Unitary AC	AWHP	$300	-$117	-$55	$529
Fuel Oil	Boiler High Temp	Split Unitary AC	AWHP	$1,294	$1,605	$1,217	$1,294
Fuel Oil	Furnace	Split Unitary AC	AWHP	$1,322	$1,633	$1,244	$1,322
Electric	Electric Resistance	Split Unitary AC	AWHP	$1,318	$942	$1,413	$1,318
Propane	Boiler Low Temp	None	Split Unitary HP	$922	$1,319	$823	$922
Propane	Boiler High Temp	None	Split Unitary HP	$922	$1,319	$823	$922
Propane	Furnace	None	Split Unitary HP	$922	$1,319	$823	$922
Methane Gas	Boiler Low Temp	None	Split Unitary HP	-$1	-$332	-$377	$228
Methane Gas	Boiler High Temp	None	Split Unitary HP	-$1	-$332	-$377	$228
Methane Gas	Furnace	None	Split Unitary HP	-$1	-$332	-$377	$228
Fuel Oil	Boiler High Temp	None	Split Unitary HP	$993	$1,390	$894	$993
Fuel Oil	Furnace	None	Split Unitary HP	$1,021	$1,418	$922	$1,021
Electric	Electric Resistance	None	Split Unitary HP	$1,017	$727	$1,090	$1,017
Propane	Boiler Low Temp	None	Packaged Unitary HP	$922	$1,319	$823	$922
Propane	Boiler High Temp	None	Packaged Unitary HP	$922	$1,319	$823	$922

Equipment Combinations				Operating Costs Savings			
Fuel Type	Baseline Heating Equipment	Baseline Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Furnace	None	Packaged Unitary HP	$922	$1,319	$823	$922
Methane Gas	Boiler Low Temp	None	Packaged Unitary HP	-$1	-$332	-$377	$228
Methane Gas	Boiler High Temp	None	Packaged Unitary HP	-$1	-$332	-$377	$228
Methane Gas	Furnace	None	Packaged Unitary HP	-$1	-$332	-$377	$228
Fuel Oil	Boiler High Temp	None	Packaged Unitary HP	$993	$1,390	$894	$993
Fuel Oil	Furnace	None	Packaged Unitary HP	$1,021	$1,418	$922	$1,021
Electric	Electric Resistance	None	Packaged Unitary HP	$1,017	$727	$1,090	$1,017
Propane	Boiler Low Temp	None	Mini-Multi Split	$1,082	$1,433	$994	$1,082
Propane	Boiler High Temp	None	Mini-Multi Split	$1,082	$1,433	$994	$1,082
Propane	Furnace	None	Mini-Multi Split	$1,082	$1,433	$994	$1,082
Methane Gas	Boiler Low Temp	None	Mini-Multi Split	$159	-$218	-$206	$388
Methane Gas	Boiler High Temp	None	Mini-Multi Split	$159	-$218	-$206	$388
Methane Gas	Furnace	None	Mini-Multi Split	$159	-$218	-$206	$388
Fuel Oil	Boiler High Temp	None	Mini-Multi Split	$1,153	$1,504	$1,066	$1,153
Fuel Oil	Furnace	None	Mini-Multi Split	$1,181	$1,532	$1,093	$1,181
Fuel Oil	Furnace	None	Mini-Multi Split	$1,181	$1,532	$1,093	$1,181
Electric	Electric Resistance	None	Mini-Multi Split	$1,177	$841	$1,262	$1,177
Propane	Boiler Low Temp	None	AWHP	$928	$1,323	$829	$928
Propane	Boiler High Temp	None	AWHP	$928	$1,323	$829	$928
Propane	Furnace	None	AWHP	$928	$1,323	$829	$928
Methane Gas	Boiler Low Temp	None	AWHP	$6	-$327	-$371	$234
Methane Gas	Boiler High Temp	None	AWHP	$6	-$327	-$371	$234
Methane Gas	Furnace	None	AWHP	$6	-$327	-$371	$234
Fuel Oil	Boiler High Temp	None	AWHP	$1,000	$1,395	$901	$1,000
Electric	Electric Resistance	None	AWHP	$1,024	$731	$1,097	$1,024

TABLE 33. OPERATING COST SAVINGS FOR DIFFERENT EQUIPMENT SCENARIOS IN MASSACHUSETTS FOR AVERAGE BUILDING VINTAGE, 2022 TO 2023

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$509	$1,731	$175	$175
Propane	Boiler High Temp	Split Unitary AC	Split Unitary HP	$509	$1,731	$175	$175
Propane	Furnace	Split Unitary AC	Split Unitary HP	$509	$1,731	$175	$175
Methane Gas	Boiler Low Temp	Split Unitary AC	Split Unitary HP	-$757	$1,667	-$1,336	-$950
Methane Gas	Boiler High Temp	Split Unitary AC	Split Unitary HP	-$757	$1,667	-$1,336	-$950
Methane Gas	Furnace	Split Unitary AC	Split Unitary HP	-$757	$1,667	-$1,336	-$950
Fuel Oil	Boiler High Temp	Split Unitary AC	Split Unitary HP	$377	$1,600	$44	$44
Fuel Oil	Furnace	Split Unitary AC	Split Unitary HP	$415	$1,637	$82	$82
Electric	Electric Resistance	Split Unitary AC	Split Unitary HP	$3,465	$1,999	$3,865	$3,865
Propane	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$509	$1,731	$175	$175
Propane	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$509	$1,731	$175	$175
Propane	Furnace	Split Unitary AC	Packaged Unitary HP	$509	$1,731	$175	$175
Methane Gas	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	-$757	$1,667	-$1,336	-$950
Methane Gas	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	-$757	$1,667	-$1,336	-$950
Methane Gas	Furnace	Split Unitary AC	Packaged Unitary HP	-$757	$1,667	-$1,336	-$950
Fuel Oil	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$377	$1,600	$44	$44
Fuel Oil	Furnace	Split Unitary AC	Packaged Unitary HP	$415	$1,637	$82	$82
Electric	Electric Resistance	Split Unitary AC	Packaged Unitary HP	$3,465	$1,999	$3,865	$3,865
Propane	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$882	$1,946	$591	$591
Propane	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$882	$1,946	$591	$591
Propane	Furnace	Split Unitary AC	Mini-Multi Split	$882	$1,946	$591	$591
Methane Gas	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	-$385	$1,882	-$921	-$535
Methane Gas	Boiler High Temp	Split Unitary AC	Mini-Multi Split	-$385	$1,882	-$921	-$535
Methane Gas	Furnace	Split Unitary AC	Mini-Multi Split	-$385	$1,882	-$921	-$535
Fuel Oil	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$750	$1,815	$460	$460
Fuel Oil	Furnace	Split Unitary AC	Mini-Multi Split	$788	$1,852	$497	$497
Electric	Electric Resistance	Split Unitary AC	Mini-Multi Split	$3,838	$2,214	$4,281	$4,281
Propane	Boiler Low Temp	Split Unitary AC	AWHP	$905	$1,960	$617	$617
Propane	Boiler High Temp	Split Unitary AC	AWHP	$905	$1,960	$617	$617
Propane	Furnace	Split Unitary AC	AWHP	$905	$1,960	$617	$617

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample " Small" Utility / Co-op	Second Largest Utility	Largest Utility
Methane Gas	Boiler Low Temp	Split Unitary AC	AWHP	-$361	$1,895	-$894	-$508
Methane Gas	Boiler High Temp	Split Unitary AC	AWHP	-$361	$1,895	-$894	-$508
Methane Gas	Furnace	Split Unitary AC	AWHP	-$361	$1,895	-$894	-$508
Fuel Oil	Boiler High Temp	Split Unitary AC	AWHP	$774	$1,828	$486	$486
Fuel Oil	Furnace	Split Unitary AC	AWHP	$811	$1,866	$524	$524
Electric	Electric Resistance	Split Unitary AC	AWHP	$3,862	$2,228	$4,307	$4,307
Propane	Boiler Low Temp	None	Split Unitary HP	$201	$1,553	-$168	-$168
Propane	Boiler High Temp	None	Split Unitary HP	$201	$1,553	-$168	-$168
Propane	Furnace	None	Split Unitary HP	$201	$1,553	-$168	-$168
Methane Gas	Boiler Low Temp	None	Split Unitary HP	-$1,066	$1,489	-$1,680	-$1,294
Methane Gas	Boiler High Temp	None	Split Unitary HP	-$1,066	$1,489	-$1,680	-$1,294
Methane Gas	Furnace	None	Split Unitary HP	-$1,066	$1,489	-$1,680	-$1,294
Fuel Oil	Boiler High Temp	None	Split Unitary HP	$69	$1,422	-$300	-$300
Fuel Oil	Furnace	None	Split Unitary HP	$107	$1,460	-$262	-$262
Electric	Electric Resistance	None	Split Unitary HP	$3,157	$1,822	$3,522	$3,522
Propane	Boiler Low Temp	None	Packaged Unitary HP	$201	$1,553	-$168	-$168
Propane	Boiler High Temp	None	Packaged Unitary HP	$201	$1,553	-$168	-$168
Propane	Furnace	None	Packaged Unitary HP	$201	$1,553	-$168	-$168
Methane Gas	Boiler Low Temp	None	Packaged Unitary HP	-$1,066	$1,489	-$1,680	-$1,294
Methane Gas	Boiler High Temp	None	Packaged Unitary HP	-$1,066	$1,489	-$1,680	-$1,294
Methane Gas	Furnace	None	Packaged Unitary HP	-$1,066	$1,489	-$1,680	-$1,294
Fuel Oil	Boiler High Temp	None	Packaged Unitary HP	$69	$1,422	-$300	-$300
Fuel Oil	Furnace	None	Packaged Unitary HP	$107	$1,460	-$262	-$262
Electric	Electric Resistance	None	Packaged Unitary HP	$3,157	$1,822	$3,522	$3,522
Propane	Boiler Low Temp	None	Mini-Multi Split	$573	$1,768	$247	$247
Propane	Boiler High Temp	None	Mini-Multi Split	$573	$1,768	$247	$247
Propane	Furnace	None	Mini-Multi Split	$573	$1,768	$247	$247
Methane Gas	Boiler Low Temp	None	Mini-Multi Split	-$693	$1,704	-$1,264	-$878
Methane Gas	Boiler High Temp	None	Mini-Multi Split	-$693	$1,704	-$1,264	-$878
Methane Gas	Furnace	None	Mini-Multi Split	-$693	$1,704	-$1,264	-$878
Fuel Oil	Boiler High Temp	None	Mini-Multi Split	$442	$1,637	$116	$116

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Fuel Oil	Furnace	None	Mini-Multi Split	$479	$1,675	$154	$154
Fuel Oil	Furnace	None	Mini-Multi Split	$479	$1,675	$154	$154
Electric	Electric Resistance	None	Mini-Multi Split	$3,530	$2,036	$3,937	$3,937
Propane	Boiler Low Temp	None	AWHP	$597	$1,782	$274	$274
Propane	Boiler High Temp	None	AWHP	$597	$1,782	$274	$274
Propane	Furnace	None	AWHP	$597	$1,782	$274	$274
Methane Gas	Boiler Low Temp	None	AWHP	-$669	$1,718	-$1,238	-$852
Methane Gas	Boiler High Temp	None	AWHP	-$669	$1,718	-$1,238	-$852
Methane Gas	Furnace	None	AWHP	-$669	$1,718	-$1,238	-$852
Fuel Oil	Boiler High Temp	None	AWHP	$466	$1,651	$142	$142
Electric	Electric Resistance	None	AWHP	$3,554	$2,050	$3,964	$3,964

TABLE 34. OPERATING COST SAVINGS FOR DIFFERENT EQUIPMENT SCENARIOS IN NEW HAMPSHIRE FOR AVERAGE BUILDING VINTAGE, 2022 TO 2023

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$608	$608	$608	$608
Propane	Boiler High Temp	Split Unitary AC	Split Unitary HP	$608	$608	$608	$608
Propane	Furnace	Split Unitary AC	Split Unitary HP	$608	$608	$608	$608
Methane Gas	Boiler Low Temp	Split Unitary AC	Split Unitary HP	-$1,278	-$1,278	-$1,024	-$1,367
Methane Gas	Boiler High Temp	Split Unitary AC	Split Unitary HP	-$1,278	-$1,278	-$1,024	-$1,367
Methane Gas	Furnace	Split Unitary AC	Split Unitary HP	-$1,278	-$1,278	-$1,024	-$1,367
Fuel Oil	Boiler High Temp	Split Unitary AC	Split Unitary HP	$360	$360	$360	$360
Fuel Oil	Furnace	Split Unitary AC	Split Unitary HP	$393	$393	$393	$393
Electric	Electric Resistance	Split Unitary AC	Split Unitary HP	$2,946	$2,946	$2,946	$2,946
Propane	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$608	$608	$608	$608
Propane	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$608	$608	$608	$608
Propane	Furnace	Split Unitary AC	Packaged Unitary HP	$608	$608	$608	$608
Methane Gas	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	-$1,278	-$1,278	-$1,024	-$1,367
Methane Gas	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	-$1,278	-$1,278	-$1,024	-$1,367

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Methane Gas	Furnace	Split Unitary AC	Packaged Unitary HP	-$1,278	-$1,278	-$1,024	-$1,367
Fuel Oil	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$360	$360	$360	$360
Fuel Oil	Furnace	Split Unitary AC	Packaged Unitary HP	$393	$393	$393	$393
Electric	Electric Resistance	Split Unitary AC	Packaged Unitary HP	$2,946	$2,946	$2,946	$2,946
Propane	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$918	$918	$918	$918
Propane	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$918	$918	$918	$918
Propane	Furnace	Split Unitary AC	Mini-Multi Split	$918	$918	$918	$918
Methane Gas	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	-$967	-$967	-$713	-$1,056
Methane Gas	Boiler High Temp	Split Unitary AC	Mini-Multi Split	-$967	-$967	-$713	-$1,056
Methane Gas	Furnace	Split Unitary AC	Mini-Multi Split	-$967	-$967	-$713	-$1,056
Fuel Oil	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$671	$671	$671	$671
Fuel Oil	Furnace	Split Unitary AC	Mini-Multi Split	$703	$703	$703	$703
Electric	Electric Resistance	Split Unitary AC	Mini-Multi Split	$3,256	$3,256	$3,256	$3,256
Propane	Boiler Low Temp	Split Unitary AC	AWHP	$990	$990	$990	$990
Propane	Boiler High Temp	Split Unitary AC	AWHP	$990	$990	$990	$990
Propane	Furnace	Split Unitary AC	AWHP	$990	$990	$990	$990
Methane Gas	Boiler Low Temp	Split Unitary AC	AWHP	-$896	-$896	-$642	-$985
Methane Gas	Boiler High Temp	Split Unitary AC	AWHP	-$896	-$896	-$642	-$985
Methane Gas	Furnace	Split Unitary AC	AWHP	-$896	-$896	-$642	-$985
Fuel Oil	Boiler High Temp	Split Unitary AC	AWHP	$742	$742	$742	$742
Fuel Oil	Furnace	Split Unitary AC	AWHP	$775	$775	$775	$775
Electric	Electric Resistance	Split Unitary AC	AWHP	$3,328	$3,328	$3,328	$3,328
Propane	Boiler Low Temp	None	Split Unitary HP	$402	$402	$402	$402
Propane	Boiler High Temp	None	Split Unitary HP	$402	$402	$402	$402
Propane	Furnace	None	Split Unitary HP	$402	$402	$402	$402
Methane Gas	Boiler Low Temp	None	Split Unitary HP	-$1,484	-$1,484	-$1,230	-$1,573
Methane Gas	Boiler High Temp	None	Split Unitary HP	-$1,484	-$1,484	-$1,230	-$1,573
Methane Gas	Furnace	None	Split Unitary HP	-$1,484	-$1,484	-$1,230	-$1,573
Fuel Oil	Boiler High Temp	None	Split Unitary HP	$154	$154	$154	$154
Fuel Oil	Furnace	None	Split Unitary HP	$187	$187	$187	$187
Electric	Electric Resistance	None	Split Unitary HP	$2,740	$2,740	$2,740	$2,740
Propane	Boiler Low Temp	None	Packaged Unitary HP	$402	$402	$402	$402
Propane	Boiler High Temp	None	Packaged Unitary HP	$402	$402	$402	$402

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Furnace	None	Packaged Unitary HP	$402	$402	$402	$402
Methane Gas	Boiler Low Temp	None	Packaged Unitary HP	-$1,484	-$1,484	-$1,230	-$1,573
Methane Gas	Boiler High Temp	None	Packaged Unitary HP	-$1,484	-$1,484	-$1,230	-$1,573
Methane Gas	Furnace	None	Packaged Unitary HP	-$1,484	-$1,484	-$1,230	-$1,573
Fuel Oil	Boiler High Temp	None	Packaged Unitary HP	$154	$154	$154	$154
Fuel Oil	Furnace	None	Packaged Unitary HP	$187	$187	$187	$187
Electric	Electric Resistance	None	Packaged Unitary HP	$2,740	$2,740	$2,740	$2,740
Propane	Boiler Low Temp	None	Mini-Multi Split	$713	$713	$713	$713
Propane	Boiler High Temp	None	Mini-Multi Split	$713	$713	$713	$713
Propane	Furnace	None	Mini-Multi Split	$713	$713	$713	$713
Methane Gas	Boiler Low Temp	None	Mini-Multi Split	-$1,173	-$1,173	-$919	-$1,262
Methane Gas	Boiler High Temp	None	Mini-Multi Split	-$1,173	-$1,173	-$919	-$1,262
Methane Gas	Furnace	None	Mini-Multi Split	-$1,173	-$1,173	-$919	-$1,262
Fuel Oil	Boiler High Temp	None	Mini-Multi Split	$465	$465	$465	$465
Fuel Oil	Furnace	None	Mini-Multi Split	$497	$497	$497	$497
Fuel Oil	Furnace	None	Mini-Multi Split	$497	$497	$497	$497
Electric	Electric Resistance	None	Mini-Multi Split	$3,050	$3,050	$3,050	$3,050
Propane	Boiler Low Temp	None	AWHP	$784	$784	$784	$784
Propane	Boiler High Temp	None	AWHP	$784	$784	$784	$784
Propane	Furnace	None	AWHP	$784	$784	$784	$784
Methane Gas	Boiler Low Temp	None	AWHP	-$1,102	-$1,102	-$848	-$1,191
Methane Gas	Boiler High Temp	None	AWHP	-$1,102	-$1,102	-$848	-$1,191
Methane Gas	Furnace	None	AWHP	-$1,102	-$1,102	-$848	-$1,191
Fuel Oil	Boiler High Temp	None	AWHP	$536	$536	$536	$536
Electric	Electric Resistance	None	AWHP	$3,122	$3,122	$3,122	$3,122

TABLE 35. OPERATING COST SAVINGS FOR DIFFERENT EQUIPMENT SCENARIOS IN NEW JERSEY FOR AVERAGE BUILDING VINTAGE, 2022 TO 2023

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$882	$882	$1,101	$882
Propane	Boiler High Temp	Split Unitary AC	Split Unitary HP	$882	$882	$1,101	$882
Propane	Furnace	Split Unitary AC	Split Unitary HP	$882	$882	$1,101	$882
Methane Gas	Boiler Low Temp	Split Unitary AC	Split Unitary HP	-$272	-$301	$130	-$456
Methane Gas	Boiler High Temp	Split Unitary AC	Split Unitary HP	-$272	-$301	$130	-$456
Methane Gas	Furnace	Split Unitary AC	Split Unitary HP	-$272	-$301	$130	-$456
Fuel Oil	Boiler High Temp	Split Unitary AC	Split Unitary HP	$1,012	$1,012	$1,231	$1,012
Fuel Oil	Furnace	Split Unitary AC	Split Unitary HP	$1,038	$1,038	$1,257	$1,038
Electric	Electric Resistance	Split Unitary AC	Split Unitary HP	$1,486	$1,486	$1,224	$1,486
Propane	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$882	$882	$1,101	$882
Propane	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$882	$882	$1,101	$882
Propane	Furnace	Split Unitary AC	Packaged Unitary HP	$882	$882	$1,101	$882
Methane Gas	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	-$272	-$301	$130	-$456
Methane Gas	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	-$272	-$301	$130	-$456
Methane Gas	Furnace	Split Unitary AC	Packaged Unitary HP	-$272	-$301	$130	-$456
Fuel Oil	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$1,012	$1,012	$1,231	$1,012
Fuel Oil	Furnace	Split Unitary AC	Packaged Unitary HP	$1,038	$1,038	$1,257	$1,038
Electric	Electric Resistance	Split Unitary AC	Packaged Unitary HP	$1,486	$1,486	$1,224	$1,486
Propane	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$1,054	$1,054	$1,242	$1,054
Propane	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$1,054	$1,054	$1,242	$1,054
Propane	Furnace	Split Unitary AC	Mini-Multi Split	$1,054	$1,054	$1,242	$1,054
Methane Gas	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	-$101	-$130	$272	-$285
Methane Gas	Boiler High Temp	Split Unitary AC	Mini-Multi Split	-$101	-$130	$272	-$285
Methane Gas	Furnace	Split Unitary AC	Mini-Multi Split	-$101	-$130	$272	-$285
Fuel Oil	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$1,184	$1,184	$1,372	$1,184
Fuel Oil	Furnace	Split Unitary AC	Mini-Multi Split	$1,209	$1,209	$1,398	$1,209
Electric	Electric Resistance	Split Unitary AC	Mini-Multi Split	$1,658	$1,658	$1,365	$1,658
Propane	Boiler Low Temp	Split Unitary AC	AWHP	$963	$963	$1,167	$963
Propane	Boiler High Temp	Split Unitary AC	AWHP	$963	$963	$1,167	$963
Propane	Furnace	Split Unitary AC	AWHP	$963	$963	$1,167	$963

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Methane Gas	Boiler Low Temp	Split Unitary AC	AWHP	-$192	-$221	$197	-$376
Methane Gas	Boiler High Temp	Split Unitary AC	AWHP	-$192	-$221	$197	-$376
Methane Gas	Furnace	Split Unitary AC	AWHP	-$192	-$221	$197	-$376
Fuel Oil	Boiler High Temp	Split Unitary AC	AWHP	$1,093	$1,093	$1,297	$1,093
Fuel Oil	Furnace	Split Unitary AC	AWHP	$1,118	$1,118	$1,323	$1,118
Electric	Electric Resistance	Split Unitary AC	AWHP	$1,567	$1,567	$1,290	$1,567
Propane	Boiler Low Temp	None	Split Unitary HP	$639	$639	$901	$639
Propane	Boiler High Temp	None	Split Unitary HP	$639	$639	$901	$639
Propane	Furnace	None	Split Unitary HP	$639	$639	$901	$639
Methane Gas	Boiler Low Temp	None	Split Unitary HP	-$515	-$544	-$70	-$699
Methane Gas	Boiler High Temp	None	Split Unitary HP	-$515	-$544	-$70	-$699
Methane Gas	Furnace	None	Split Unitary HP	-$515	-$544	-$70	-$699
Fuel Oil	Boiler High Temp	None	Split Unitary HP	$769	$769	$1,031	$769
Fuel Oil	Furnace	None	Split Unitary HP	$795	$795	$1,057	$795
Electric	Electric Resistance	None	Split Unitary HP	$1,243	$1,243	$1,024	$1,243
Propane	Boiler Low Temp	None	Packaged Unitary HP	$639	$639	$901	$639
Propane	Boiler High Temp	None	Packaged Unitary HP	$639	$639	$901	$639
Propane	Furnace	None	Packaged Unitary HP	$639	$639	$901	$639
Methane Gas	Boiler Low Temp	None	Packaged Unitary HP	-$515	-$544	-$70	-$699
Methane Gas	Boiler High Temp	None	Packaged Unitary HP	-$515	-$544	-$70	-$699
Methane Gas	Furnace	None	Packaged Unitary HP	-$515	-$544	-$70	-$699
Fuel Oil	Boiler High Temp	None	Packaged Unitary HP	$769	$769	$1,031	$769
Fuel Oil	Furnace	None	Packaged Unitary HP	$795	$795	$1,057	$795
Electric	Electric Resistance	None	Packaged Unitary HP	$1,243	$1,243	$1,024	$1,243
Propane	Boiler Low Temp	None	Mini-Multi Split	$811	$811	$1,042	$811
Propane	Boiler High Temp	None	Mini-Multi Split	$811	$811	$1,042	$811
Propane	Furnace	None	Mini-Multi Split	$811	$811	$1,042	$811
Methane Gas	Boiler Low Temp	None	Mini-Multi Split	-$344	-$372	$72	-$528
Methane Gas	Boiler High Temp	None	Mini-Multi Split	-$344	-$372	$72	-$528
Methane Gas	Furnace	None	Mini-Multi Split	-$344	-$372	$72	-$528
Fuel Oil	Boiler High Temp	None	Mini-Multi Split	$941	$941	$1,172	$941

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Fuel Oil	Furnace	None	Mini-Multi Split	$967	$967	$1,198	$967
Fuel Oil	Furnace	None	Mini-Multi Split	$967	$967	$1,198	$967
Electric	Electric Resistance	None	Mini-Multi Split	$1,415	$1,415	$1,165	$1,415
Propane	Boiler Low Temp	None	AWHP	$720	$720	$967	$720
Propane	Boiler High Temp	None	AWHP	$720	$720	$967	$720
Propane	Furnace	None	AWHP	$720	$720	$967	$720
Methane Gas	Boiler Low Temp	None	AWHP	-$435	-$463	-$3	-$619
Methane Gas	Boiler High Temp	None	AWHP	-$435	-$463	-$3	-$619
Methane Gas	Furnace	None	AWHP	-$435	-$463	-$3	-$619
Fuel Oil	Boiler High Temp	None	AWHP	$850	$850	$1,097	$850
Electric	Electric Resistance	None	AWHP	$1,324	$1,324	$1,090	$1,324

TABLE 36. OPERATING COST SAVINGS FOR DIFFERENT EQUIPMENT SCENARIOS IN NEW YORK FOR AVERAGE BUILDING VINTAGE, 2022 TO 2023

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$513	$596	$844	$17
Propane	Boiler High Temp	Split Unitary AC	Split Unitary HP	$513	$596	$844	$17
Propane	Furnace	Split Unitary AC	Split Unitary HP	$513	$596	$844	$17
Methane Gas	Boiler Low Temp	Split Unitary AC	Split Unitary HP	-$596	$296	$322	-$1,092
Methane Gas	Boiler High Temp	Split Unitary AC	Split Unitary HP	-$596	$296	$322	-$1,092
Methane Gas	Furnace	Split Unitary AC	Split Unitary HP	-$596	$296	$322	-$1,092
Fuel Oil	Boiler High Temp	Split Unitary AC	Split Unitary HP	$626	$709	$957	$130
Fuel Oil	Furnace	Split Unitary AC	Split Unitary HP	$655	$738	$986	$159
Electric	Electric Resistance	Split Unitary AC	Split Unitary HP	$2,281	$2,181	$1,884	$2,875
Propane	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$513	$596	$844	$17
Propane	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$513	$596	$844	$17
Propane	Furnace	Split Unitary AC	Packaged Unitary HP	$513	$596	$844	$17
Methane Gas	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	-$596	$296	$322	-$1,092
Methane Gas	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	-$596	$296	$322	-$1,092

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Methane Gas	Furnace	Split Unitary AC	Packaged Unitary HP	-$596	$296	$322	-$1,092
Fuel Oil	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$626	$709	$957	$130
Fuel Oil	Furnace	Split Unitary AC	Packaged Unitary HP	$655	$738	$986	$159
Electric	Electric Resistance	Split Unitary AC	Packaged Unitary HP	$2,281	$2,181	$1,884	$2,875
Propane	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$761	$833	$1,049	$330
Propane	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$761	$833	$1,049	$330
Propane	Furnace	Split Unitary AC	Mini-Multi Split	$761	$833	$1,049	$330
Methane Gas	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	-$348	$533	$527	-$779
Methane Gas	Boiler High Temp	Split Unitary AC	Mini-Multi Split	-$348	$533	$527	-$779
Methane Gas	Furnace	Split Unitary AC	Mini-Multi Split	-$348	$533	$527	-$779
Fuel Oil	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$874	$946	$1,162	$443
Fuel Oil	Furnace	Split Unitary AC	Mini-Multi Split	$903	$975	$1,191	$472
Electric	Electric Resistance	Split Unitary AC	Mini-Multi Split	$2,529	$2,419	$2,089	$3,189
Propane	Boiler Low Temp	Split Unitary AC	AWHP	$750	$822	$1,039	$316
Propane	Boiler High Temp	Split Unitary AC	AWHP	$750	$822	$1,039	$316
Propane	Furnace	Split Unitary AC	AWHP	$750	$822	$1,039	$316
Methane Gas	Boiler Low Temp	Split Unitary AC	AWHP	-$359	$523	$518	-$793
Methane Gas	Boiler High Temp	Split Unitary AC	AWHP	-$359	$523	$518	-$793
Methane Gas	Furnace	Split Unitary AC	AWHP	-$359	$523	$518	-$793
Fuel Oil	Boiler High Temp	Split Unitary AC	AWHP	$863	$935	$1,152	$429
Fuel Oil	Furnace	Split Unitary AC	AWHP	$892	$964	$1,181	$458
Electric	Electric Resistance	Split Unitary AC	AWHP	$2,518	$2,408	$2,080	$3,174
Propane	Boiler Low Temp	None	Split Unitary HP	$281	$374	$652	-$276
Propane	Boiler High Temp	None	Split Unitary HP	$281	$374	$652	-$276
Propane	Furnace	None	Split Unitary HP	$281	$374	$652	-$276
Methane Gas	Boiler Low Temp	None	Split Unitary HP	-$828	$74	$130	-$1,385
Methane Gas	Boiler High Temp	None	Split Unitary HP	-$828	$74	$130	-$1,385
Methane Gas	Furnace	None	Split Unitary HP	-$828	$74	$130	-$1,385
Fuel Oil	Boiler High Temp	None	Split Unitary HP	$394	$486	$765	-$163
Fuel Oil	Furnace	None	Split Unitary HP	$423	$515	$794	-$134
Electric	Electric Resistance	None	Split Unitary HP	$2,048	$1,959	$1,692	$2,583
Propane	Boiler Low Temp	None	Packaged Unitary HP	$281	$374	$652	-$276
Propane	Boiler High Temp	None	Packaged Unitary HP	$281	$374	$652	-$276

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample “ Small” Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Furnace	None	Packaged Unitary HP	$281	$374	$652	-$276
Methane Gas	Boiler Low Temp	None	Packaged Unitary HP	-$828	$74	$130	-$1,385
Methane Gas	Boiler High Temp	None	Packaged Unitary HP	-$828	$74	$130	-$1,385
Methane Gas	Furnace	None	Packaged Unitary HP	-$828	$74	$130	-$1,385
Fuel Oil	Boiler High Temp	None	Packaged Unitary HP	$394	$486	$765	-$163
Fuel Oil	Furnace	None	Packaged Unitary HP	$423	$515	$794	-$134
Electric	Electric Resistance	None	Packaged Unitary HP	$2,048	$1,959	$1,692	$2,583
Propane	Boiler Low Temp	None	Mini-Multi Split	$529	$611	$857	$37
Propane	Boiler High Temp	None	Mini-Multi Split	$529	$611	$857	$37
Propane	Furnace	None	Mini-Multi Split	$529	$611	$857	$37
Methane Gas	Boiler Low Temp	None	Mini-Multi Split	-$580	$311	$335	-$1,072
Methane Gas	Boiler High Temp	None	Mini-Multi Split	-$580	$311	$335	-$1,072
Methane Gas	Furnace	None	Mini-Multi Split	-$580	$311	$335	-$1,072
Fuel Oil	Boiler High Temp	None	Mini-Multi Split	$642	$724	$970	$150
Fuel Oil	Furnace	None	Mini-Multi Split	$671	$753	$999	$179
Fuel Oil	Furnace	None	Mini-Multi Split	$671	$753	$999	$179
Electric	Electric Resistance	None	Mini-Multi Split	$2,297	$2,197	$1,897	$2,896
Propane	Boiler Low Temp	None	AWHP	$518	$600	$848	$23
Propane	Boiler High Temp	None	AWHP	$518	$600	$848	$23
Propane	Furnace	None	AWHP	$518	$600	$848	$23
Methane Gas	Boiler Low Temp	None	AWHP	-$591	$301	$326	-$1,086
Methane Gas	Boiler High Temp	None	AWHP	-$591	$301	$326	-$1,086
Methane Gas	Furnace	None	AWHP	-$591	$301	$326	-$1,086
Fuel Oil	Boiler High Temp	None	AWHP	$631	$713	$961	$136
Electric	Electric Resistance	None	AWHP	$2,285	$2,186	$1,888	$2,882

TABLE 37. OPERATING COST SAVINGS FOR DIFFERENT EQUIPMENT SCENARIOS IN PENNSYLVANIA FOR AVERAGE BUILDING VINTAGE, 2022 TO 2023

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$924	$1,190	$747	$1,013
Propane	Boiler High Temp	Split Unitary AC	Split Unitary HP	$924	$1,190	$747	$1,013
Propane	Furnace	Split Unitary AC	Split Unitary HP	$924	$1,190	$747	$1,013
Methane Gas	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$70	-$679	-$268	-$16
Methane Gas	Boiler High Temp	Split Unitary AC	Split Unitary HP	$70	-$679	-$268	-$16
Methane Gas	Furnace	Split Unitary AC	Split Unitary HP	$70	-$679	-$268	-$16
Fuel Oil	Boiler High Temp	Split Unitary AC	Split Unitary HP	$1,188	$1,454	$1,011	$1,277
Fuel Oil	Furnace	Split Unitary AC	Split Unitary HP	$1,217	$1,483	$1,040	$1,306
Electric	Electric Resistance	Split Unitary AC	Split Unitary HP	$1,596	$1,277	$1,809	$1,489
Propane	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$924	$1,190	$747	$1,013
Propane	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$924	$1,190	$747	$1,013
Propane	Furnace	Split Unitary AC	Packaged Unitary HP	$924	$1,190	$747	$1,013
Methane Gas	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$70	-$679	-$268	-$16
Methane Gas	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$70	-$679	-$268	-$16
Methane Gas	Furnace	Split Unitary AC	Packaged Unitary HP	$70	-$679	-$268	-$16
Fuel Oil	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$1,188	$1,454	$1,011	$1,277
Fuel Oil	Furnace	Split Unitary AC	Packaged Unitary HP	$1,217	$1,483	$1,040	$1,306
Electric	Electric Resistance	Split Unitary AC	Packaged Unitary HP	$1,596	$1,277	$1,809	$1,489
Propane	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$1,123	$1,349	$972	$1,198
Propane	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$1,123	$1,349	$972	$1,198
Propane	Furnace	Split Unitary AC	Mini-Multi Split	$1,123	$1,349	$972	$1,198
Methane Gas	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$269	-$520	-$43	$169
Methane Gas	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$269	-$520	-$43	$169
Methane Gas	Furnace	Split Unitary AC	Mini-Multi Split	$269	-$520	-$43	$169
Fuel Oil	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$1,387	$1,613	$1,236	$1,462
Fuel Oil	Furnace	Split Unitary AC	Mini-Multi Split	$1,416	$1,642	$1,265	$1,491
Electric	Electric Resistance	Split Unitary AC	Mini-Multi Split	$1,795	$1,436	$2,034	$1,675
Propane	Boiler Low Temp	Split Unitary AC	AWHP	$899	$1,170	$718	$989
Propane	Boiler High Temp	Split Unitary AC	AWHP	$899	$1,170	$718	$989
Propane	Furnace	Split Unitary AC	AWHP	$899	$1,170	$718	$989

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Methane Gas	Boiler Low Temp	Split Unitary AC	AWHP	$45	-$699	-$297	-$40
Methane Gas	Boiler High Temp	Split Unitary AC	AWHP	$45	-$699	-$297	-$40
Methane Gas	Furnace	Split Unitary AC	AWHP	$45	-$699	-$297	-$40
Fuel Oil	Boiler High Temp	Split Unitary AC	AWHP	$1,163	$1,434	$982	$1,253
Fuel Oil	Furnace	Split Unitary AC	AWHP	$1,192	$1,463	$1,011	$1,282
Electric	Electric Resistance	Split Unitary AC	AWHP	$1,571	$1,256	$1,780	$1,466
Propane	Boiler Low Temp	None	Split Unitary HP	$525	$871	$295	$640
Propane	Boiler High Temp	None	Split Unitary HP	$525	$871	$295	$640
Propane	Furnace	None	Split Unitary HP	$525	$871	$295	$640
Methane Gas	Boiler Low Temp	None	Split Unitary HP	-$329	-$998	-$721	-$389
Methane Gas	Boiler High Temp	None	Split Unitary HP	-$329	-$998	-$721	-$389
Methane Gas	Furnace	None	Split Unitary HP	-$329	-$998	-$721	-$389
Fuel Oil	Boiler High Temp	None	Split Unitary HP	$789	$1,135	$558	$904
Fuel Oil	Furnace	None	Split Unitary HP	$818	$1,164	$587	$933
Electric	Electric Resistance	None	Split Unitary HP	$1,197	$957	$1,356	$1,117
Propane	Boiler Low Temp	None	Packaged Unitary HP	$525	$871	$295	$640
Propane	Boiler High Temp	None	Packaged Unitary HP	$525	$871	$295	$640
Propane	Furnace	None	Packaged Unitary HP	$525	$871	$295	$640
Methane Gas	Boiler Low Temp	None	Packaged Unitary HP	-$329	-$998	-$721	-$389
Methane Gas	Boiler High Temp	None	Packaged Unitary HP	-$329	-$998	-$721	-$389
Methane Gas	Furnace	None	Packaged Unitary HP	-$329	-$998	-$721	-$389
Fuel Oil	Boiler High Temp	None	Packaged Unitary HP	$789	$1,135	$558	$904
Fuel Oil	Furnace	None	Packaged Unitary HP	$818	$1,164	$587	$933
Electric	Electric Resistance	None	Packaged Unitary HP	$1,197	$957	$1,356	$1,117
Propane	Boiler Low Temp	None	Mini-Multi Split	$724	$1,030	$520	$826
Propane	Boiler High Temp	None	Mini-Multi Split	$724	$1,030	$520	$826
Propane	Furnace	None	Mini-Multi Split	$724	$1,030	$520	$826
Methane Gas	Boiler Low Temp	None	Mini-Multi Split	-$130	-$839	-$495	-$203
Methane Gas	Boiler High Temp	None	Mini-Multi Split	-$130	-$839	-$495	-$203
Methane Gas	Furnace	None	Mini-Multi Split	-$130	-$839	-$495	-$203
Fuel Oil	Boiler High Temp	None	Mini-Multi Split	$988	$1,294	$784	$1,090

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Fuel Oil	Furnace	None	Mini-Multi Split	$1,017	$1,323	$813	$1,119
Fuel Oil	Furnace	None	Mini-Multi Split	$1,017	$1,323	$813	$1,119
Electric	Electric Resistance	None	Mini-Multi Split	$1,396	$1,117	$1,582	$1,303
Propane	Boiler Low Temp	None	AWHP	$500	$851	$266	$617
Propane	Boiler High Temp	None	AWHP	$500	$851	$266	$617
Propane	Furnace	None	AWHP	$500	$851	$266	$617
Methane Gas	Boiler Low Temp	None	AWHP	-$354	-$1,019	-$749	-$412
Methane Gas	Boiler High Temp	None	AWHP	-$354	-$1,019	-$749	-$412
Methane Gas	Furnace	None	AWHP	-$354	-$1,019	-$749	-$412
Fuel Oil	Boiler High Temp	None	AWHP	$764	$1,115	$530	$881
Electric	Electric Resistance	None	AWHP	$1,172	$937	$1,328	$1,094

Table 38. Operating Cost Savings For Different Equipment Scenarios In Rhode Island For Average Building Vintage, 2022 to 2023

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$966	-$402	$1,703	$966
Propane	Boiler High Temp	Split Unitary AC	Split Unitary HP	$966	-$402	$1,703	$966
Propane	Furnace	Split Unitary AC	Split Unitary HP	$966	-$402	$1,703	$966
Methane Gas	Boiler Low Temp	Split Unitary AC	Split Unitary HP	-$1,125	-$2,494	-$388	-$1,125
Methane Gas	Boiler High Temp	Split Unitary AC	Split Unitary HP	-$1,125	-$2,494	-$388	-$1,125
Methane Gas	Furnace	Split Unitary AC	Split Unitary HP	-$1,125	-$2,494	-$388	-$1,125
Fuel Oil	Boiler High Temp	Split Unitary AC	Split Unitary HP	$614	-$754	$1,351	$614
Fuel Oil	Furnace	Split Unitary AC	Split Unitary HP	$649	-$720	$1,386	$649
Electric	Electric Resistance	Split Unitary AC	Split Unitary HP	$2,905	$4,546	$2,021	$2,905
Propane	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$966	-$402	$1,703	$966
Propane	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$966	-$402	$1,703	$966
Propane	Furnace	Split Unitary AC	Packaged Unitary HP	$966	-$402	$1,703	$966
Methane Gas	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	-$1,125	-$2,494	-$388	-$1,125
Methane Gas	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	-$1,125	-$2,494	-$388	-$1,125

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Methane Gas	Furnace	Split Unitary AC	Packaged Unitary HP	-$1,125	-$2,494	-$388	-$1,125
Fuel Oil	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$614	-$754	$1,351	$614
Fuel Oil	Furnace	Split Unitary AC	Packaged Unitary HP	$649	-$720	$1,386	$649
Electric	Electric Resistance	Split Unitary AC	Packaged Unitary HP	$2,905	$4,546	$2,021	$2,905
Propane	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$1,308	$132	$1,941	$1,308
Propane	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$1,308	$132	$1,941	$1,308
Propane	Furnace	Split Unitary AC	Mini-Multi Split	$1,308	$132	$1,941	$1,308
Methane Gas	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	-$784	-$1,959	-$150	-$784
Methane Gas	Boiler High Temp	Split Unitary AC	Mini-Multi Split	-$784	-$1,959	-$150	-$784
Methane Gas	Furnace	Split Unitary AC	Mini-Multi Split	-$784	-$1,959	-$150	-$784
Fuel Oil	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$956	-$220	$1,589	$956
Fuel Oil	Furnace	Split Unitary AC	Mini-Multi Split	$991	-$185	$1,624	$991
Electric	Electric Resistance	Split Unitary AC	Mini-Multi Split	$3,246	$5,081	$2,258	$3,246
Propane	Boiler Low Temp	Split Unitary AC	AWHP	$1,078	-$228	$1,781	$1,078
Propane	Boiler High Temp	Split Unitary AC	AWHP	$1,078	-$228	$1,781	$1,078
Propane	Furnace	Split Unitary AC	AWHP	$1,078	-$228	$1,781	$1,078
Methane Gas	Boiler Low Temp	Split Unitary AC	AWHP	-$1,013	-$2,319	-$310	-$1,013
Methane Gas	Boiler High Temp	Split Unitary AC	AWHP	-$1,013	-$2,319	-$310	-$1,013
Methane Gas	Furnace	Split Unitary AC	AWHP	-$1,013	-$2,319	-$310	-$1,013
Fuel Oil	Boiler High Temp	Split Unitary AC	AWHP	$726	-$580	$1,429	$726
Fuel Oil	Furnace	Split Unitary AC	AWHP	$761	-$545	$1,464	$761
Electric	Electric Resistance	Split Unitary AC	AWHP	$3,016	$4,721	$2,098	$3,016
Propane	Boiler Low Temp	None	Split Unitary HP	$435	-$1,234	$1,334	$435
Propane	Boiler High Temp	None	Split Unitary HP	$435	-$1,234	$1,334	$435
Propane	Furnace	None	Split Unitary HP	$435	-$1,234	$1,334	$435
Methane Gas	Boiler Low Temp	None	Split Unitary HP	-$1,656	-$3,326	-$758	-$1,656
Methane Gas	Boiler High Temp	None	Split Unitary HP	-$1,656	-$3,326	-$758	-$1,656
Methane Gas	Furnace	None	Split Unitary HP	-$1,656	-$3,326	-$758	-$1,656
Fuel Oil	Boiler High Temp	None	Split Unitary HP	$83	-$1,586	$982	$83
Fuel Oil	Furnace	None	Split Unitary HP	$118	-$1,551	$1,017	$118
Electric	Electric Resistance	None	Split Unitary HP	$2,373	$3,714	$1,651	$2,373
Propane	Boiler Low Temp	None	Packaged Unitary HP	$435	-$1,234	$1,334	$435
Propane	Boiler High Temp	None	Packaged Unitary HP	$435	-$1,234	$1,334	$435

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample " Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Furnace	None	Packaged Unitary HP	$435	-$1,234	$1,334	$435
Methane Gas	Boiler Low Temp	None	Packaged Unitary HP	-$1,656	-$3,326	-$758	-$1,656
Methane Gas	Boiler High Temp	None	Packaged Unitary HP	-$1,656	-$3,326	-$758	-$1,656
Methane Gas	Furnace	None	Packaged Unitary HP	-$1,656	-$3,326	-$758	-$1,656
Fuel Oil	Boiler High Temp	None	Packaged Unitary HP	$83	-$1,586	$982	$83
Fuel Oil	Furnace	None	Packaged Unitary HP	$118	-$1,551	$1,017	$118
Electric	Electric Resistance	None	Packaged Unitary HP	$2,373	$3,714	$1,651	$2,373
Propane	Boiler Low Temp	None	Mini-Multi Split	$776	-$700	$1,571	$776
Propane	Boiler High Temp	None	Mini-Multi Split	$776	-$700	$1,571	$776
Propane	Furnace	None	Mini-Multi Split	$776	-$700	$1,571	$776
Methane Gas	Boiler Low Temp	None	Mini-Multi Split	-$1,315	-$2,791	-$520	-$1,315
Methane Gas	Boiler High Temp	None	Mini-Multi Split	-$1,315	-$2,791	-$520	-$1,315
Methane Gas	Furnace	None	Mini-Multi Split	-$1,315	-$2,791	-$520	-$1,315
Fuel Oil	Boiler High Temp	None	Mini-Multi Split	$424	-$1,052	$1,219	$424
Fuel Oil	Furnace	None	Mini-Multi Split	$459	-$1,017	$1,254	$459
Fuel Oil	Furnace	None	Mini-Multi Split	$459	-$1,017	$1,254	$459
Electric	Electric Resistance	None	Mini-Multi Split	$2,715	$4,249	$1,888	$2,715
Propane	Boiler Low Temp	None	AWHP	$546	-$1,060	$1,411	$546
Propane	Boiler High Temp	None	AWHP	$546	-$1,060	$1,411	$546
Propane	Furnace	None	AWHP	$546	-$1,060	$1,411	$546
Methane Gas	Boiler Low Temp	None	AWHP	-$1,545	-$3,151	-$680	-$1,545
Methane Gas	Boiler High Temp	None	AWHP	-$1,545	-$3,151	-$680	-$1,545
Methane Gas	Furnace	None	AWHP	-$1,545	-$3,151	-$680	-$1,545
Fuel Oil	Boiler High Temp	None	AWHP	$194	-$1,412	$1,059	$194
Electric	Electric Resistance	None	AWHP	$2,485	$3,889	$1,728	$2,485

TABLE 39. OPERATING COST SAVINGS FOR DIFFERENT EQUIPMENT SCENARIOS IN VERMONT FOR AVERAGE BUILDING VINTAGE, 2022 TO 2023

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$1,331	$789	$1,331	$1,331
Propane	Boiler High Temp	Split Unitary AC	Split Unitary HP	$1,331	$789	$1,331	$1,331
Propane	Furnace	Split Unitary AC	Split Unitary HP	$1,331	$789	$1,331	$1,331
Methane Gas	Boiler Low Temp	Split Unitary AC	Split Unitary HP	-$1,265	-$1,806	-$1,265	-$1,265
Methane Gas	Boiler High Temp	Split Unitary AC	Split Unitary HP	-$1,265	-$1,806	-$1,265	-$1,265
Methane Gas	Furnace	Split Unitary AC	Split Unitary HP	-$1,265	-$1,806	-$1,265	-$1,265
Fuel Oil	Boiler High Temp	Split Unitary AC	Split Unitary HP	$1,194	$653	$1,194	$1,194
Fuel Oil	Furnace	Split Unitary AC	Split Unitary HP	$1,239	$698	$1,239	$1,239
Electric	Electric Resistance	Split Unitary AC	Split Unitary HP	$3,248	$3,897	$3,248	$3,248
Propane	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$1,331	$789	$1,331	$1,331
Propane	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$1,331	$789	$1,331	$1,331
Propane	Furnace	Split Unitary AC	Packaged Unitary HP	$1,331	$789	$1,331	$1,331
Methane Gas	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	-$1,265	-$1,806	-$1,265	-$1,265
Methane Gas	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	-$1,265	-$1,806	-$1,265	-$1,265
Methane Gas	Furnace	Split Unitary AC	Packaged Unitary HP	-$1,265	-$1,806	-$1,265	-$1,265
Fuel Oil	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$1,194	$653	$1,194	$1,194
Fuel Oil	Furnace	Split Unitary AC	Packaged Unitary HP	$1,239	$698	$1,239	$1,239
Electric	Electric Resistance	Split Unitary AC	Packaged Unitary HP	$3,248	$3,897	$3,248	$3,248
Propane	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$1,672	$1,199	$1,672	$1,672
Propane	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$1,672	$1,199	$1,672	$1,672
Propane	Furnace	Split Unitary AC	Mini-Multi Split	$1,672	$1,199	$1,672	$1,672
Methane Gas	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	-$924	-$1,397	-$924	-$924
Methane Gas	Boiler High Temp	Split Unitary AC	Mini-Multi Split	-$924	-$1,397	-$924	-$924
Methane Gas	Furnace	Split Unitary AC	Mini-Multi Split	-$924	-$1,397	-$924	-$924
Fuel Oil	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$1,536	$1,062	$1,536	$1,536
Fuel Oil	Furnace	Split Unitary AC	Mini-Multi Split	$1,580	$1,107	$1,580	$1,580
Electric	Electric Resistance	Split Unitary AC	Mini-Multi Split	$3,589	$4,307	$3,589	$3,589
Propane	Boiler Low Temp	Split Unitary AC	AWHP	$1,764	$1,309	$1,764	$1,764
Propane	Boiler High Temp	Split Unitary AC	AWHP	$1,764	$1,309	$1,764	$1,764
Propane	Furnace	Split Unitary AC	AWHP	$1,764	$1,309	$1,764	$1,764
Methane Gas	Boiler Low Temp	Split Unitary AC	AWHP	-$832	-$1,286	-$832	-$832

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Methane Gas	Boiler High Temp	Split Unitary AC	AWHP	-$832	-$1,286	-$832	-$832
Methane Gas	Furnace	Split Unitary AC	AWHP	-$832	-$1,286	-$832	-$832
Fuel Oil	Boiler High Temp	Split Unitary AC	AWHP	$1,628	$1,173	$1,628	$1,628
Fuel Oil	Furnace	Split Unitary AC	AWHP	$1,673	$1,218	$1,673	$1,673
Electric	Electric Resistance	Split Unitary AC	AWHP	$3,681	$4,417	$3,681	$3,681
Propane	Boiler Low Temp	None	Split Unitary HP	$1,119	$535	$1,119	$1,119
Propane	Boiler High Temp	None	Split Unitary HP	$1,119	$535	$1,119	$1,119
Propane	Furnace	None	Split Unitary HP	$1,119	$535	$1,119	$1,119
Methane Gas	Boiler Low Temp	None	Split Unitary HP	-$1,477	-$2,061	-$1,477	-$1,477
Methane Gas	Boiler High Temp	None	Split Unitary HP	-$1,477	-$2,061	-$1,477	-$1,477
Methane Gas	Furnace	None	Split Unitary HP	-$1,477	-$2,061	-$1,477	-$1,477
Fuel Oil	Boiler High Temp	None	Split Unitary HP	$982	$398	$982	$982
Fuel Oil	Furnace	None	Split Unitary HP	$1,027	$443	$1,027	$1,027
Electric	Electric Resistance	None	Split Unitary HP	$3,036	$3,643	$3,036	$3,036
Propane	Boiler Low Temp	None	Packaged Unitary HP	$1,119	$535	$1,119	$1,119
Propane	Boiler High Temp	None	Packaged Unitary HP	$1,119	$535	$1,119	$1,119
Propane	Furnace	None	Packaged Unitary HP	$1,119	$535	$1,119	$1,119
Methane Gas	Boiler Low Temp	None	Packaged Unitary HP	-$1,477	-$2,061	-$1,477	-$1,477
Methane Gas	Boiler High Temp	None	Packaged Unitary HP	-$1,477	-$2,061	-$1,477	-$1,477
Methane Gas	Furnace	None	Packaged Unitary HP	-$1,477	-$2,061	-$1,477	-$1,477
Fuel Oil	Boiler High Temp	None	Packaged Unitary HP	$982	$398	$982	$982
Fuel Oil	Furnace	None	Packaged Unitary HP	$1,027	$443	$1,027	$1,027
Electric	Electric Resistance	None	Packaged Unitary HP	$3,036	$3,643	$3,036	$3,036
Propane	Boiler Low Temp	None	Mini-Multi Split	$1,460	$944	$1,460	$1,460
Propane	Boiler High Temp	None	Mini-Multi Split	$1,460	$944	$1,460	$1,460
Propane	Furnace	None	Mini-Multi Split	$1,460	$944	$1,460	$1,460
Methane Gas	Boiler Low Temp	None	Mini-Multi Split	-$1,136	-$1,652	-$1,136	-$1,136
Methane Gas	Boiler High Temp	None	Mini-Multi Split	-$1,136	-$1,652	-$1,136	-$1,136
Methane Gas	Furnace	None	Mini-Multi Split	-$1,136	-$1,652	-$1,136	-$1,136
Fuel Oil	Boiler High Temp	None	Mini-Multi Split	$1,323	$808	$1,323	$1,323
Fuel Oil	Furnace	None	Mini-Multi Split	$1,368	$853	$1,368	$1,368
Fuel Oil	Furnace	None	Mini-Multi Split	$1,368	$853	$1,368	$1,368

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Electric	Electric Resistance	None	Mini-Multi Split	$3,377	$4,052	$3,377	$3,377
Propane	Boiler Low Temp	None	AWHP	$1,552	$1,055	$1,552	$1,552
Propane	Boiler High Temp	None	AWHP	$1,552	$1,055	$1,552	$1,552
Propane	Furnace	None	AWHP	$1,552	$1,055	$1,552	$1,552
Methane Gas	Boiler Low Temp	None	AWHP	-$1,044	-$1,541	-$1,044	-$1,044
Methane Gas	Boiler High Temp	None	AWHP	-$1,044	-$1,541	-$1,044	-$1,044
Methane Gas	Furnace	None	AWHP	-$1,044	-$1,541	-$1,044	-$1,044
Fuel Oil	Boiler High Temp	None	AWHP	$1,416	$918	$1,416	$1,416
Electric	Electric Resistance	None	AWHP	$3,469	$4,163	$3,469	$3,469

Table 40. Operating Cost Savings For Different Equipment Scenarios In Virginia For Average Building Vintage, 2022 to 2023

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Propane	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$1,412	$1,412	$1,412	$1,412
Propane	Boiler High Temp	Split Unitary AC	Split Unitary HP	$1,412	$1,412	$1,412	$1,412
Propane	Furnace	Split Unitary AC	Split Unitary HP	$1,412	$1,412	$1,412	$1,412
Methane Gas	Boiler Low Temp	Split Unitary AC	Split Unitary HP	$94	-$575	-$153	$45
Methane Gas	Boiler High Temp	Split Unitary AC	Split Unitary HP	$94	-$575	-$153	$45
Methane Gas	Furnace	Split Unitary AC	Split Unitary HP	$94	-$575	-$153	$45
Fuel Oil	Boiler High Temp	Split Unitary AC	Split Unitary HP	$1,418	$1,418	$1,418	$1,418
Fuel Oil	Furnace	Split Unitary AC	Split Unitary HP	$1,448	$1,448	$1,448	$1,448
Electric	Electric Resistance	Split Unitary AC	Split Unitary HP	$1,390	$1,390	$1,390	$1,390
Propane	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$1,412	$1,412	$1,412	$1,412
Propane	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$1,412	$1,412	$1,412	$1,412
Propane	Furnace	Split Unitary AC	Packaged Unitary HP	$1,412	$1,412	$1,412	$1,412
Methane Gas	Boiler Low Temp	Split Unitary AC	Packaged Unitary HP	$94	-$575	-$153	$45
Methane Gas	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$94	-$575	-$153	$45
Methane Gas	Furnace	Split Unitary AC	Packaged Unitary HP	$94	-$575	-$153	$45

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Fuel Oil	Boiler High Temp	Split Unitary AC	Packaged Unitary HP	$1,418	$1,418	$1,418	$1,418
Fuel Oil	Furnace	Split Unitary AC	Packaged Unitary HP	$1,448	$1,448	$1,448	$1,448
Electric	Electric Resistance	Split Unitary AC	Packaged Unitary HP	$1,390	$1,390	$1,390	$1,390
Propane	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$1,571	$1,571	$1,571	$1,571
Propane	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$1,571	$1,571	$1,571	$1,571
Propane	Furnace	Split Unitary AC	Mini-Multi Split	$1,571	$1,571	$1,571	$1,571
Methane Gas	Boiler Low Temp	Split Unitary AC	Mini-Multi Split	$253	-$416	$7	$204
Methane Gas	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$253	-$416	$7	$204
Methane Gas	Furnace	Split Unitary AC	Mini-Multi Split	$253	-$416	$7	$204
Fuel Oil	Boiler High Temp	Split Unitary AC	Mini-Multi Split	$1,578	$1,578	$1,578	$1,578
Fuel Oil	Furnace	Split Unitary AC	Mini-Multi Split	$1,607	$1,607	$1,607	$1,607
Electric	Electric Resistance	Split Unitary AC	Mini-Multi Split	$1,550	$1,550	$1,550	$1,550
Propane	Boiler Low Temp	Split Unitary AC	AWHP	$1,495	$1,495	$1,495	$1,495
Propane	Boiler High Temp	Split Unitary AC	AWHP	$1,495	$1,495	$1,495	$1,495
Propane	Furnace	Split Unitary AC	AWHP	$1,495	$1,495	$1,495	$1,495
Methane Gas	Boiler Low Temp	Split Unitary AC	AWHP	$178	-$491	-$69	$129
Methane Gas	Boiler High Temp	Split Unitary AC	AWHP	$178	-$491	-$69	$129
Methane Gas	Furnace	Split Unitary AC	AWHP	$178	-$491	-$69	$129
Fuel Oil	Boiler High Temp	Split Unitary AC	AWHP	$1,502	$1,502	$1,502	$1,502
Fuel Oil	Furnace	Split Unitary AC	AWHP	$1,532	$1,532	$1,532	$1,532
Electric	Electric Resistance	Split Unitary AC	AWHP	$1,474	$1,474	$1,474	$1,474
Propane	Boiler Low Temp	None	Split Unitary HP	$1,195	$1,195	$1,195	$1,195
Propane	Boiler High Temp	None	Split Unitary HP	$1,195	$1,195	$1,195	$1,195
Propane	Furnace	None	Split Unitary HP	$1,195	$1,195	$1,195	$1,195
Methane Gas	Boiler Low Temp	None	Split Unitary HP	-$123	-$792	-$369	-$172
Methane Gas	Boiler High Temp	None	Split Unitary HP	-$123	-$792	-$369	-$172
Methane Gas	Furnace	None	Split Unitary HP	-$123	-$792	-$369	-$172
Fuel Oil	Boiler High Temp	None	Split Unitary HP	$1,202	$1,202	$1,202	$1,202
Fuel Oil	Furnace	None	Split Unitary HP	$1,231	$1,231	$1,231	$1,231
Electric	Electric Resistance	None	Split Unitary HP	$1,174	$1,174	$1,174	$1,174
Propane	Boiler Low Temp	None	Packaged Unitary HP	$1,195	$1,195	$1,195	$1,195
Propane	Boiler High Temp	None	Packaged Unitary HP	$1,195	$1,195	$1,195	$1,195
Propane	Furnace	None	Packaged Unitary HP	$1,195	$1,195	$1,195	$1,195

Equipment Combinations				Operating Costs Savings			
Fuel Type	Base Heating Equipment	Base Cooling Equipment	Measure Equipment	EAI State Avg.	Sample "Small" Utility / Co-op	Second Largest Utility	Largest Utility
Methane Gas	Boiler Low Temp	None	Packaged Unitary HP	-$123	-$792	-$369	-$172
Methane Gas	Boiler High Temp	None	Packaged Unitary HP	-$123	-$792	-$369	-$172
Methane Gas	Furnace	None	Packaged Unitary HP	-$123	-$792	-$369	-$172
Fuel Oil	Boiler High Temp	None	Packaged Unitary HP	$1,202	$1,202	$1,202	$1,202
Fuel Oil	Furnace	None	Packaged Unitary HP	$1,231	$1,231	$1,231	$1,231
Electric	Electric Resistance	None	Packaged Unitary HP	$1,174	$1,174	$1,174	$1,174
Propane	Boiler Low Temp	None	Mini-Multi Split	$1,354	$1,354	$1,354	$1,354
Propane	Boiler High Temp	None	Mini-Multi Split	$1,354	$1,354	$1,354	$1,354
Propane	Furnace	None	Mini-Multi Split	$1,354	$1,354	$1,354	$1,354
Methane Gas	Boiler Low Temp	None	Mini-Multi Split	$37	-$632	-$210	-$13
Methane Gas	Boiler High Temp	None	Mini-Multi Split	$37	-$632	-$210	-$13
Methane Gas	Furnace	None	Mini-Multi Split	$37	-$632	-$210	-$13
Fuel Oil	Boiler High Temp	None	Mini-Multi Split	$1,361	$1,361	$1,361	$1,361
Fuel Oil	Furnace	None	Mini-Multi Split	$1,391	$1,391	$1,391	$1,391
Fuel Oil	Furnace	None	Mini-Multi Split	$1,391	$1,391	$1,391	$1,391
Electric	Electric Resistance	None	Mini-Multi Split	$1,333	$1,333	$1,333	$1,333
Propane	Boiler Low Temp	None	AWHP	$1,279	$1,279	$1,279	$1,279
Propane	Boiler High Temp	None	AWHP	$1,279	$1,279	$1,279	$1,279
Propane	Furnace	None	AWHP	$1,279	$1,279	$1,279	$1,279
Methane Gas	Boiler Low Temp	None	AWHP	-$39	-$708	-$285	-$88
Methane Gas	Boiler High Temp	None	AWHP	-$39	-$708	-$285	-$88
Methane Gas	Furnace	None	AWHP	-$39	-$708	-$285	-$88
Fuel Oil	Boiler High Temp	None	AWHP	$1,286	$1,286	$1,286	$1,286
Electric	Electric Resistance	None	AWHP	$1,258	$1,258	$1,258	$1,258